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PROCEEDINGS AND GENERAL

London Section

Meeting at the Barrett Street Trade School, London, W. 18th November, 1931; Chairman: Mr. A. R.

FASHION—COLOUR AND DESIGN

At this meeting the lecture was given by Mr. Robert F. Wilson, General Manager and Secretary of the British Colour Council. He was introduced by the Chairman, who referred to the foundation of the Colour Council some two years ago and its work in the interests of British Colour-using Industry since.

Mr. Wilson, after referring to the wide field covered by the title of his lecture, even if restricted to Textiles, said he would attempt to define where this country stood in regard to the production of textiles from the point of view of design and colour. As a first step towards providing an answer he reviewed the history of these two important things. In this review he pointed out that it was necessary in an attempt to appreciate the art of any age, to try to understand the artist and the conditions under which he worked and the people for whom he produced his work.

In the earliest woven fabrics a symbol, for example the pomegranate, was invariably the motive of the pattern, and a repeat of pattern was also an essential factor in fabric ornamentation. The lecturer then dealt in sequence with the fabrics, tapestries, etc., of the Egyptians, of the Greeks, and of Eastern peoples such as the Hindus, the Chinese, and the Japanese. He then described the effect on weaving, so far as ornamentation and colour was concerned, of the rise of Mohammedan power. The Arabs, by religion and conquest, developed into the most powerful and influential nation of mediaeval times. They assimilated and encouraged the industrial arts and their influence on weaving designs and structure of fabrics was very marked. In Sicily, under Mohammedan rule, the art of pattern weaving reached its highest point. In Spain, also, splendid Saracenic fabrics were produced under the influence of the Arab conquerors of that country.

The lecturer next described the effect of the conquest of Sicily by the French, in 1266, which resulted in the weavers of Palermo migrating to Italy. Later the Florentines dominated the world as weavers and designers and with this town and period is associated the name of the Velutti family, the probable inventors of Velvets.

Turning to developments outside Italy, Mr. Wilson described the rise of weaving and the typical pattern motifs in Bruges, Ghent, Ypres, Arras, Oudenarde and Brussels. French and Belgian designs and progress were outlined, and reference then made to developments in England which, from early times, had a reputation for embroidery and for producing fabrics of linen and wool.

Mr. Wilson next gave an outline of the sources of early colours and of the art of dyeing from remote times, passing, in review, over the countries of India, China, Japan and Persia, and defining their influence upon later developments.

Reference was also made to the transition from natural to artificial dyestuffs, the latter predominant not only from the point of view of colour but also because of their infinitely superior fastness to various damaging influences such as light, washing, etc.

The lecturer, reviewing the primary colours—red, blue and yellow—described the properties thought to be associated with each colour in various countries, reference being made among many others to the royal yellow of China, and the use of red in Eastern countries as a safeguard against cholera. " From such considerations as the foregoing," said Mr. Wilson, " it was possible to proceed to the forecasting of colours for general use in the coming seasons."

In conclusion, the lecturer attempted an answer to the question of where we stood to-day in the matter of design and colour. He continued, " Do modern designs in this country reflect the spirit of the age, or do manufacturers never consider these things, and remain content to re-hash the mixture as before ? If this is so we have not much hope of success as a manufacturing nation. Generally speaking, the older generation believes in naturalism ; they like a full budget of facts. The naturalistic designs relying on numerous or fancy weaves and textures do not, however, represent the spirit of this age. The people of to-day, all over the world, are tending towards the Greek ideas of open air, health, and light. We live in an age of speed. We can draw upon the designs of the past for inspiration, but the motifs should in some degree reflect this age, although the principles of structure should be those used by Eastern and early European weavers, with whom insistence is laid upon harmony of line and mass, and the perfect distribution and significance of the ornament. You will find that the principles of good design are constant—but weaves and motifs vary. But in the matter of colour there is no variation. If we are to regain our prestige, we must lead in design and colour—for, as *The Times* said recently, ' these things are too intimate for another nation to settle for us '—we must set out house in order in relation to these two important points."

A vote of thanks to the lecturer was proposed by Mr. H. S. Newsome, and cordially agreed to. Mr. Wilson suitably acknowledged the vote.

Midlands Section

Joint Meeting with the Society of Dyers and Colourists, Colleges of Art and Technology, Leicester, Wednesday, 9th December, 1931; Mr. S. E. Ward, Nottingham, presiding.

AIMS AND OBJECTS OF RESEARCH IN KNITTING

The lecturers on this occasion were Mr. J. B. Lancashire and Mr. H. L. Long. Mr. Lancashire's contribution concerned the physical side of hosiery research and also applied science in regard to the evolution of new stitches and new fabrics. He said that very little research or investigation on the properties of knitted fabrics had been carried out, and suggested that it was necessary to find means to measure the various properties such as elasticity, which was distinct from extensibility, lustre, porosity, wear, etc. A little work had been done in both England and U.S.A., but the latter country had the advantage of possessing a Knit Goods Research Association, whereas in Great Britain, no such body existed, though some work had been done by private individuals in colleges and works.

He proceeded to review the efforts being made to improve or modify stitch formation in order to obtain certain qualities or effects and exhibited slides to illustrate his remarks. Ladderproof fabrics were in existence and these were being investigated with the object of improving their elasticity and applying them to the manufacture of knitted footwear. Experiments were being carried out with

the insertion and actual knitting of rubber threads covered with textile materials. Lingerie fabrics were being improved and ornamented in self-coloured patterns. Intarsia fabrics had been greatly improved. He suggested possible lines of development and said that though both machine builders and manufacturers were carrying out investigations, no collective efforts had been made. He felt sure that research into the measurement of the properties of fabrics and stitch structure offered a wide field and distinct hopes of success.

The finishing side of the hosiery industry was dealt with by Mr. H. L. Long, who pointed out that there had been little investigation of the specific problems of the knitting industry. The lecturer then dealt with recent researches, including those still in progress.

In connection with fibres and dyes, research on the action of sunlight, the influence of humidity and the effect of micro-organisms was in progress. Dealing with scouring, it was pointed out that a search for new detergents, which would allow the use of hard water without deposition of lime soaps, might have valuable results. Many wetting agents had been introduced for use in textile processes involving water. The most interesting development relating to bleaching was the introduction of the sulphur dioxide/caustic soda method which promised to be of great use.

Progress had been made in moth- and mould-proofing and in rain proofing and scientific methods for testing water-proofness had been studied. Methods of measurement of various properties hitherto not susceptible of exact measurement were being devised and progress had been made with fibre and fabric thickness, porosity and lustre.

Some work had been done in connection with hydro-extracting, drying, boarding and pressing but much still remained to be investigated to ascertain the effect of various conditions on the finish.

The influence of various factors on the transmission of heat, moisture, and light by knitted fabrics and the bearing on health should be fully investigated.

The possibility of the introduction of more automatic machinery into hosiery dyeing required study, and faults developing during dyeing and laundering were discussed. Defects in the yarn are the most serious cause of trouble in laundering knitted goods. Work had been done on shrinkage. Research on possible methods to reduce shrinkage with less damage to other intrinsic properties of the wool fibre was needed. In dealing with faults, the lecturer showed how scientific investigations had helped to allocate the responsibility for the trouble.

Research was needed in the hosiery industry because the yarn, fabric structures and modifications of surface brought about by chemical and mechanical treatment were generally of greater importance than the intrinsic properties of the fibre itself.

Irish Section

Meeting at the Municipal College of Technology, Belfast, on Wednesday, 16th December, 1931; Mr. W. H. Webb, Chairman of the Section Committee, presiding.

MONETARY LEADERSHIP: PLAN FOR AN EMPIRE CURRENCY

The Chairman, in calling upon Mr. J. F. Darling, C.B.E., a Director of the Midland Bank, said that the problem confronting the country appeared to be one of repairing the damage done by the attempt to maintain the gold standard at a time which had proved quite inopportune. They were fortunate, indeed, in having secured the services of an individual of world-wide reputation to address them on the subject of monetary science. The large and influential attendance demonstrated the keen interest in this subject which was of vital importance.

Mr. Darling, introducing his subject, said: "The world is anxiously awaiting for courageous guidance out of the terrible crisis in which it has become involved." He continued that he was convinced that "Britain as a nation and as the centre of a Great Empire," could show the way out if prepared to assume the responsibilities of leadership. He felt that, on the contrary, Britain had shown unaccustomed reluctance to take the initiative in world progress. She had mistaken the dollar for her true objective. On an unsound basis of borrowing abroad we had returned to the Gold Standard in 1925. By spending, lending, and borrowing freely we had courted disaster. Business men would appreciate that this had resulted in temporary embarrassment and in plain terms, the Federal Reserve Bank of New York had refused our cheque. "In what way," asked the speaker, "could we profit from this humiliating experience?" To resolve never to do so again, he continued, was the right course, but it needed monetary leadership of a high order to maintain that resolve. In passing he ventured to draw attention to the fact that in 1925, through the columns of the *National Review*, he had warned the nation that the then contemplated return to the Gold Standard was "a very grave risk." He had urged then what he wished to urge now—Empire economic unity. He felt that that ideal was perhaps more easily realisable now, than then, if the opportunity be promptly seized.

We had regained freedom for the pound, continued Mr. Darling, and we must plan to use that freedom to the best advantage. He would urge the creation of an imperial monetary unit on which to base the pound and other Empire currencies. If strong enough it would attract the dollar and the franc—they could not afford to remain apart. The determination to have a balanced Budget and a balanced International trade position was a good beginning. But this was not entirely under our control. Unless world trade expanded in volume we should not succeed; we might not survive. "Well-nigh all budgets have been thrown out of balance and taxation has become unsupportable. The crisis goes far beyond anything that the mere provision of added credit facilities can cure. The credit machine is now compelled to run dead slow—through lack of security."

The lecturer then postulated that our immediate pressing concern was for some dynamic price-raising power to restore values and make possible the effective use of credit and world recovery. This power, in the opinion of the lecturer, was ready to hand—nature's abundant provision for all sorts of products. To enjoy these it was essential to have the facility of exchanging them. Nature, too, seemed to him to have provided both gold and silver as metals eminently suited for use as money and he proceeded to plead for the re-monetisation of silver at a natural relative value to gold.

The lecturer said he had outlined a plan, published in pamphlet form, for an Empire Monetary unit. The outline of the plan was then given and involved the creation of a Super-Bank of the Empire to take over the existing stocks of gold and silver held by Empire governments and banks which issue currency. This Super-Bank would be given a new, purely book-keeping, monetary unit—a "rex"—for its exclusive use for the purchase of gold and silver. The rate of purchase of gold and silver would be fixed at a minimum of one "rex" for 113 grains of fine gold, or for 2,260 grains of fine silver.

The gold/silver ratio suggested, approximated to the sterling parity of the Indian rupee, which was 1s. 6d. The value of the "rex" would be uniform and gold and silver produced in the Empire would be purchased on the spot as it came from the mines. By pooling the Empire's gold, continued Mr. Darling, and reserving the all-important right to raise its price should need arise, the Empire could simultaneously rehabilitate the value of silver and to a large extent prevent the undue accumulation of gold in any one country.

By retaining sufficient gold to balance its holding of silver—if necessary raising the price of gold to do so—silver would become stable, in terms of the Empire's monetary unit and gold would become the adjusting factor in determining the ratio between the two metals. There were several reasons why the price of silver should be stabilised and of these, the chief were given by the lecturer. Its primary use was for coinage and the weight of pure silver in the silver coin must be definitely fixed. It was essential to restore the value of silver coinage in the East, more particularly so in India. Silver-using countries such as China, Mexico, Central and South America, would be affiliated to the " rex " through silver. In addition, it would be in the interests of the United States and France to adjust their currencies to the " rex " and in a word, said Mr. Darling, the new monetary unit could become the pivot for the world's currencies.

Continuing, Mr. Darling pointed out that if the adoption of a common monetary unit for the Empire was, temporarily, too difficult to arrange, Britain, through her relationship with India, was in a position to restore the value of silver unaided. It could be done by authorising the Bank of England to hold rupees, or their silver content in reserve against Bank of England notes at a value equal to the exchange parity of 1s. 6d. per rupee. The results of this momentous action, said the lecturer, would be that silver production would become far more profitable and the purchasing power of those interested would be increased. The basis of credit would be enlarged with an effect on purchasing power analogous to big new discoveries of gold. The value of the great mass of silver already in existence would be substantially increased. The restorative effect on all values would be immediate and world-wide, enabling business to resume its normal course and to become profitable again. In conclusion, he indicated that the decision as to Britain's leadership, or otherwise, rested on Mr. Ramsay MacDonald,and he, the lecturer felt that serious consideration of this matter by the Prime Minister would lead to recognition by him that silver provides an answer to some of the Nation's pressing problems.

Discussion

Mr. Darling was asked many questions and, in his replies, said that if silver and gold were both working, the stabilising effect would be greater than with gold alone. He did not regard the fact that sovereigns were not in ordinary circulation as of any psychological significance. It was an economy for gold not to be in general circulation.

Asked if one of the reasons for the present conditions throughout the world was the insufficiency of gold, he said he regarded the supply as sufficient, at any rate for the next ten years or so, if it were properly distributed. As to silver, an important matter in this connection was the relationship between Great Britain and India. The restoration in value of the great mass of silver ornaments and the better prices at which the Indian peasant could sell his produce, as the result of the remonetization of silver, might well prove to be the very salvation of India.

Lord Craigavon, Prime Minister for Northern Ireland, moved a vote of thanks to Mr. Darling and complimented him on the lucid character of his address on this complicated question of currency. He could only hope that the ventilation of frank opinion on the problem would result in a solution of the difficulties which would prevent the country from going further in an undesirable direction.

Mr. F. Anderson (Portadown) seconded, and the motion was carried by acclamation.

In acknowledging the vote, Mr. Darling said his visit to Belfast gave him great pleasure. The attendance and the spirit of inquiry indicated by the questions clearly showed that people were thinking deeply on this vast subject.

Scottish Section

Meeting at Greenock

The first meeting of the current session was held at Greenock on Thursday, 17th December, and, although the attendance was smaller than usual, it was representative of practically every district in the Section area. The members from outlying districts travelled together from Glasgow, and, on arrival at Greenock, were conveyed by private bus to the Tontine Hotel, where the party assembled for lunch at 12.30 p.m. As guests of the Section, there were present, Mr. J. M. Galbreath and Mr. G. B. Hebblethwaite, of Messrs. Fleming, Reid & Co., Ltd., Greenock. Mr. T. M. Lees, Chairman of the Section Committee, presided, and expressed the party's thanks for the opportunity and privilege afforded by Messrs. Fleming, Reid & Co., Ltd., of visiting their worsted spinning and knitting mills. After lunch the party proceeded to the mills, and were conducted throughout the various departments by Mr. Galbreath and Mr. Hebblethwaite, who explained the different processes carried out in the manufacture of the firm's well-known brands of rug, and knitting wools, and hosiery. An interesting afternoon was spent in the works, and in the administrative departments, where Mr. Hastie, Secretary of the Company, explained the various mechanical accounting and book-keeping appliances in connection with the firm's shops. Thereafter, the Members were entertained to tea by the Company.

NOTES AND NOTICES

Annual Meeting and Next Conference

The Council of the Institute has decided that the next Annual General Meeting of Members shall take place at Headquarters, Manchester, on Wednesday, 20th April, and the Council will meet on the same day. It is not intended to extend the proceedings beyond the ordinary agenda providing for the election of Officers and the presentation of the usual reports for the approval of the meeting. In due course, nomination forms for the annual election of ten members of Council will be circulated. In addition to the fixing of the date of the Annual Meeting, the Council has decided to hold a Conference during next Whit-week, and inquiries are proceeding with a view to the event taking place at Leamington. It is considered that this centre should prove quite attractive, particularly from the point of view of visits which might be arranged. The district is convenient for Members in several of the areas covered by Sections of the Institute whilst, industrially, the neighbourhood is of great and varied interest. Next Whit-week will be the third week of May, the 16th May being Whit-Monday.

Design and Structure of Fabrics

The Institute's prospectus of Competitions for the current year is now published. Supplies of printed copies have been circulated to the textile departments of technical colleges and schools, and any Member of the Institute may secure a copy on request to the General Secretary. The conditions attached to the various competitions have been considerably amended, and both teachers and students are urged to note the alterations effected. For the first time, a competition in reference to the design and structure of knitted fabric is included and the Committee of the Midlands Section of the Institute has prepared the scheme. The plan adopted is submitted as an experimental effort and may be modified in a subsequent year in the light of experience. Not only have the conditions in respect of the established competitions been subjected to revision, but the printed forms to be used by competitors have been reconstructed. A new Entry Form is provided which is common to the whole of the competitions.

Federation of Textile Societies

The Annual Meeting and Conference of this Federation is to take place on Saturday, 7th May, next at Bradford, by invitation of the Bradford Textile Society. It was reported at last meeting of the Committee of Management of the Federation that permission had been secured from Mr. Edford Priestley for a visit to works at Bramley, whilst Captain Pitchers would permit a visit to the Airedale Combing Company's works, and Mr. Hugh Dawson had consented to a visit to the works of Messrs. Joseph Wilson, Ltd., Grange Shed. Luncheon is to be provided by Mr. Edford Priestley, President of the Bradford Textile Society, and, during the afternoon, an address on "Worsted Spinning" will be contributed by Mr. Priestley. It is recommended that delegates should arrange to be at Bradford not later than 10 a.m., and meet at the Alhambra Theatre. Full particulars will be issued in due course to secretaries of the various affiliated Societies.

Textile Institute Diplomas

Elections to Associateship have been completed since the appearance of the previous list (December issue of this *Journal*)—

ASSOCIATESHIPS

FAIRCLOUGH, Willan (Chorley).
CALLANDER, John (Paisley).
LIVINGSTON, Hamilton (Lurgan, N. Ireland).

Institute Membership

At the January meeting of the Council, the following were elected to Membership of the Institute:—W. W. Adams, 11 Saunders Road, London, W.11 (Clerical Assistant, L.C.C. Supplies Department); E. G. Baverstock, "Pennington," 83 Perryn Road, Acton, London, W.3 (Textile Analyst); Wm. Breakell, 8 Mellor Street, Hollinwood, Oldham (Operative Cotton Spinner); J. E. Greathead, 378 Gt. Cheetham Street, Higher Broughton, Salford (Assistant Cotton Yarn Tester, Lancashire Cotton Corporation); G. Grogan, c/o 237 Stockport Road, Cheadle Heath, Stockport (Research Asst. in Weaving, British Cotton Industry Research Association); R. E. V. Hampson, c/o British Launderers' Research Association, The Laboratory, Hill View Gardens, Hendon, London, N.W.4 (Acting Director of Research); R. J. Harfield, Cosby Road, Countesthorpe, near Leicester (Elastic Web Factory Manager); J. Haslam, 33 Beverley Street, Moss Side, Manchester (Laboratory Assistant, Calico Printers' Association, Ltd.); Thos. Hodkin, 91 Warwick Road, Ealing, London, W.5 (Textile Testing and General Technical Adviser to Silk and Cotton Depts.); R. Horner, 30 Bullroyd Drive, Alliton Road, Bradford, Yorks. (Yarn tester); H. Isherwood, c/o Madura Mills Co., Ltd., Madura, S. India (Carding and Spinning Master); S. H. Kjellstrand, Tekniska Elementarskolan, Boras, Sweden (Head of Textile Department); F. B. Lindley, c/o Hunter, "Arkleston Cottage," off Renfrew Road, Paisley (Textile Chemist, J. & P. Coats, Ltd.); T. E. Nuttall, 140 Hibson Road, Nelson (Cloth Tester, Lancashire Cotton Corporation); A. M. Paterson, 114 Rose Street, Dunfermline (Linen Damask Designer, Hay & Robertson, Ltd.); G. R. V. Pitre, The Swadeshi Cotton Mills, Indore, Central India (Carder and Spinner); James Rae, 79 Main Street, Townhill, Dunfermline (Apprentice Manager, Hay and Robertson, Ltd.); N. Rhodes, 247 Burnley Lane, Chadderton, Oldham (Big Piecer, Fernhurst Spinning Co.); C. Smith, 11 Scar View, Cowling, near Keighley (Designer-Manager, Walton & Co., Ltd., Knaresborough); J. Woods, 95 South Street, Boston, Mass., U.S.A. (Latin-America Representative, Universal Winding Company).

REVIEWS

Annual Reports of the Society of Chemical Industry on the Progress of Applied Chemistry. Vol. XV, 1930.

In conformity with its usual practice, the Society of Chemical Industry has produced a further valuable summary of the last year's outstanding developments in the field of industrial chemistry, and most technologists, to whom time is of value, and facilities for making individual, comprehensive surveys of current literature out of the question, have welcomed the appearance of this publication. The sections dealing with fibres, textile cellulose and paper, and with bleaching, dyeing, printing, and finishing, will be specially useful to those connected with the technical side of the textile industry. These sections, written by Dr. J. C. Withers, of the British Cotton Industry Research Association, and Mr. A. J. Hall, contain comprehensive surveys of the outstanding developments in the particular fields dealt with, and both writers have shown an excellent discrimination in the treatment of their subjects, and incorporated a good deal of extremely valuable criticism in the preparation of their reviews. Another section, which will be of interest to those connected with the dyeing industry, is that dealing with colouring matters and dyes. This particular part of the report has been written by Mr. L J. Hooley, and contains a detailed account of the most recent advances in the chemistry of intermediates, dyestuffs, and allied compounds. In addition to being useful to textile chemists and technologists, the publication should be of immense value to students training for their higher qualifications in technological subjects. F.L.B.

The Testing of Yarns and Fabrics. By H. P. Curtis. Published by Sir Isaac Pitman & Sons, Ltd., London. Second edition (179 pages plus index. 5s. net).

This small book, which has been written primarily for manufacturers, warehousemen, and textile operatives, and also with the idea of giving those concerned in the industries connected with the utilisation of textiles an insight into textile testing methods, is a second edition of an earlier publication of the same name. In the preparation of this second edition a certain amount of revision has been carried out, and this, together with the amplification of certain sections, has considerably enhanced the value of the book. It is also gratifying to discover that a number of errors which had unfortunately found their way into the text of the earlier edition, have been eliminated, although it is regrettable that several still remain uncorrected in the present publication. The various sections of the book are well arranged, and the tests mentioned are those which may be carried out by persons with little or no knowledge of scientific technique. On the whole it has been very well produced; the illustrations of various testing appliances being specially good. The book contains a short glossary of textile terms used in the text, and should be extremely valuable to those requiring an insight into the methods employed for the testing and evaluation of textile materials. F.L.B.

The Preparation and Spinning of Flax Fibre. By S. A. G. Caldwell. Published by Emmott & Co., Ltd., Manchester. (15s. net.)

This is a well-bound and printed book of 364 pages. There are few books on the subject of flax spinning in existence so that this book may be said to meet a long-felt want. The author provides evidence throughout the book of his practical and up-to-date experience of flax spinning as it exists in Northern Ireland. He has confined himself to wet-spinning and its associated technique of preparation, so that information on dry-spinning as practised by the Scottish section of the linen industry is not provided.

The book traces the passage of the flax fibre through the successive processes of dressing, preparing, spinning and reeling and gives separate accounts of the treatment of tow. Separate sections are devoted to the upkeep of plant and to the costs of yarn production. The latter is very complete and practical and should prove to be a valuable feature of the book. The machinery and mechanism used in each process is clearly and simply described and illustrated and the mode of operation of the machine on the material presented to it, with detailed information on the procedure to be adopted to give satisfactory results, is dealt with very fully. Altogether this book should prove a valuable work of reference to the student and to the practical flax spinner.

A misprint noticed on page 15 is " scutched " instead of " broken " in line 22.

L.I.R.A.

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PROCEEDINGS AND GENERAL

OFFICIAL REPORT CONCERNING A TEST OF AUTOMATIC LOOMS, ETC., MADE IN 1931*

By The Lancashire Cotton Corporation Ltd.

PREFACE

The Lancashire Cotton Corporation Ltd. desires to express its thanks to all those Companies mentioned below who kindly placed looms and attachments at its disposal for the purposes of the test

Messrs. ***The British Northrop Loom Co. Ltd.,*** *Blackburn*
,, ***Platt Bros. & Co. Ltd.,*** *Oldham*
,, ***The Stafford Corporation,*** *Crayford, Kent.*
,, ***Whittaker Automatic Looms Ltd.,*** *Blackburn.*

and also to ***The Universal Winding Co. Ltd.,*** *Manchester, for the loan of a T60 G.F. Cone Winding Machine and a high speed Beaming Machine.*

The plant was installed under the arrangements of the Corporation's own Technical Department, and personally supervised by Mr. A W. Brierley. The test was conducted at Higher Walton Mill, under the management of Mr. R. C. Garnett. The test itself was controlled by Mr J. B. Aitken and the records were collected by Mr. C. Yates who together have compiled the report with the collaboration of Mr. J S Taylor, the Cost Accountant of the Corporation.

Every care has been taken to cover every point of interest in the manufacture of the cloth and the report as issued has been examined by all the loom makers concerned.

GENERAL DESCRIPTION OF THE VARIOUS TYPES OF LOOMS TESTED

There were, at the commencement of the experiment, three types of automatic loom and three types of automatic attachment—

1. The Northrop loom (bobbin changing loom)
2. The Toyoda loom (shuttle changing loom)
3. The Vickers-Stafford loom (shuttle changing loom)
4. The Whittaker attachment (bobbin changing attachment)
5. The Terry attachment (bobbin changing attachment)
6. The Gawsworth attachment (self-weaving attachment).

The Terry and Gawsworth makers decided to retire and the " test proper " started on April 7th, 1931, between Northrop, Vickers-Stafford, and Toyoda looms, the Whittaker attachment, and the Plain loom ; 40 looms of each type, and all these ran continuously from that date.

The Northrop Loom—45 in. reed space

This loom is built by the British Northrop Loom Co. Ltd., Blackburn, and is known as the 40 in. Model " S." It is extremely well made and has many features which save time in weaving and which speed-up and ease the tackler's work. It is of extremely strong construction and runs easily and with comparatively little vibration. There is much steel used in its construction in place of cast iron and component parts of the looms are very accurately made.

The crank shaft bearings, tappet shaft bearings and rocking rail bearings are all fixed by bolts which are a push-fit in the loom side and in consequence

all distortion is avoided. Also if any of these parts wear out new parts can at once be fitted with absolute accuracy and little or no hand-fitting. The standardisation of parts is very good and only three sizes of nuts and bolts are used throughout the loom. Ample bearing surfaces are provided and means of adjustment to every part of motion which may need it.

The 45 in. loom weighs 21½ cwts., which is additional testimony to the excellence of the material used and the workmanship. The loom is the simplest of the fully Automatics and has the fewest working parts.

Another feature is the fact that all the looms have the magazine at the right hand side and starting handle on the left. This makes the weaver's work simpler and helps the standardisation of loom parts. The driving is, of course, left or right hand as desired. Great use is made of split and spring washers to prevent parts coming loose by vibration. This seems an excellent feature.

The Toyoda Loom– 46 in. reed space

These were built by Messrs. Platt Bros. & Co. Ltd., of Oldham, and were the first 40 Toyoda looms made in England. In consequence of this there have been many troubles due directly to the loom being a new production, and whilst a report can only be made on the results obtained, it must be borne in mind that Messrs. Platt Bros. are taking every advantage of their experiences at Higher Walton and many of the faults discovered will not occur again.

This type of loom has a very heavy slay and in conjunction with the comparatively high speed of 187 picks per minute a great deal of vibration is created with a detrimental effect on the yarn. The framing and crank shaft are not strong enough to hold the heavy moving parts. So great was the vibration that the looms, which were held down by rag bolts sunk in Fox's cement, pulled loose the bolts and had to be refixed.

One of the main features of the loom is an excellent warp let-off motion. There are rather too many set screws and bolts, which may slip and the loom gives the impression of having had an attachment built into it instead of being a fully automatic weaving machine. The loom turns the scale at 18 cwts., the framing being light but the slay heavy.

There are also features which do not conform to American Automatic loom practice ; for example, the use of a heavy wooden cloth roller and a very heavy weaver's beam, the flanges of which are inclined to slip. Chromium plating is extensively employed and has been a success for many small parts, and a failure for others. Time will prove its usefulness.

The loom is not well designed for the weaver as it is too deep for a short girl to reach across and too low. The warp stop is of a type which makes a broke. end comparatively difficult to find, as time tests have shown. Again, the loom is very heavy to handle and the usual fast and loose pulley arrangement is not satisfactory for automatic weaving, as it puts too much physical strain on a weaver.

There has been an excessive breakage of loom parts, caused partially by the newness of the loom, but also accounted for by the extremely fierce action of putting a 15 in. shuttle into a fast-running slay and ejecting the spent shuttle in one motion. The loom uses the side lever picking arrangement which is very sharp in action and this is reflected in broken picking sticks and worn pick points.

The Vickers-Stafford Loom—45 in. reed space

The loom was made by Messrs. Vickers (Crayford) Ltd., Crayford, Ken from the pattern of the Stafford Corporation of America. The loom is we made but is of light construction, the total weight being about 16½ cwts. The is that frailness that is often associated with American-made motor cars, y the loom runs most sweetly and there has been very little breakage on the so of cloth woven. A special note is made later of the value of this loom in weavin fine yarns, artificial silk, etc.

Many of the motions are extremely good and compare favourably with the best of the other looms. The loom is well put together and apparently is mechanically sound. Certain parts, however, are beginning to wear rather rapidly, principally the changing cams, the re-starting motion, and parts of the warp stop-motion.

The loom has a great many more working parts than the Northrop loom for example, yet its slow running at 164 picks per minute, and its gentle action have cut loom breakages down to very small proportions. The loom is very easy to handle both for the weaver and the tackler and the general finish of the loom is good.

The Whittaker Attachment—45 in. reed space

Whittaker attachments are made by Messrs. Whittaker Automatic Looms Ltd., Blackburn. The motion performs the act of putting a pirn into a shuttle when the pirn which is weaving has become empty.

No attempt at standardisation has been made and in gaiting up the motions an immense amount of hand fitting has to be done. This is largely because the ordinary loom is not designed to take any form of weft replenishing device.

It would appear that no loom of say 56 reed space or under has a framing sufficiently strong to stand up to Automatic weaving for any length of time. The action of putting a new bobbin into a loom running at 175 picks per minute is very severe and becomes much more so if any parts get out of adjustment. Consequently to fit attachments to old looms must shorten their life considerably.

There are other defects which become apparent as time goes on, and the most noticeable is the deterioration in the cloth due mainly to the tackler being so busy working on the motion that he has no time to attend to the loom parts. The looms took a very long time to gait up by comparison with the fully automatics, notes on which appear later.

The advantages are: (*a*) comparatively low first cost and (*b*) using up of good Lancashire looms.

The "Lancashire" Loom

Forty 45 in. "Henry Livesey Ltd" looms were gaited up with the idea of forming a direct comparison with the Automatics, but very soon it was found that by standardizing the Lancashire loom and giving four beams of one suitable sort to a weaver, the operative could get a much better production than with four mixed sorts. This led to various tests and experiments which have proved that much can be done with the Lancashire loom if it is worked under better conditions.

The specific alterations made were:—

1. Taking the weft to the weaver.
2. Removing the cloth from the weaver.
3. Elimination of loom stops for weft or beams.
4. Larger pirns and suitable shuttles.

Thus the Automatic loom test has brought to light the enormously increased production possible if a Lancashire loom shed be filled with one or two sorts of cloth only, as would be the case in using the automatic to its fullest advantage.

THE ACTUAL TEST

The following details have been compiled during the period of testing and are set out in the order of processing the yarn, commencing at the spinning room.

Spinning: Particulars for Yarns used

Warp	Counts	Strength Constant (Average)	Average Production (lb. per 1000 spindles)
	24s	1740	1312

The frames were not altered in any way from normal.

Weft	Counts	Strength Constant (Average)
	24s	1300

The average productions have varied very considerably according to the type of bobbin or pirn used. The table below gives the results from April 7th to July 31st.

Type	Production per 1000 spindles. (lb.)	
Lancashire Loom, 6 in. Tube	1253	Average 1212
7 in. Pirn	1192	
The Northrop loom	989	
The Toyoda loom	1019	
The Vickers-Stafford loom	881	
The Whittaker attachment	953	

The alterations made to the Frames were :—

(1) Fitting 1¼ in. rings to allow the Northrop, Whittaker, and Toyoda bobbins to pass through the ring without damaging the travellers.

(2) New cap bar nebs to replace those badly worn.

(3) The fitting of a " Bunching " motion on all frames except those spinning for the Lancashire loom.

(4) In the case of the Northrop loom only, the fitting of Draper clutch spindles.

The " Bunching " motion is a mechanical device for running a short length of yarn in a fixed position on the pirn, usually at the bottom. When all the yarn except the " bunch " has woven off the pirn, the feeler of the loom operates and a new pirn or shuttle is put into the loom. The small reserve of yarn, or " bunch," fills in the gap of 1 to 3 picks whilst the changing mechanism is brought into action and thus ensures a " pick found " cloth.

The bunching motions have not been an unqualified success, being too uncertain in action. The motion although semi-automatic requires considerable skill on the operative's part to get really good results. Loss of production has been caused because doffings of these bunches have to be made occasionally so that a stock of bunches is to hand in the ring room to replace those bobbins on which the end has broken immediately the ring frame is started at the beginning of the sett

Some portion of the low spinning production has been attributed to frames waiting for the return of bobbins from the shed. This fault, however, would not occur in a large plant. The Vickers-Stafford loom was most affected by this delay and the low production is no reflection on the type of bobbin, the loom used, or on the loom itself.

Pirns

Each type of loom uses a different pirn and some have been unsatisfactory.

The Northrop Loom Co. made their own pirns and these have given no trouble. For the Whittaker attachment they have also been good but the pirns are half-an-inch too short, causing misthreading. The Toyoda loom pirns are of the cone base type and had to be redesigned twice, but the latest pattern is fairly good.

Very careful attention has to be paid to pirns and only the very best can be used as the strain of changing on " bobbin changing " looms causes cheap pirns to warp and even break.

The Vickers-Stafford loom uses an ordinary ring weft pirn and those in use at Higher Walton are not grooved in the best manner causing a certain amount of trouble in weaving off. A suitable grooving has, however, been found by experiment.

Warp Preparation : Coning

Eighty per cent. of the total length of warp for the Automatic Shed has been run on the Draper High Speed Beamer with the magazine and creel made by the Universal Winding Co., and the remainder by the ordinary beaming process for purposes of technical comparison. The cone winding was done on a Type 60 G.F. Cone Winding Machine lent by the Universal Winding Company.

Warp Preparation: Beaming

The Draper High Speed beamer with the Universal Magazine creel for 504 ends has run 24s counts on to 28 in. flanged beams at speeds varying from 250 to 325 yards per minute. The setts were made up of 5 beams of 440 ends each, 18,770 yards, against the usual length of 12,520 yards put on the 21 in. flange Lancashire type warper's beam. The length run on is therefore 50 per cent. greater than on the usual system. The full beams average 520 lbs. gross, and require a special truck and suitable runways over the tape frame creel to handle them.

Owing to the equal tension put on each individual end, the beams are exceedingly level and the quick-acting brake on the beamer makes a lost end almost impossible. The result is clearly shown in the shed by noting the scarcity of crossed ends and lappers on the weaver's beams. This is a big advantage in Automatic weaving especially where a good twist is used and a large number of looms given to one weaver.

The machine was speeded up to see the effect on both the yarn and the motions of the headstock itself. The yarn suffered at once, but the machine ran just as sweetly at 325 yards per minute as at 250 yards per minute.

It may be noted that 18,770 yards was the maximum length on a beam that could be handled at Higher Walton because of the great weight of the beam. Given suitable lifting tackle and runways, a greater length can be run on, 21,500 yards having been run experimentally.

Taping

From December, 1930, until tape room alterations commenced in July, 1931, all the beams for the test were run on an ordinary cylinder drying machine.

Loom Preparation: Looming and Drawing

To draw in economically some form of Patent Warp Drawing-in Machine is required. For the test, however, no such machine was used. A set of healds has lasted about seven rounds on the average, and thus the actual increased cost per piece as a result of the slow hand drawing-in is very little.

Beams

Not all the beams are satisfactory. The normal type wooden-barrelled beam with pressed steel flanges and cast iron ruffles was used in the Plain looms, and in the looms with the Whittaker attachment, and gave little trouble.

The Vickers-Stafford beam is much too heavy. The flanges are not movable and therefore adjustable flanges were fitted. The normal weight is 95 lbs. and 115 lbs. with adjustable flanges.

The Toyoda loom has a heavy steel tube beam with cast iron flanges. This beam weighs 96 lbs. and is difficult to handle. The flanges, which act as the beam drive for the let-off motion, were chromium plated and this has been a failure as the plating chips and then peels off, cutting the yarn at the sides. The flanges also slip occasionally, causing much inconvenience.

The Northrop loom uses a steel tube beam with adjustable pressed steel flanges. A separate beam let-off wheel is used. This is detached at the loom. The beam weighs 65 lbs. and is very good but, in common with all tube type beams, it is not so easy to lift up and down as the piked beam.

Healds

The normal type of cotton healds, 16/50s quality, were used and have lasted very well; many setts being good after seven rounds.

Reeds

Only the best reeds should be used, especially in "bobbin changers," where a single shuttle runs all the time. Reeds have proved to be good after seven rounds.

The Shed

Higher Walton No. 2 Shed, in which are housed the Automatic looms, was built in 1910 and is very well lighted, both in daylight or by electricity at night,

but the temperature and humidity are difficult to control. The looms are all belt driven from overhead shafts, the drive being very steady and trouble-free, even when running light. It is considered that the ideal spacing is an 18 in. weaver's alley and 24 in. back alley. To obtain this for Northrop or Toyoda looms would mean 25 ft. pillar centres or for Vickers-Stafford looms 24 ft.

Running In

When all the looms were gaited, the efficiencies were checked and various tests made to try to increase production. The Toyoda looms were never really run-in at all and, in fact, the last six looms to start never ran until the morning of April 7th, the date of the commencement of the test proper.

The Running of the Looms from April 7th to July 31st, 1931

The cloth weaving in all looms was identical, being a standard bleaching cloth approximately 64 × 66 24s/24s.

The *Northrop Loom :* This loom ran without trouble at 174 picks per minute. The cloth was perhaps too light to warrant the use of such a substantial loom. The main breakages were picking sticks. Pickers last about four to six months, probably longer with lighter shuttles. The chief mechanical breakages are :— Pick noses, picking bowl studs (owing to faulty design), swell parts, guide rollers, bunters, trip levers and various small brackets and studs.

The efficiency and production has been most consistent throughout. The loom will run well up to 180 picks per minute but not faster. The loom was weaving a " pick found " cloth until June 20th, at that date Toyoda and Whittaker had thirty looms each changing on the weft fork as well as the " feeler." This, of course, is a great advantage, for if the feeler fails to act, or if the weft breaks, the loom puts in another pirn and goes on weaving instead of knocking-off.

As a result of Toyoda's and Whittaker's inability to weave on the feeler only, the Northrop and Vickers-Stafford looms were permitted to change thirty looms on to the weft fork motion. The increase in efficiency was 2½ per cent. in the Northrop loom and 1½ per cent. in the Vickers-Stafford loom. Pick found cloths are mentioned later.

The *Toyoda Loom :* This loom first ran at a speed of 191 picks per minute and later at 187. The framing being too light, much vibration was caused and the warp and weft-break rates were both up out of all proportion to the increase of speed, comparing this loom with Northrop or Vickers-Stafford looms.

The loom suffers from many broken parts. There are three causes :—

1. Speed.
2. Faulty designs due to the motions being new.
3. The fierce action of the motion.

The main breakages were :—Box tops, various odd brackets parts of the warp stop motion, shuttle shute, brackets and magazine setting brackets.

There has also been wear in most of the bushes. Shuttles have suffered severely from crushing. Picking sticks break up quickly mainly due to the use of the side lever picking arrangement and also on account of the special shape of stick used. The temple cutters have given a great deal of trouble and are not correctly designed.

The ultimate speed of this loom is stated to be 210 picks per minute but this particular model cannot exceed 190 without excessive vibration. At this lower speed a tackler has always to be tightening up brackets and parts that have worked loose.

The *Vickers-Stafford Loom :* This loom has run very well indeed at a normal speed of 164 picks per minute. Two or three pick shafts have broken, odd brackets have gone and a conveyor lever broken. With the wearing of shuttle pegs the pirns oscillated at each pick causing the yarn to slough off badly. Shuttle wear is not yet pronounced except in the tongues and clips.

The loom is not as complicated as it looks and there seems very little tackling to be done once a warp is started.

The speed is limited to 167 picks per minute because the loom must be stopped on or near back centre to effect the change and at a greater speed no brake motion could stop the loom accurately. Similarly no clutch can start the loom and get it running at full speed in half a revolution of the crank shaft, which is necessary to get a strong first pick.

The *Whittaker Attachment :* Looms fitted with this attachment ran at a speed of 173 picks per minute.

Certain mechanical breakdowns occurred resulting in some broken pick shafts and in one case a slay sword broke. The loom needs constant tackling and can soon get out of adjustment which causes bad changing, broken hammers, broken pirns, worn shuttles, etc. The maximum speed is determined by mechanical breakdown more than by the warp and weft and a limit of 175 picks might be suggested.

The looms lack those detail refinements such as automatic warp let-off motions, friction driving, special checking motions, etc., which distinguish the fully automatic loom.

The feeler on this loom is practically valueless as it quickly wears out and in any case makes much waste.

Changing " Sorts "

As far as can be seen the Northrop and Vickers-Stafford looms would experience no difficulty at all in changing " sorts." All the motions such as warp let-off motion, take-up motion and warp stop-motion are easy to adjust. The temples are normal and the picking and checking can be altered just as simply as in a plain loom.

The Toyoda loom might have a little more difficulty because the various motions are not so readily accessible, but there is nothing to prevent rapid changing from one type of cloth to another.

Much the same should apply to the Whittaker attachment although in this case it took so long to gait up the looms in the first instance that there is a doubt about the motion's adaptability to various cloths.

Type of Cloth

The widest range of cloths can be woven on the *Northrop* loom. Any plain cloth from say 60's twist to 80's weft down to as heavy as 64 × 64 14/14 should be quite easy to weave on this loom.

The range in the *Toyoda* loom is more restricted, but at the finer end there seems to be no reason why 60/80's cloth cannot be woven About 60 × 60.16/16 would be sufficiently strong to test thoroughly the Toyoda warp let-off motion. Experimentally the loom made 64 × 64.24/15 and was near to the limit.

The *Vickers-Stafford* loom speciality is the weaving of fine fabrics. The loom is not really heavy enough to go much coarser than at present, i.e. 24/24, but this loom should weave any fine sort which a Lancashire loom can make, including voiles and art silks.

The *Whittaker* attachment can make down to say 60 × 60.16/16, and the limit in fineness would be about 44's " T " and 54's " W." The loom does not make a sufficiently good cloth to consider the weaving of better yarns than ordinary qualities in these counts. Too much cloth is spoiled to warrant weaving two-fold yarns in Poplins and similar goods, but for coarse work and sheetings the attachment should be successful.

The Cloth

All three Automatic looms made a highly satisfactory cloth on the " Test " sort, the quality being superior in cover, feel, and freedom from faults, by comparison with the Lancashire loom cloth.

The *Vickers-Stafford* loom makes the best cloth especially in feel and cover, but the *Toyoda* and *Northrop* looms are most satisfactory, there being nothing to choose between these two for quality. The *Lancashire* loom is not much behind but weaving faults do occur which are eliminated in a good Automatic.

The *Whittaker* attachment is not up to the standard set by the Lancashire loom, and from the appearance of the cloth, the Lancashire loom with an attachment makes a definitely inferior cloth than either the plain loom or the fully Automatic. The cloth is, however, fairly satisfactory for this particular case.

The tape length, counts of heald and reed, etc., were purposely left alone to note the variation in cloth particulars obtained from the same yarns prepared, and woven under similar conditions.

It will be seen that the *Northrop* loom shows better in some ways than the plain loom. The *Vickers-Stafford* loom is nearly as good. The *Toyoda* loom is very wide and rather short but the cloth is there as the weight is good.

From the *Whittaker* attachment the cloth is short and narrow : short because the increase of weight means the risk of shuttle traps ; narrow mainly because of tackling faults.

Yarn Problems

The main troubles in an Automatic shed appear to be :—

1. Definitely weak yarn, especially in twist.
2. Crossed and slack ends.
3. Bad sides on beam.
4. Bad sizing, especially to light sizing as the droppers then damage the yarn.
5. Soft bobbins in weft.
6. Bad bunching.
7. Spinning under or over in weft.

All these faults sometimes happen and the various looms have different ways of overcoming them.

No. 1 can be helped in the shed by moving the position of back rest, droppers, etc. The *Northrop* loom probably gives most assistance to poor warp yarn, the *Whittaker* attachment the least.

No. 2 cannot be assisted at all.

No. 3. The usual plan is to remove the drop wires and assist weaving by using wax or rags on the warp.

No. 4. The *Vickers-Stafford* and *Northrop* looms can assist an undersized warp better than the other looms on account of their greater stretch and delicate let-off motions.

No. 5. The *Vickers-Stafford* and *Toyoda* looms are hardly affected by soft weft unless the bobbins are so large that they will not go in the shuttle or so soft that serious sloughing off occurs. Both types can have bad smashes if shuttles get fast owing to yarn sloughing off and holding the shuttle in the shed. The *Toyoda* sometimes puts two shuttles in the loom at once under these circumstances. The *Northrop* loom can weave almost any weft providing it will go into the shuttle. The *Whittaker* attachment has great difficulty in this connection as big bobbins get fast in the magazine and have been known to break the hammer, due to this part becoming wedged crossways in the slide.

No. 6. Bad bunching gives trouble to all looms, but the *Northrop* and *Vickers-Stafford* looms can usually weave a set of bad bunches if the sett is marked in the spinning room and woven up on one or two looms.

No. 7. Spinning under and over :—The *Northrop* loom is unaffected by " spinning under " unless the fault becomes severe. The *Toyoda* loom either knocks-off altogether if the yarn is spun under or throws the bobbins out if not spun fairly well down the pirn. Bobbins spun under will not go into the *Whittaker* magazine and are either wasted or have to be woven up by hand changing. If setts are spun over and the battery filler does not " ready " the bobbin properly, double picks and yarn sloughing into the shed occur.

Taken generally the *Vickers-Stafford* and *Northrop* looms can get over most weft spinning faults but the *Toyoda* loom and the *Whittaker* attachment are adversely affected.

The Workpeople

The employees have assisted us in every possible way and no real complaints of any kind have been received.

Waste

The weft waste figures are given below.

The Draper clutch spindles which ensure that all bunches are in the same relative position on the pirns give the Northrop loom a slight advantage especially if a pickfound cloth is required, but the small amount of waste made by Vickers-Stafford and Toyoda looms proves that satisfactory results can be obtained on the ordinary ring spindles.

The small amount of waste made by the Plain loom is remarkable and is accounted for by the use of bobbin weft and the skill the weaver acquires when handling one type and count of yarn only.

Type	Percentage Waste made.*	Percentage Waste made when changing on "feeler."†
The Northrop loom.. ..	1·083	0·939
The Toyoda loom	1·114	0·963
The Vickers-Stafford loom..	1·837	1·514
The Whittaker attachment	2·941	5·114
Plain loom	0·716	—

The Warehouse

The use of Automatic looms for common printers and bleaching cloths practically removes the necessity of cut-looking as the cloth has in any case to be cropped, not only to remove loose ends which the weaver cannot pick, but also to cut off the tag of weft which the temple cutter fails to remove at each bobbin end.

STATISTICAL DATA

Table I—Machine Efficiency

Type of Loom	Speed (Picks per Min.)	Efficiency	Comparative Efficiency
Northrop loom ...	174	92·835%	100·000
Toyoda loom ...	187	84·595%	91·555
Vickers-Stafford loom	164	92·263%	99·857
Whittaker attachment	173	84·900%	91·888
Plain loom	208	85·849%	92·909

Table II—Production (running week, 47½ hours)

Type of Loom	Pieces per Loom Week	Comparative Production
Northrop loom	1·626	92·67
Toyoda loom	1·609	91·66
Vickers-Stafford loom ...	1·520	85·58
Whittaker attachment...	1·494	84·13
Plain loom	1·776	100·00

Table III—Cloth Particulars

Type of loom	Average Width Ins.	Average Length yds.	Average Picks	Average Weight lb. oz.
Northrop loom... ...	34·5	118·52	66·22	29 7
Toyoda loom	34·76	116·95	65·60	29 0
Vickers-Stafford loom...	34·35	117·85	66·25	29 2
Whittaker attachment	34·36	116·57	65·60	28 12
Plain loom	34·63	118·05	66·10	29 6

* This figure is the actual recovered waste as against the total weight of weft transferred to the shed.

† This figure is the actual amount of waste made when a pickfound cloth is being produced. Note the effect on the Whittaker attachment.

Table IV—Cloth Variation

Type of loom	Extreme Variations		Percentage of pieces within 2 per cent. Variation in Length
	Width	Length	
Northrop loom ...	2·16%	3·87%	96·5
Toyoda loom	1·43%	3·03%	98·0
Vickers-Stafford loom...	2·19%	4·72%	96·0
Whittaker attachment	2·52%	4·84%	91·0
Plain loom	2·16%	3·86%	96·0

Table V—Loom Stops Summary (Stops per Loom Hour)

Type of Loom	Speed	Warp Breaks	Slack Ends	Weft Breaks	Stop on Change	Miscellaneous	TOTAL
Northrop loom... ...	174	1·10	0·15	0·70	Neg.	0·29	2·24
Toyoda loom	189	1·89	0·41	0·66	0·82	0·79	4·57
Vickers-Stafford loom...	164	1·23	0·28	0·40	0·11	0·27	2·29
Whittacker attachment	173	1·45	0·12	0·93	0·38	0·65	3·53
Plain loom	208	2·66	Neg	1·03	—	Neg.	3·39

Table V shows the loom stoppages recorded in a series of tests on each type of loom. The testing period was approximately 120 hours in each case, and the tests were taken about twice a month, from January onwards. The table infers that the warp and weft break rate increases with the speed of the loom.

The high rate of stoppages " on change " in the case of the Toyoda loom, is caused by the feeler failing to act and the high miscellaneous stoppages are due to trouble with the weft fork causing the loom to bang-off and also due to mechanical breakdown. The stops on the Toyoda loom have recently been reduced to 3·50 per loom hour.

In the case of the Whittaker attachment, the same two items are high because of the feeler failing to work and shuttles mis-threading respectively, but here again a considerable improvement has taken place.

From this table, in conjunction with the loom efficiency table and practical experience, the suggested number of looms per operative has been obtained for the costings of a full shed of Automatic looms.

NOTES ON VARIOUS MOTIONS

Warp Let-off Motions

These appear to be an essential for Automatic weaving as a weaver cannot look after the weights on 20 or more looms.

Of the three motions fitted at Higher Walton, the " Roper " let-off on the Northrop and the Toyoda looms are both excellent, the " Roper " being particularly easy to adjust and maintain.

The Vickers-Stafford loom let-off, as fitted, is not suitable for low picked cloths as it cannot let-off fast enough when weaving the bottom of the beam and it also tends to make the last cut on a beam long.

Warp Stop-Motions

These are of two distinct types. The so-called " Castle " or sliding-bar type and the " Nipper " type. Both are satisfactory but the " Castle " type appears to be the easier to handle for the weaver.

The Northrop loom uses this type and their make is, taken all round, the best motion. The broken end is easy to find and the motion can be used either with two, three or four banks of drop wires. The Northrop loom type driving gear and cam box is neat and substantial and the warp stop bars can be used as lease rods if desired.

The Whittaker attachment uses a Castle type motion made by Messrs. Mather and Platt, Ltd., which is much lighter in pattern than that on the Northrop loom. Two, three or four banks of drop wires may be used, but four banks makes the wires very crowded.

The Toyoda loom is fitted with a "Nipper" type stop-motion which is effective, but a broken end is rather difficult for the weaver to find. A special type of

drop wire assists to some extent in finding the lost end, but the motion is not too easy to handle. Two to four banks may be used but the four-bank motion is very crowded.

The Vickers-Stafford loom has a two-bank " Nipper " type warp stop which is quite good but more floats occur with this type than on the others through ends weaving down when the warp stop has failed to act. The droppers used are rather too light for the type of warp weaving. The stop motion bars act as lease rods.

Driving of Looms

The Northrop and Vickers-Stafford looms use a clutch of the cork-insert type which is entirely satisfactory and makes both looms exceedingly easy to handle for the weaver. With these clutches is incorporated, in both looms, an excellent brake motion.

The Whittaker attachment and the Toyoda loom have the usual fast and loose pulley drive and this is not satisfactory where a weaver has 20 or more looms, as she has frequently to help the slay in starting the loom up.

Fast-Reed v. Loose Reed

The Northrop and Vickers-Stafford looms are of the fast-reed type and there seems little doubt that for automatic weaving this type of motion is most advantageous as, when a loom bangs-off, the shuttle will not damage the warp to the same extent as in a loose-reed, if it happens to be caught in the shed. The motion positively prevents the loom from picking over with shuttle out of the box. Fast-reeds will work well up to about 190 picks per minute only.

On the loose-reed motion the loom will sometimes lock the shuttle in the warp by picking over after the loom has knocked off and there is also the danger of setting the loom on with the shuttle in the shed and severely damaging the warp.

Feelers

There are three types of " feeler " in use :—

(1) The Side-slip type as fitted to the Northrop and Vickers-Stafford looms. Both these are extremely good ; the Northrop " Midget " feeler in particular being practically perfection for sensitiveness, reliability, and simplicity.

(2) The " Depth " feeler, as fitted to the Whittaker attachment. This feeler makes a fair amount of waste and is soon worn out. It is by no means certain in action and will often damage soft yarn.

(3) The Toyoda loom " slot " feeler. This feeler is correct in theory but distinctly unsatisfactory in practice as it is uncertain in action and necessitates a very tightly-built bobbin which it is not always possible to spin.

COMPARISON OF PRODUCTION COSTS

Capital Value of Looms

In cases where certain items are included in one or other of the makers' specifications, and not in others, such items have been deleted, or the equivalent added to the others to make them comparative.

Interest and Depreciation

These items have been placed on a standard basis for the purpose of comparison, and the rates used are 5 per cent. for Interest and $7\frac{1}{2}$ per cent. for Depreciation.

Spinning Costs

As the same type of Warps have been used in each type of loom, therefore, the same costs operate. Winding and Beaming Costs are based on 60 G.F. Cone Winding and the high-speed beaming machine.

Additional Interest and Depreciation has been included on the Capital outlay involved for the re-conditioning of the Ring Weft frames, the fitting of $1\frac{1}{4}$ in. Ring and Bunching Motions. On the Northrop frames, provision has also been made for the fitting of Draper Clutch Spindles.

Weaving Costs

These Costs are based on the actual consumptions of Stores and other materials and on the actual wages paid. The actual average productions obtained have also been used.

Table VI—Capital Values per Loom

Northrop Loom	Toyoda Loom	Vickers-Stafford Loom	Whittaker Attachment	Plain Loom
£69 11 6	£70 2 7	£64 10 0	£37 2 0	£15 0 0

Table VII—Interest and Depreciation

	Northrop Loom d.	Toyoda Loom d.	Vickers-Stafford Loom d.	Whittaker Attachment d.	Plain Loom d.
Interest and Depreciation per loom per week	42·12	42·46	39·05	22·46	9·08
Interest and Depreciation per piece	27·44	28·19	26·97	16·83	4·97
Other Interest and Depreciation	1·01	1·01	1·01	1·01	1·01
	28·45	29·20	27·98	17·84	5·98

Table VIII- Spinning Costs per Pound.

	Ring Twist 24's	24's Ring Weft: Northrop Loom	Toyoda Loom	Vickers-Stafford Loom	Whittaker Attachment	Plain Loom
SPINNING :						
Expenses and Wages ...	3·177	4·151	3·886	4·217	4·032	3·432
WINDING :						
Expenses and Wages ...	0·810					
	3·987					
BEAMING						
Expenses and Wages ...	0·138					
Total Expenses and Wages	4·125d					

Table IX

Summary of Weaving Production Costs.—Expenses and Wages per Piece.

	Plain Loom	Northrop Loom	Toyoda Loom	Vickers-Stafford Loom	Whittaker Attachment
Wages	82·99	66·86	74·12	71·09	79·69
Expenses	30·70	67·24	71·88	63·42	56·02
	113·69	134·10	146·00	134·51	135·71

THE EXPERIENCE OF THE TEST APPLIED TO COMPLETE AUTOMATIC SHED

As a result of the experience gained during the test, certain conclusions have been drawn. The following costings are estimates based on these conclusions, and these figures should be obtained in practice if a shed, such as Higher Walton new shed, was laid out for Automatic Weaving.

This particular shed has been chosen for the sake of easy comparison and whilst the figures are no more than estimates, it is believed that they could be obtained with Cloths and Yarns similar to those under observation in the test. It is suggested that Higher Walton Shed could comfortably house 532 45 in. looms of either Northrop, Vickers or Toyoda make, or 556 Whittaker attachment looms. This would allow reasonable alley spaces and the looms would be set in fours.

This lay-out also allows space for carrying Weft to the looms and wheeling trucks in the main alleys for removal of cloth, bobbins and sweepings.

Sweepers. In the test, Sweeping and Oiling were linked together into one job but there is no doubt that it should be divided. Women are not generally satisfactory as oilers. The amount of oil consumed in the test was out of all proportion to the work done by that oil and this was largely due to the haphazard methods of the women employed.

The productions are estimates based on those which have obtained during the test.

The suggested staffing is as follows :—

The Northrop Loom

The Tackler would have an 88 loom set which should be easily workable.

The Weavers average just under 40 looms each.

Spare Hands or Smash Piecers. It is reasonable to expect one girl or youth to act as Spare hand for every 78 looms and if a rather low-grade cloth was weaving this number of looms per operative could be very considerably exceeded.

It is suggested that one *Sweeper* on each " set " of 88 looms and two oilers to two " sets," or one to each block of 132 looms would be used.

The number of *Battery Fillers* employed depends directly on the " life " of each bobbin and the number suggested (one filler to 38 looms) is based on the use of 24's Weft on Higher Walton's size of ring bobbins.

It is believed that two *Weft Servers* and two *Cut Carriers* could easily manage a shed of 532 looms.

The Vickers-Stafford Loom

The wage costs of these looms would be identical with Northrop looms except that additional *Battery Fillers* would be required. One girl to 29 looms is not unreasonable.

The Toyoda Loom

From experience gained it is probable that on this loom, as it is made at present, a greater number of operatives would be required than would be the case on Vickers-Stafford or Northrop looms

Tacklers : A 60 loom set would keep a man fully occupied.

Weavers : The loom makes more work for the weaver than the other fully Automatic looms and the suggested number of looms per Weaver is, therefore, 30.

This loom has more serious stoppages than the other two types and therefore one *Spare Hand* is allowed for each 60 looms.

Sweeper, Oilers and Shed Labourers : These are as before and the number of battery fillers is the same as for Vickers looms, that is, 29 looms to each operative.

The Whittaker Attachment

On these attachments if a reasonable efficiency is to be maintained, a *Tackler's* set should not exceed 60 looms.

A *Weaver* would not be overworked on 20 looms.

The number of *Spare Hands* in the 556 loom shed is suggested as 8, which gives 70 looms each.

Sundry Labour is the same as for Northrop looms.

The *Warehouse* staff is given as the same in each case but it is more than probable that a *Whittaker* attachment shed would need additional labour in this department.

Additional Cost of Spinning

In the test there was, from various causes, a definite increase in the cost of spinning but it is believed that, for a plain cloth of similar grade to the one made in the test, the increased cost of spinning would be very little, nevertheless, provision for this item has been made in the costings.

Table X—Spinning Costs per Pound

		Ring Twist 24's	24's Ring Weft			
		d	Northrop Loom	Toyoda Loom	Vickers-Stafford Loom	Whittaker Attachment
SPINNING :	Expenses	1·732	1·983			
	Wages	1·445	1·729			
		3·177	3·712	3·712	3·712	3·712
WINDING :	Expenses	0·216				
	Wages	0·549				
BEAMING :	Expenses	0·068				
	Wages	0·070				
Total Expenses and Wages (pence)		4·080	3·712	3·712	3·712	3·712
Winding and Beaming : Waste 0·3%						
Production (per thousand spindles)		1312	1100	1100	1100	1100

Table XI—Annual Expense: Estimate (Higher Walton New Shed)

	Northrop Looms	Toyoda Looms	Vickers-Stafford Looms	Whittaker Attachments
	£	£	£	£
Interest	1933	1949	1793	1111
Depreciation	2900	2923	2689	1667
	4833	4872	4482	2778
Rent and Rates	77	77	77	77
Taxes	129	129	129	129
Painting and Limewashing...	37	37	37	37
Repairs to Buildings ..	40	40	40	40
	283	283	283	283
Insurance	220	220	200	120
Mill Salaries	331	331	331	331
Head Office	694	694	694	694
Coal Heating	651	651	651	651
Gas and Water	34	34	34	34
Electric Light	22	22	22	22
Telephone	23	23	23	23
Printing and Stationery ...	15	15	15	15
Carriage Inwards	178	177	168	172
Carriage Outwards	313	313	312	313
Machinery Repairs	266	744	306	348
Strapping and Laces ...	66	64	64	57
Pirns	285	108	88	398
Brushes	14	14	14	14
Sizing Materials	800	798	708	775
Healds and Reeds	310	319	300	326
Shuttles, Pickers, Picking Sticks, etc	744	900	771	640
Paper and Twine	10	10	10	10
Sundries				
Ambulance				
Engineering Sundries	30	30	30	30
Fire Appliances ...				
Welfare				
	5006	5467	4741	4973
Coal Driving	1200	1200	1200	1040
Electric Power . .				
Oil and Grease	31	31	31	32
Boiler Composition	2	2	2	2
	1233	1233	1233	1074
Expenses per Piece, less Interest and Depreciation	d. 36·90	d. 39·76	d. 37·26	d 37·09

Table XII—Interest and Depreciation

	Northrop Loom d.	Toyoda Loom d.	Vickers-Stafford Loom d.	Whittaker Attachment d.	Plain Loom d.
Interest and Depreciation per loom per week	42·12	42·46	39·05	22·46	9·08
Interest and Depreciation per piece	27·35	27·73	26·87	16·27	5·98

Table XIII—Summary of Weaving Costs (Wages and Expenses per Piece)

	Plain Loom d.	Northrop Loom d.	Toyoda Loom d.	Vickers-Stafford Loom d.	Whittaker Attachment d.
Wages	82·99	45·91	55·32	49·47	64·25
Expenses	30·70	68·82	72·06	68·70	57·93
	113·69	114·73	127·38	118·17	122·18

Table XIV—Cloth Costings (in Pence)

The Plain Loom	lb.				
Twist	13·48	at 10d. ...	... ...		134·80
Selvedges ...	0·15	,, 14d. ...	... ...		2·10
Weft	14·31	,, 9·5d. ...	... ...		135·95
,, Waste, 2½%	0·35	,, 9·5d. ...	... ...		3·32
					276·17
			Wages ...	67·75	
			Expenses ...	45·94	... 113·69
					389·86
				2½% ...	10·00
					399·86
The Northrop Loom					
Twist	13·45	at 10d. ...	... ...		134·50
Selvedges ...	0·15	,, 14d. ...	... ...		2·10
Weft	14·31	,, 9·78d. ...	... ...		139·95
,, Waste 1¼%	0·18	,, 9·78d. ...	... ...		1·76
					278·31
			Wages ...	45·91	
			Expenses ...	68·82	... 114.73
					393·04
				2½% ...	10·07
					403·11
The Vickers-Stafford Loom					
Twist	13·48	at 10d. ...	... ...		134·80
Selvedges ...	0·15	,, 14d. ...	... ...		2·10
Weft	14·31	,, 9·78d. ...	... ...		139·95
,, Waste 1¼%	0·18	,, 9·78d. ...	... ...		1·76
					278·61
			Wages ...	49·47	
			Expenses ...	68·70	... 118·17
					396·78
				2½% ...	10·17
					406·95
The Whittaker Attachment					
Twist	13·68	at 10d. ...	... ...		136·80
Selvedges ...	0·15	,, 14d. ...	... ...		2·10
Weft	14·31	,, 9·78d. ...	... ...		139·95
,, Waste, 2½%	0·35	,, 9·78d. ...	... ...		3·42
					282·27
			Wages ...	64·25	
			Expenses ...	57·93	... 122·18
					404·45
				2½% ...	10·37
					414·82

The Toyoda Loom

Twist	13·64	at 10d.		136·40
Selvedges ...	0·15	„ 14d.		2·10
Weft	14·31	„ 9·78d.		139·95
„ Waste, 1¼%	0·18	„ 9·78d.		1·76
				280·21
		Wages ...	55·32	
		Expenses ...	72·06	127.38
				407·59
			2½% ...	10·44
				418·03

DOUBLE SHIFT WORKING IN AUTOMATIC WEAVING

A costing is submitted here, showing the probable saving obtained by double shift working. This costing is based on an 87½ hour week, composed of five days of two 8-hour shifts each, and a 7½ hour shift on Saturdays; half an hour being allowed on that day for sand-papering shuttles, extra sweeping and oiling and other work, to keep the looms in first-class condition. Wages are based on the operative earning the same wage in the 8-hour shift as is earned under normal working in 8¾ hours.

There seems to be no reason why the results suggested could not be obtained in practice as the efficiency has been reduced to allow for night time working.

A further costing is submitted, showing the effect of running through the dinner hour with a skeleton staff. This simply means arranging for the various weavers and extra helpers to leave the looms half at a time, the first section having from, say, 12 till 1, and the second section from 1 till 2 p.m. for their dinner hour. The efficiency has been reduced to allow for losses caused by reduction in staff during the dinner period.

Table XV—Double Shift Working: Wages Summary

(532 Automatic Looms)

	d.
Shed	38·86
Warehouse	3·51
General	1·19
Cropping	0·93
Bobbin Stripping	0·37
Sizing	2·30
Drawing and Looming	2·96
	50·12

Production per loom per week = 2·8 pieces.

Table XVI—Wages Estimate: 52½ Hour Week

(532 Automatic Looms)

SHED WAGES. Total as per previous estimates, £120,124
Production at 85% Efficiency = 1·66 pieces per loom week.
= 884 pieces per week = 32·75d. per piece

WAREHOUSE WAGES. Total as per previous estimate, £14 10s. 6d.
= 3·95d per piece.

GENERAL WAGES. Increased from 1237d. to 1307d.
= 1·48d. per piece.

Cropping ... ...
Bobbin Stripping ... ...
Sizing ... ...
Drawing and Looming ...
} as per previous estimate.

Wages Summary

	d.
Shed	32·75
Warehouse	3·95
General	1·48
Cropping	0·93
Bobbin Stripping	0·37
Sizing	2·30
Drawing and Looming	2·96
	44·74

Table XVII—Budget of Expenses per Annum
(532 Automatic Looms)

	Double Shift. 87½ hrs. £	Skeleton Staff. 52½ hrs. £
Interest	1933	1933
Depreciation	3561	1933
	5494	3866
Power Costs	2271	1364
Other Fixed and Running Expenses	8262	5477
	£10533	6841

Double Shift. Depreciation has been based on 5 per cent. normal working or 9·21 per cent. Double Shift.

52½ Hour Week. Depreciation has been based on 5 per cent.

Table XVIII—Double Shift and 52½ Hour Week: Summary of Costs

	Double Shift (Pence).	52½-hour Week. (Pence).
Wages	50·12	44·74
Expenses	34·25	37·46
Interest and Depreciation	17·86	21·19
Other Interest and Depreciation	1·01	1·01
	103·24	104·40
Cropping Overhead and Running	3·39	3·39
,, Interest and Depreciation	1·18	1·18
	107·81	108·97

INCREASE OF NUMBER OF LOOMS TO A WEAVER

The effect of the " more looms to a weaver " system applies to the Automatic Loom Test cloth. A glance at the particulars of this cloth, 34½ ins., 117, 64 × 66, 24/24, shows that it is a cloth which might be woven satisfactorily on a 6-loom to a weaver system but probably could not be made on an 8 looms per weaver basis.

Running at 208 picks per minute, a bobbin lasting 5¾ minutes can be made at Higher Walton. This bobbin would, therefore, last 6 minutes 20 seconds at 185 picks per minute. This is generally agreed as being too short a life for an 8 loom system.

It is considered, therefore, that this particular cloth is ideal for a 4 loom system, but unsuited to " more looms to a weaver " principles.

CONCLUSIONS

It must be definitely understood that the conclusions reached as a result of this test apply only to a type of cloth similar to that made in the test. It appears that different results are likely for coarser and finer cloths or cloths of different

construction. It is obvious that an indefinite number of tests cannot be made, but the test has been followed by one of a coarser cloth and this is now proceeding.

With these reservations and considering only the type of cloth made, the following conclusions are possible :—

The Northrop Loom has proved highly satisfactory from a productive angle and has shown the cheapest production of the Automatics, the cloth being one well suited to it. In most details it has the advantage of all other types, but it appears that there are limitations to the range of cloth which can be made.

The Vickers-Stafford Loom has shown almost as good results as the Northrop, and in the quality and cover of the cloth is the best of all. It appears more suitable for the finer types of fabrics.

The Toyoda Loom has suffered on account of its newness. There are certain defects which need alteration.

The Whittaker Attachment has caused many difficulties and has imposed an undue strain upon the Lancashire looms to which it has been attached. It has been suggested that this will not be a difficulty on broad, heavy, slow running looms.

The Lancashire Loom, with 4-loom weavers, has shown a remarkable efficiency, run under ideal conditions. There are very few weaving sheds in Lancashire where an all-round efficiency of 85 per cent. for a 45 in. loom run at 208 picks per minute exists.

Actually the cloth is a very suitable sort for the Lancashire loom. It should be noted that the necessary cropping of the Automatic Loom cloths entails an additional expense of 7d. per piece approximately which is not borne by the Lancashire loom cloths. The cloth as a result, is a more acceptable cloth, but it is not established that it would command a higher price on the market. It would probably, however, be given preference at the same price.

In the case of Looming and Drawing for the Automatics additional expense is incurred as compared with the Plain Lancashire Looms for these processes.

The costings show a definite wage cost advantage for all the automatic looms against the Lancashire Loom, but the additional expenses more than off-set this advantage. The bulk of the additional expense is due to the much greater Interest and Depreciation charge and in addition the weft for the automatics has been costly. This latter item might be reduced when operatives become more skilled in the conditions.

On single shift working, the Lancashire loom shows a final advantage of $3\frac{1}{4}$d. per piece over the Northrop loom and 7·09d. over the Vickers-Stafford loom. If, however, the Automatics run double shifts, the position is 6d. per piece in favour of the lowest automatic cost.

It is considered that this cloth could not be woven on a 6-loom basis, except at a higher cost than that shown by the 4-loom basis.

If, however, the weft was pirned and warp stop motions employed, it might then be a cheaper proposition, and experiments in this direction are to be attempted.

(*Signed*) JOHN RYAN,
Managing Director.

THE LANCASHIRE COTTON CORPORATION, LTD.,
BLACKFRIARS HOUSE,
MANCHESTER.
March, 1932.

NOTES AND NOTICES

Institute Annual Conference

Arrangements in connection with the Conference which is to take place at Leamington Spa in the latter part of Whit-week next, are proceeding most satisfactorily. The prospects are decidedly favourable to a good attendance of members, and the preliminary announcements have been well received. Members contemplating attendance should give the earliest possible indication of their requirements as to hotel accommodation. It seems probable that many members will be accompanied by ladies on this occasion. In view of inquiries as to whether ladies may attend the Institute dinner—to be held on the Thursday evening—it may be useful to state here that accompanying ladies will be welcome at any or all of the events programmed. In regard to the outline of programme recently issued to Members, it has already been found advisable to extend the time allotted for the actual proceedings of the Conference. In other words, the excursion part of the programme will be limited to one afternoon—that of Thursday—when Coventry will be visited. The journey will be made by motor-coach and the return journey to Leamington will be *via* Warwick. At Coventry, the works of Messrs. J. & J. Cash, Ltd. (Ribbons, Gloves, Friction Towels, etc), the Quinton Hosiery Co., Ltd. (Hosiery Manufacturers), and Messrs. Humber, Ltd. (autocars), will be visited. In the case of the works of the first-named firm, the number of the visiting party is limited and members engaged in competitive works are not invited.

The Programme of Papers

With the exception of the Mather Lecture, the Papers to be contributed will deal with various aspects of the subject of Textile Testing. It is felt that even at this early stage many Members may desire information as to the names of lecturers and the titles of their contributions. The following list, with allocation of dates and times, is therefore presented subject to modification later. A final programme will be printed and circulated to Members notifying attendance :—

Thursday, 19th May

ROOM 1 (10 a.m. to 12.45 p.m.).

(*a*) " An Instrument for the Measurement of Fibre Length," by W. Sever, M.Sc. (Dept. of Textiles, The University, Leeds).

(*b*) " The Testing of Yarns for Levelness and Counts," by G. R. Stanbury, B.Sc., A.R.C.Sc., F.Inst.P. (Wool Industries Research Association).

(*c*) " The Testing of Yarns and Fabrics," by W. E. King, A.T.I. (The Technical College, Bradford).

ROOM 2 (10 a.m. to 12. 45 p.m.).

(*a*) " Apparatus for the Testing of Air Porosity," by Dr. Guy Barr, B.A., D.Sc. (National Physical Laboratory).

(*b*) " The Testing of Eyeletted Tapes," by Professor W. E. Morton, F.T.I. (College of Technology, Manchester).

(*c*) " Quantitative Determination of Cotton, Wool, Silk, and Artificial Silks in Mixed Textiles," by Professor Dr. P. Krais (Deutsches Forschungs-institut für Textilindustrie, Dresden).

Friday, 20th May

ROOM 1 (10 a.m. to 12.45 p.m.).

(*a*) " Detection and Estimation of Chemical Damage in Wool," by Professor Dr. P. Krais (Deutsches Forschungsinstitut für Textilindustrie, Dresden).

(*b*) " Chemical Tests in the Wool Industries," by E. Hill, F.I.C., A.R.C.Sc., (Wool Industries Research Association).

(*c*) " Testing of Linen Fabrics from the point of view of their Uses," by W. H. Gibson, O.B.E., D.Sc. (Linen Industry Research Association).

ROOM 2 (10 a.m. to 12.45 p.m.).

(*a*) "The Significance of Results in Textile Testing" by F. P. Slater, M.A.,M.Sc. (Research Department, Fine Cotton Spinners, and Doublers Association).

(*b*) "The Testing of Laundered Fabrics" by R. E. V. Hampson, D.Sc. (British Launderers' Research Association).

(*c*) "Faults Produced from Textile Operations on Process Dyed Goods," by Dr. L. L. Lloyd, Ph.D. (Bern.), F.I.C.,(The Technical College, Bradford).

ROOM 1 (2 p.m. to 3 p.m.).

"The Standardisation of Testing of Hosiery Yarns and Knitted Fabrics," by J. Lomax, F.I.C. (Testing House, University of Nottingham).

ROOM 2 (2 p.m. to 3 p.m.).

"Commercial Strength Standards for Linen Yarn and Fabrics" by W. J. Cowden, F.T.I. (City and County Bcrough of Belfast Public Testing House).

ROOM 1 (3 p.m. to 4 p.m.).

Mather Lecture: "Liberal Education and Modern Business," by Sir Michael Sadler, K.C.S.I. (University College, Oxford).

ROOM 1 (4.15 p.m. to 6 p.m.).

"The Strength of Textile Fabrics and their satisfaction—giving Qualities in Conditions of Normal Use," by J. G. Williams, B.Sc. (Lond.), A.I.C. (Selfridge & Co., Ltd.).

ROOM 2 (4.15 p.m. to 6 p.m.).

(Papers may be announced later).

Institute Competitions: 1931 Specimens

This year has witnessed an increased demand for special displays of the examples of fabrics and yarns resulting from the Textile Institute's Annual Competitions (1931). Already, the prize-winning specimens have been exhibited at Bradford (Technical College), Ashton-under-Lyne, Nelson, and Radcliffe, whilst on the 27th February the exhibits were displayed at a Section meeting held in the Institute rooms at 104 Newgate Street, London. On the 21st February under the auspices of the Scottish Section, the specimens were shown at the Scottish Woollen Technical College. In the case of the London and the Galashiels meetings the General Secretary of the Institute (Mr. J. D. Athey) attended and contributed an address on "Fabrics and Fashions." At the London meeting, Mr. G. A. Rushton presided, and considerable discussion followed the address, Mr. Heylin stressing the importance of cloth structure. The General Secretary pointed out that this matter of structure had received definite consideration by the adjudicators right through the whole of the years during which the competitions had taken place. At the Galashiels meeting, Dr. Oliver criticised the competitions from the standpoint of wool interests and urged the establishment of separate competitions for students connected therewith. In reply, the General Secretary, whilst claiming that under modern conditions segregation as to fibre was not necessarily in the best interests of the student, stated that endeavour was being made to secure funds whereby special prizes could be offered in relation to woollen and worsted cloths. Meantime, it was hoped that students in wool centres would not neglect the opportunities already existing under the present scheme of competitions. The "B," the "C" and the "D" Competitions were free from restriction as to the kind of fibre or fibres employed in the yarn. For 1932, prizes were being offered in respect of knitted fabric.

Examination in General Textile Technology

This examination, the passing of which completes the qualification requirements of applicants for the Associateship of the Institute, will in future take place once each year instead of twice as hitherto. The next examination has been fixed to be held on Wednesday, 22nd June, 1932, and, each year, the examination will recur in the latter part of June. Some amount of misapprehension persists regarding admission to this examination. The Institute

continues to receive communications requesting candidature, whereas only applicants for the Associateship whose applications have been approved for reference to the examination are eligible. Already, several approved applicants have notified their intention to take the examination on 22nd June next.

Death of an Institute Vice-President

A prominent figure in the textile industry of the North of Ireland was removed on the 10th March, by the passing of Mr. Frank Anderson, M.B.E., F.T.I., at his residence, at Portadown. A Vice-President of the Institute and actively associated for many years with the Irish Section Committee, Mr. Anderson took a wide interest in both public and textile-industry affairs. A Director of the Tavanagh Weaving Company, he was regarded as an employer of distinctly progressive outlook. Chairman of the Irish Power Loom Manufacturers Association for a period of three years up to end of 1926, he became President of the Belfast Chamber of Commerce, in 1928. Over the past twenty years, he has attended most of the general conferences of the Textile Institute and it was in warm appreciation of his devoted support and services that he was elected a Vice-President in 1927. It was for his services and generosity in many directions during the period of the Great War that he was awarded the M.B.E.

Obituary Announcement

With profound regret the death is recorded of a distinguished leader in the Dyestuffs and Chemical Industries—Mr. Werner Stauffacher, managing director of the Sandoz Chemical Works, Basle, Switzerland. The demise, at 64 years of age, followed a motoring accident at Basle. In May, 1921, Mr. Stauffacher took an enthusiastic interest in the local arrangements for the Conference of the Textile Institute held at Basle, and in the course of the proceedings he was elected an Honorary Member of the Institute in appreciation of his services. He was a man of remarkable energy and capability and, in addition to his commercial pursuits, devoted a great deal of time to public affairs, being prominently identified with the Basle Economical Association and other organisations.

Textile Institute Diplomas

Elections to Fellowship and Associateship have been completed since the appearance of the previous list (January issue of this *Journal*) as follow—

FELLOWSHIP

MORTON, William Ernest (Manchester).

ASSOCIATESHIP

McPHERSON, David Brown (Nottingham).
LATHAM, Edward (Bolton).
DUCKWORTH, Edward (Didcot, Berks.).
FIELDING, George Whittaker (Bolton).
MANTON, William Woodford (Bolton).
SMITH, Richard James (Leeds).
BIGNALL, Walter Norman (Nottingham).
LAPPIN, Lawrence Arthur (Nottingham).
McILVEEN, John Caryll (Belfast).
RATCLIFFE, Alan (Walkden).
WILSON, Leslie Gordon (Morley).
FRANKS, Herbert (Keighley).

Wool Industries Research Association

There was a large and influential gathering representative of textile interests at the annual luncheon of the above-named Association which took place at Bradford, on Monday, 14th March. Lord Barnby, the President, occupied the chair, and presented figures indicative of recent progress in the wool textile industry. Dealing with imports and exports of tops and yarns, his lordship expressed the amounts in terms of bales of wool, thus conveying an immediate

idea of the expansion in the use of raw material. The chief guest was Sir Robert Horne, who expressed his pleasure at being associated with a gathering promoted to encourage scientific research. It was, of course, on the financial situation which Sir Robert spoke for the most part, and he insistently advocated bi-metallism. The remonetisation of silver, he suggested, would be of immense advantage to the world and if America and the British Empire together could adopt some such policy, this would do a very great deal towards clearing up the difficulties in regard to trading between nations.

Institute Notices: Membership

At the March meeting of the Council, the following were elected to Membership of the Institute :—P. Ashworth, 10 Coronation Road, Lytham St. Annes (Mill Manager, Sizing and Beaming Machines); John Day, Barnfield, Dewsbury, Yorks. (Post Graduate Research Student); A. Fattah, c/o Scottish Woollen Technical College, Galashiels (Textile Student); A. S. Greenwood, 18 Huntley Drive, Kirkhill, Cambuslang, Lanarkshire (Manager, Wm. Hollins & Co., Ltd., Glasgow); D. O. Moss, "Denholme," Morley, Yorks. (Textile Student); H. Wood, Fabrica de Tecidos, "Sao Joaquim," Nictheroy, Est. do. Rio, Brazil, S. America (Cotton Mill Manager). R. Belshaw, "Thornlea," Cornholme, Todmorden (Group Manager, Lancashire Cotton Corporation); V. J. Tarbett, M.Sc.Tech., c/o. Arthur H. Lee & Sons Ltd., Stanley Road, Birkenhead (Textile Chemist).

REVIEWS

Wool Quality. By S. G. Barker, Ph.D., F.T.I. Published by His Majesty's Stationery Office for the Empire Marketing Board. (328 pages. Price £1 1s.)

Dr. Barker's book is a very welcome addition to the literature of the wool fibre, and can be confidently recommended to all engaged in research on wool. The developments which have taken place in exact knowledge of the wool fibre during the past ten years are little short of phenomenal, yet singularly little attempt appears to have been made to impart the new information to the personnel of the wool trade through the medium of text-books in English. In this respect, the British student has been at a disadvantage compared with the Continental one; German students, in particular, having been well served through the medium of one or two noteworthy text-books published recently in that language. This defect, so far as the subject of wool quality is concerned, can now be regarded as definitely remedied, for the book under review is an exhaustive survey of most of the original scientific papers which have any bearing on the subject.

The first section of the book is devoted to a survey of fleece characteristics, followed by a chronological review of the methods employed in the past for measuring the attributes of the wool fibre, culminating in a description of methods of experiment now in use at the Wool Industries Research Association. This work on fibre-measurement, extending as it does over a period of 100 years or more, has little bearing on sorting practice: it might indeed be said that it has taken this length of time for the scientist to discover that the wool sorter, much as he might resent it, is essentially scientific, working as he does on the basis of the well-known Fechner law. The discovery of a sound technique of fibre measurement is, however, vitally necessary for the interpretation of the results of breeding experiments, and for the study of the behaviour of a wool during manipulation in practice. Such a technique is, indeed, an essential preliminary to most scientific studies of wool textile processes, and it is here that justification for its development must be realised. The second section of the book is devoted to a review of the literature of the constitution and structure of the wool fibre, including descriptions of the technique used in elucidating its physical and chemical properties. The value of the whole treatise to all workers on wool is greatly enhanced by the inclusion of some six hundred references.

The treatment of the subject is throughout definitely non-critical and the book may be justly summarised as being a collection of abstracts from papers bearing on the problem of wool quality, the abstracts being welded together to form a homogeneous whole. Responsibility for the statements included in the text is not, as a rule therefore, the author's. While such a method of treatment

has its peculiar advantages, it does, on the other hand, mean that the book cannot be recommended as a guide to the uncritical student. It leads inevitably to the perpetuation of errors, two examples of which will suffice. On page 24, the work of Wright and Hill is quoted to show that wool fat will absorb water from the air. Actually, the results obtained by these authors are vitiated by the contamination of their samples of fat with suint, which is highly hygroscopic. Similarly, on pages 247 and 248, the influence of the grease content of wool on its elasticity and behaviour in practice is discussed in the light of Mark's experiments. Mark defines a quantity " E " as the ratio of the amount by which a fibre contracts after being stretched 10 per cent. of its length, to the original extension. Values for " E " must therefore be pure numbers, but those given in the table on page 248 are expressed as kilograms per square millimetre. In actual fact it is difficult to discover any relation between the data given on this page and the relevant text, but as has already been indicated, the error occurs in Mark's original paper. In any event, Mark's failure to discriminate between wool fat and suint renders his results valueless.

The book is well produced and the number of printer's errors small. Among the more serious of these are the incorrect descriptions of Figs. 67 and 68. J.B.S.

Technical Terms in the Textile Trade. By Eber Midgley. Published by Emmott & Co., Ltd., Manchester. (260 pages. 12/6 net.)

No one is likely to dispute the claim that there is a definite need for a Dictionary of Textile terms, especially since the training of students, and the interest of those in industry, is developing in the direction of a more comprehensive study of Textiles as a whole as distinct from that of one Textile in particular. Those who read widely on textile matters are constantly coming across terms which may be used in reference to several quite different things, and things which may be described by several quite different terms, according to the particular branch of the textile industry to which reference is made

The compilation of such a dictionary is a stupendous and responsible undertaking, and the edge of criticism must be tempered accordingly in the case of the present volume Even so, one cannot help regretting that it falls so far short of the concise but comprehensive encyclopaedia which would be the ideal

A casual glance through its pages gives the impression that its substance is very heavily weighted in favour of the woollen and worsted industries, and detailed examination confirms this. For terms in common use in these industries, therefore, it will no doubt prove a useful book of reference, but for those interested in the technical terms of other industries it will be a disappointment. Thus the Linen, Rayon and Silk industries are very largely ignored, while the Cotton terms are scarcely representative of those in common use, several of them being in addition, incorrectly defined or discussed.

Perhaps the greatest disappointment to the present reviewer, however, is the failure to deal with synonymous terms used in the different industries. Thus while Ratch is defined for worsted, no reference is made to the fact that for cotton the term Setting and for linen the term Reach, are used to mean the same thing. Many other examples of a similar nature could be given.

On the whole, therefore, the publication of this volume can scarcely be described as a successful effort to standardise the technical terms for use throughout the Textile industries. On the other hand, it is only fair to the author to say that, in view of the nature of the task, probably no other single individual could have accomplished it any better. W.M.

Publications received and placed in the Institute Library

City and Guilds of London Institute: Department of Technology. Programme for the Session 1931-1932. London. John Murray. (Price 4/-.)

Alterations are notified in the following Sections :—20-22 Dyeing of Textiles ; 26 Woollen and Worsted Weaving and Designing ; 27 Cotton Spinning ; 27 and 28 C Engineering as applied to the Cotton Industry.

Textile Recorder Year Book, 1932. John Heywood, Ltd., Manchester. (Price, 7/6.)

Revised and brought up-to-date. Silk Statistics have been added and the section on Textile Testing revised.

The Silk and Rayon Directory and Buyers Guide of Great Britain, 1932. John Heywood, Ltd., Manchester. (Price, 21/–.)

A revised edition of this well-known Directory. It has no rivals and its growth measures the growth of the Industries to which it is a guide.

British and Dominion Textile Industry, 1932 (Excluding Lancashire and Yorkshire). John Worrall, Ltd., Oldham. (Price, 13/6.)

This Directory has been given a new cover and generally improved in design and typography. It retains its useful features and embodies a new feature of machinery and accessories marketed by advertisers. C.

Cotton Year Book, 1932. Published by "The Textile Mercury," Manchester. (Price, 7/6 net.)

This is the twenty-seventh issue of an annual now well-known and appreciated. Surveys of development have been included and will be welcome additions to this reference book.

Wool Year Book, 1932. Published by "The Textile Mercury," Manchester. (Price, 7/6 net.)

This, the twenty-fourth edition, also includes new matter, such as statistics, reviews of development, etc., which definitely increases the worth of this volume.

Foreign Trade. With special reference to the Cotton Trade and to the Payment for a Motor Car from Abroad. By Gilbert Beard. Published by John Heywood, Limited, Manchester. (83 pages. Price, 6d.)

The author emphasises the great variety and uneven distribution of natural resources and of human capabilities in the world. International trading encourages each country to specialise in the production of the things for which it is best adapted and enables mankind to enjoy the advantages of the wider Division of Labour. "The policy of free exchanges, as far as we can make them so, has enabled us to extend these advantages far beyond the limits to which the Protectionist nations have allowed them to be applied and has made us one of the richest nations of all time"

Foreign trading transactions are simply explained proving that an exact balance obtains between the aggregate imports and exports of goods, services and gold.

With the Free Trade doctrine essentially a doctrine of prosperity, the author is at pains to explain the depressed state of British Industry. This he attributes to the dearness of our goods relative to the general world fall in prices; and the onus for responsibility for the decline in trade is thrust upon wage-earners and others who have resisted the necessary downward readjustment in scale of remuneration. The Cotton Trade has been particularly at fault. C.

Untersuchungen von Garnen und Stoffen. Von Max Dubrau. Published by Gebruder Borntraeger, Berlin. (Bound 10, 60 R.M. paper covers, 9 R.M., 171 pages. 105 figures, including 34 photomicrographs.)

This book gives a general account of the examination and testing of textile yarns and fabrics. The usual topics are discussed—raw materials and their determination—the microscope and microscopy of textile fibres—moisture absorption and conditioning—yarn numbering and determination—twist—strength and extensibility—weaving principles—fabric tensile, bursting, ripping, wearing tests—fastness tests of colours.

There are some useful tables, *e.g.*, removal of stains. The determination of weight, thickness, fat content of yarns, loss on carbonisation, silk weighting, waterproofing and its testing are considered briefly.

An appendix of 37 pages gives specifications for army, navy, police, etc., clothing. A column on page 5 is headed "Yarn sample," but contains no samples. On page 10 the differentiation tests for rayons omit some of the more recent valuable tests. There are only references to standard works of Matthews, Hermann, etc., and not to original literature, so that a reader would not be encouraged to consult original papers.

The whole subject is dealt with in an elementary manner suitable for the general reader employed in the textile industries. For English readers, the work is sufficiently cheap to be useful to the serious student of A.T.I. standard, to acquire some vocabulary of German textile terms. The copy sent for review was mostly uncut, and quite unfit for handling with patience until this had been remedied. F.C. V

THE JOURNAL OF THE
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PROCEEDINGS

TWENTY-SECOND ANNUAL GENERAL MEETING AT MANCHESTER

The Annual Meeting of the members of the Institute was held on Wednesday afternoon, April 20th, at the Institute, Manchester. The president, Mr. George Garnett occupied the chair, and at the outset made a sympathetic reference to the losses by death which the Institute had sustained during the past year. Among these was one of the Institute's late presidents, Sir William Priestley who had been in indifferent health for some time. There were also Mr. W. Stauffacher and just recently Mr. Oscar S. Hall. These gentlemen, said the President, had given splendid service to the Institute. They were men whom they regarded as the finest type to be associated with an institute of this kind. They mourned their demise, and they sympathised with the relatives.

The Minutes of the previous Annual Meeting were passed and the Council's annual report was accepted as printed.

COUNCIL'S ANNUAL REPORT

The Council is convinced that the vigorous pursuit of the main object of the Royal Charter — the advancement of science and technology—was never more vitallv urgent than now. Such pursuit is fostered by our scheme of professional qualification of members; publications in the monthly *Journal* of the Institute; the Scholarship Scheme; Papers and Lectures before Section and General Meetings; Annual Competitions for advanced students in Design and Structure of Fabrics; and by the services of the Library and Information Bureau. Although our undertakings are already comparatively extensive, the Council will proceed with the further development of its activities so far as financial resources will allow, more immediately with reference to the adequate organisation of an Information Bureau which is at present receiving special consideration.

Balance Sheet and Accounts

The Annual Balance-Sheet and Accounts (to 31st December, 1931), which accompany this report, will be presented at the Annual General Meeting which is fixed to take place at the Institute Headquarters at 3 p.m. on Wednesday, 20th April. The Council regrets that the Revenue Account for the past year discloses an augmented deficit. The deficiency is mainly due, however, to items of expenditure of a non-recurring character, including income-tax claims and expense incurred in connection with adjustment (£252), the cost of the Institute's Coming-of-Age Celebrations (£140), and the special publications issued on that occasion (£102). Due largely to unemployment, the Membership of the Institute has been somewhat reduced, but new members have been elected during the year at a rate never previously attained.

Annual and Other General Meetings

At the Annual General Meeting, held at the Institute on 20th May, 1931, Mr. George Garnett, J.P., of Bradford, was unanimously elected President in appreciation of his services from the time of the inauguration of the Institute. It is pleasing to be able to state that Mr. Garnett has kindly accepted nomination for re-election for an additional year. The Coming-of-Age Celebrations, which took place at Manchester in May last, were successfully carried out and the various events were all well attended. The occasion was regarded as especially fitting for the presentation of Institute honours. For the first time, the Warner Medal of the Institute (in memory of the late Sir Frank Warner, K.B.E., former President) was awarded in respect of Investigations in Textile Technology recorded in the *Journal* of the Institute, the recipients being—J. A. Matthew, M.Sc., A.R.C.S., F.Inst.P.; J. B. Speakman, D.Sc., F.I.C.; and A. J. Turner, M.A., D.Sc. The Honorary Fellowship of the Institute was conferred upon Mr. J. W. Nasmith, the inventor of the Nasmith Comber. In appreciation and recognition of services to the Textile Industry and in particular to the Textile Institute, the Medal of the Institute was awarded to :—A. F. Barker, M.Sc., F.T.I. (Leeds); W. T. Boothman, F.T.I. (Bolton); F. Bradbury, F.T.I. (Belfast); H. P. Greg, M.A., F.T.I. (Manchester); F. Nasmith, F.T.I. (Manchester): and H. Nisbet, F.T.I. (Manchester).

In connection with the Celebrations of the Coming-of-Age, the Council desires to record its hearty appreciation of contributions to the funds on the part of Members both at home and abroad.

" A Twenty-One Years' Chronology of Textiles," accompanied later by " A Statistical Summary," was published by the Institute in association with the Celebrations and the issue was not only well received at the time but the demand for copies continues and it is hoped that the sales will yet materially reduce the debit balance on the Celebrations Account.

Journal of the Institute

There has been no diminution in *Journal* work during 1931. Original researches have been submitted to the Publications Committee in even greater number than previously, and this is regarded in a favourable light. At the same time, it imposes upon the Institute a financial problem not at all easy of solution. Largely as a result of this situation, the total *Journal* expenditure for the year, on the basis of the printing contract in force, could not be materially reduced. Where practicable, economies have been effected, but it is thought that the interests of members have not suffered since the volume of matter published in all Sections has been maintained as far as possible by the exercise of careful selection. During the year, the Coming-of-Age Celebrations of the Institute were held and a full record of the Proceedings thereat appeared in the May issue of the *Journal*. In connection with this event, the *Journal* staff compiled and published a " 21 Years' Chronology of Textiles " together with a Statistical Summary covering fibre, yarn, and cloth production during the same period. This publication, which is referred to elsewhere in this Report, constitutes a unique record, not only of the Institute history, but of events, inventions, and progress in the Technology and Economics of Textiles.

Early in the year, a Sub-Committee was appointed to review the whole *Journal* policy and after some six meetings the Sub-Committee presented a comprehensive report. As one result of this report, an Advertisement Representative, Mr. A. Crickmore, was appointed. He commenced work on the 1st August and his efforts during the last five months of the year have been very gratifying. An excellent advertisement revenue for 1932 is confidently anticipated. The Sub-Committee also made recommendations in regard to the Proceedings Section of the *Journal*, advocating special developments. These have been accepted in principle and it is hoped to carry out some of the suggestions in the ensuing year.

The subscribers' list has been increased and the sale of back issues is regular. Though the advertisement revenue undoubtedly suffered as a result of the trade depression, there is felt to be every reason for satisfaction with the final position.

Institute Diplomas

The scheme of professional qualification of Members continues to receive the closest consideration with a view to development, and the success of the efforts of the Selection

Committee is reflected by the substantial increase in the number of applicants for the Associateship who have taken the Institute's Examination. Experience of a few years of the operation of the Regulations governing award of the Associateship and Fellowship has pointed to the desirability of revision. A sub-committee has been specially engaged in the consideration of amendment and it is expected that revised regulations will be available at an early date. The new regulations will provide for an additional examination to meet the requirements of applicants for Associateship whose attainments in general education are inadequate.

Applications for Institute diplomas during 1931 totalled 53 (9 Fellowship and 44 Associateship) as compared with 69 in the previous year (15 Fellowship and 54 Associateship) and 52 in 1929 (11 and 41), bringing the total number of applications since the inauguration of the scheme in 1925 up to 636 (254 and 382).

Examinations were held at Manchester, Nottingham, London, Glasgow, Belfast, Bombay, Sao Paulo (S. America), Buenos Aires (S. America), and Mt. Gambier (S. Australia). Twenty-two candidates took the examination in June and 21 in December, as against 17 and 13 respectively in the previous year. For the year there were 43 candidates, 32 of whom passed and thus completed qualification for the Associateship, compared with 30 and 19 in 1930.

In future, examinations will only take place annually, in the latter part of June each year.

Annual Competitions : Woven Fabrics and Yarns

The numbers of competitors in the respective competitions for 1931 and 1930 were :— (A) Competition (1931) 10 and (1930) 13 ; (B) 8 and 6 ; (C) 20 and 14 ; (D) 12 and 24. The total for all competitions reached 52 in 1931 as against 57 in 1930. Mr. H. Binns (Bradford), Chairman of Council, attended and distributed last year's prizes.

The Competitions Committee have effected several changes in the particulars of competitions for the current year. In the case of the principal competition (A), the total number of specimens required is reduced to 16 though the variety demanded remains undiminished. For the first time, the experiment is made of inclusion of a competition in respect of knitted fabric.

Invested Funds

The total amount to the credit of the Foundation Fund of the Institute at the end of 1931 reached the sum of £19,020 10s. 6d., which sum includes, in addition to donations, the following items :—£289 9s. 5d. profit on conversion of War Bonds in 1927 and 1928 ; £861 9s. 6d. from Institute Diplomas Account ; £250 from relinquishment of tenacy of former London Office. The total amount is invested excepting a small credit balance of £4 16s. 6d. The interest from the Crompton Fund is applied to the Competitions Scheme, that from the London Office tenancy surplus to the London Section Account, and that from the special donation of the Cotton Reconstruction Board and Cotton Trade War Memorial Fund to Institute Scholarships inaugurated in 1930.

Council and Committee Meetings

The following is the record of meetings during 1931 :—Council 11 ; Finance and General Purposes, 12 ; Selection, 10 ; Publications, 11 ; Propaganda (now merged into Finance and General Purposes Committee), 1 ; Competitions, 3 ; Coming-of-Age Committee 2 ; Library Committee, 2 ; Scholarships Committee, 4 ; Lancashire Section, 2 ; London, 8 ; Yorkshire, 5 ; Midlands, 6 ; Scottish, 2 ; Irish, 1 ; total, 80, as against 72 in the previous year. In addition to the foregoing, six sub-committees met for the consideration of special matters.

Section Meetings and Lectures

Four meetings of the Lancashire Section , 2 of the Yorkshire Section, and one joint meeting ; 5 of the London Section, and 2 visits to works ; 3 of the Irish Section ; 2 of the Scottish Section ; 4 of the Midlands Section (and two visits) took place during 1931, at which papers were read and discussed.

Membership

The membership list at the end of 1931—to be carried forward to 1932—was made up as follows :—Honorary Members, 6 ; Life Members, 36 ; Ordinary Members, 1284 ; Junior Members, 117 ; total 1443 as against 1542 at the end of 1930. Of the members at 31st December last, 169 had been admitted to the Fellowship and 217 to the Associateship. Thus, approximately 27 per cent. of the Members hold Institute Certificates of Qualification.

The Council lament the loss by death during 1931 of R. Garrett Campbell (Belfast) ; W. G. Cryer (Farnworth) ; H. E. Danner (U.S.A.) ; A. Kato (Japan) ; S. V. Krishnamoorthy (Bombay, India) ; J. W. F. McLean (Dunmurry, Ireland) ; F. Shirley (Bolton) ; E. Whittaker (Oldham) ; John Whittaker (Blackburn).

In the early part of the present year, the death took place of W. Stauffacher, of Basle, Switzerland, an Honorary Member of the Institute. In March, the demise of Mr. Frank Anderson, of Portadown, a Vice-President of the Institute, was recorded with profound regret Mr. Anderson had for many years been prominently identified with the Irish Section of the Institute.

The Institute has also suffered a great loss by the death of Sir William E. B. Priestley, of Bradford, which took place on the 25th March of the present year. Sir William was President of the Institute for two years (1913-14 and 1914-15) and assisted greatly in the promotion of the Foundation Fund to which he was a substantial contributor.

TREASURER'S REPORT

The Hon. Treasurer, Mr. W. W. L. Lishman, making his annual report, said " Although it is to be regretted that the Revenue Account discloses the largest deficiency of income over expenditure recorded in any one year, yet, having regard to prevailing conditions, the financial position as a whole is not such as to cause alarm. Non-recurring items of expenditure, such as retropective income-tax demands and expenditure on the Coming-of-Age Celebrations, account for a considerable measure of the deficiency—£200 in respect of income-tax and £243 Celebrations. As a result of effective husbanding of resources in past years on the part of the Finance Committee, the Institute is not without resources to off-set the deficiency. Nevertheless, in the current year every possible effort should be made to restore the normal financial position Already definite steps in this direction have been taken, economy having been effected in regard to the *Journal* printing contract. The income from Membership Subscriptions has been almost fully maintained in comparison with the previous year, and whilst a considerable number of withdrawals of membership have arisen, yet new members have been enrolled in recent months at a highly encouraging rate. There has been no addition to the Foundation Fund during the past year, and, in view of the check to progress in this connection, it is evident that at the present time the most promising field from which additional revenue may be derived is that of ordinary Membership Subscriptions Existing members could assist greatly in the matter of introduction of new members and it is sincerely hoped that the satisfactory rate of influx already referred to will be well maintained. The total sum credited to the Foundation Fund, including subsidiary funds, is now £19,020 10s. 6d "

The Chairman remarked that it was easy to slide into debt but difficult to get out of it. They ought to maintain the Institute out of revenue and not out of capital. He made an appeal for a large increase in the number of members.

Mr. W. Frost, moving the treasurer's report, auditors' report, balance sheet, and account be accepted, said that he thought the way in which the Institute had held its own in this difficult time was worthy of all praise. They had nothing to feel alarmed about at the way in which they were going on in these difficult times.

Mr. W. Kershaw seconded, and the resolution was agreed to.

Dr. The Textile Institute—Balance Sheet as at 31st December 1931 Cr.

1930 £ s. d.	LIABILITIES	£ s. d.	£ s. d.
155 18 6	Subscriptions paid in advance		143 15 0
	Life Membership Subscriptions Account—		
	Balance as on 31st December, 1930 .	51 4 9	
51 4 9	*Less* 10% transferred to Subscription Account	8 10 10	42 13 11
	Sundry Reserves, viz.:—		
2500 0 0	Crompton Prize Fund	2500 0 0	
298 0 0	Life Membership Reserve Account . .	298 0 0	
97 10 0	Perpetual Membership Reserve Account .	97 10 0	
10417 2 6	Foundation Fund	10417 2 6	
5000 0 0	Do. (Cotton Reconstruction Board Grant)	5000 0 0	
861 9 6	Do. (Diplomas Account)	861 9 6	
250 0 0	Do. (London Section Reserve Account) ...	250 0 0	19424 2 0
	Competition Scheme—Income and Expenditure		
63 1 10	Account Balance		69 9 10
441 7 4	Scholarship Scheme Reserve Account		411 3 0
295 18 5	Sundry Creditors and Reserves as per List ...		462 12 2
166 2 1	Bank Overdraft: General Account		696 16 7
£20597 14 11		£21250 12 6	

NOTE—There is a contingent liability for Income Tax in respect of final agreement of assessments for 1926-27 to 1931-32 inclusive.

1930 £ s. d.	ASSETS	£ s. d.	£ s. d.
4 16 6	Cash in Bank. Foundation Fund		4 16 6
8 16 2½	Cash in Hand		11 18 8
	Sundry Debtors—		
	Journal Account—		
223 9 6	Outstanding Adverts.	264 2 9	
184 0 1	Outstanding Reprints	35 18 6	
20 0 0	Outstanding Grant Ring Yarn Association	10 0 0	
– – –	*Chronological Record*: Outstanding Adverts. . .	16 0 0	326 1 3
	Furniture, Fittings and Library Account—		
	Balance as on 31st December, 1930... ..	582 19 5	
	Additions during year	6 13 0	
		589 12 5	
582 19 5	*Less* Depreciation	77 5 8	512 6 9
	London Furniture Account—		
	Balance as on 31st December, 1930	36 12 5	
36 12 5	*Less* Depreciation	4 11 6	32 0 11
9 10 0	Gas and Electricity Deposits		9 10 0
– – –	Stock of *Chronological Records* A/c (Estimated Value)		135 0 0
	Investment Account (see Schedule)—		
16515 14 0	Foundation Fund	16515 14 0	
2500 0 0	Crompton Prize Fund	2500 0 0	
105 0 0	Life Membership Account	105 0 0	
97 10 0	Perpetual Membership Account	97 10 0	19218 4 0
130 13 5	Office and Rooms Alteration Account: Balance		87 2 3
	Revenue Account		
	Balance as on 31st December, 1930... ...	178 13 4½	
178 13 4½	*Add* Excess Expenditure over Income for 1931	734 18 9½	913 12 2
£20597 14 11			£21250 12 6

AUDITORS' REPORT TO MEMBERS

We report to the members that we have examined the above Balance Sheet together with the books and vouchers of the Institute, and that we have obtained all the information and explanations we have required.

We further report that in our opinion the Balance Sheet is properly drawn up so as to exhibit a true and correct view of the Institute's affairs according to the best of our information, and the explanations given to us, and as shown by the books of the Institute.

W. W. L. LISHMAN, *Hon. Treasurer.*
H. BINNS, *Chairman of Council.*
W. FROST, *Chairman, Finance Committee.*

16*th March*. 1932

(*Signed*) ARTHUR E. PIGGOTT, SON & SOUTHWORTH,
37 York Street, Manchester. *Incorporated Accountants, Auditors.*

Dr. The Textile Institute—Revenue Account for the Year ended 31st December 1931 Cr.

1930 £ s. d.	EXPENDITURE.	£ s. d.	£ s. d.
	To Rent and Rates—Manchester	267 18 7	
204 15 0	,, *Less* to *Journal* Account	89 6 2	178 12 5
	,, Salaries	1313 16 0	
650 0 0	*Less* to *Journal* Account	663 16 0	650 0 0
	,, Wages...	352 3 2	
246 0 0	*Less* to *Journal* Account	104 2 6	248 0 8
	,, Heating, Lighting, and Cleaning	104 2 4	
65 4 11	*Less* to *Journal* Account	34 14 1	69 8 3
103 4 6	,, Offices, Canteen, and General Expenses		66 0 2½
58 7 1	,, Meetings and Travelling Expenses		39 0 10
104 16 11½	,, Postages, Telegrams and Telephones		113 2 4
117 19 8	,, General Printing and Stationery		152 17 3
7 5 9	,, Insurances		6 16 11
23 5 0	,, Audit Fee, Legal, and Reserve for Accountancy Charges *re* Taxation		89 2 0
5 5 0	,, Subscriptions to Institutions		5 5 0
104 0 11	,, Library Account		54 13 7
	,, Section Expenses—		
221 14 7	London (including Office and Rooms) ...	185 7 6	
21 12 7	Lancashire	17 8 7	
32 15 11½	Yorkshire	36 18 2	
9 17 8	Scotland	20 11 4	
12 9 5	Ireland	6 15 0	
13 11 7	Midlands	5 10 2	272 10 9
	,, Office Alterations—		
43 11 2	Amount written off		43 11 2
47 9 5	,, Diplomas Account: Expenses		56 17 7
8 0 0	,, Medal Account		– – –
16 16 0	,, Savings Association Contributions		32 16 0
	,, Income Tax—on account 1926-27 to 1930-31 inc.		
– – –	(See Note on Balance Sheet)...		200 0 0
97 15 8	,, *Journal* Account		194 17 3
– – –	,, Bank Charges, *less* Interest		6 7 11
93 19 5	,, Depreciation on Furniture		81 17 2
– – –	,, Coming-of-Age Celebrations Account	140 4 9	
– – –	,, Chronological Record and Statistical Summary...	102 15 3	243 0 0
£2309 18 3			£2804 17 3½

1930 £ s. d.	INCOME.	£ s. d.	£ s. d.	£ s. d.
	By Membership Subscriptions—			
	1221 Members at £2 2s.	2564 2 0		
	22 Members at £1 1s. (Half-year) ...	23 2 0		
	97 Junior Members at £1 1s.	101 17 0		
	9 Junior Members at 10s. 6d. (Half-year)	4 14 6		
	Life Members—10% of Balance	8 10 10		
	Subscriptions in advance as per Balance Sheet 31st December, 1930	155 18 6		
	Subscriptions in Arrear paid during 1931 ...	66 0 9		
	Interest from Diploma, Life Membership, and Perpetual Membership Investments ...	52 5 10		
	Special Subscription—The Weavers' Company	21 0 0		
	Diploma Fees	156 3 2		
		3153 14 7		
2053 17 0	*Less* amount transferred to *Journal* Account ...	1103 16 1	2049 18 6	
20 0 0	,, Crompton Fund Administration Expenses ...			20 0 0
5 1 1	,, Bank Interest, *less* Charges			– –
2078 18 1			2069 18 6	
231 0 2	,, Excess Expenditure over Income for Year 1931...		734 18 9½	
£2309 18 3				£2804 17 3½

SUBSCRIPTIONS:—

TOTAL ARREARS at 31st December, 1931	£346 13 2
ARREARS written off	30 2 11
Total Arrears Current	£316 10 3

Audited and found correct,
16*th March*, 1932.
37 York Street, Manchester.

ARTHUR E. PIGGOTT, SON & SOUTHWORTH,
Incorporated Accountants, Auditors.

Dr. The Textile Institute—Journal Account for the Year ended 31st December 1931 Cr.

1930 £ s. d.	EXPENDITURE.	£ s. d.
3213 4 11	To Printing, Reprints, and Postages (Distribution)	2856 17 0
27 11 1	,, Literary Contributions and Abstracts	82 4 0
643 16 0	,, Salaries (*less* £10 Ring Yarn Association)	653 16 0
102 15 10	,, Wages	104 2 6
52 17 6	,, Postages, Telegrams and Telephones	75 5 2
45 5 8	,, Stationery, Binding and *Journals* purchased	42 17 0
56 4 3	,, Advertisement Commission	56 4 3
20 14 9	,, Travelling Expenses	12 13 7
76 10 9	,, Rent and Rates (Proportion)	89 6 2
32 12 5	,, Heating, Lighting, and Cleaning (Proportion)	34 14 1
£4271 13 2		£4007 19 9

1930 £ s. d.	INCOME	£ s. d.
75 0 0	By Reserve—Subscription from B.C.I.R.A., brought forward	– – –
	,, Grants—	
81 17 6	Linen Industry Research Association	163 2 6
10 10 0	,, Subscription from Clothworkers' Company	10 10 0
1615 19 9	,, Advertisements and *Journal* Subscriptions	1757 11 2
800 5 1	,, Reprints	295 8 3
1105 18 3	,, Transfer from Membership Subscriptions	1103 16 1
484 6 11	,, Transfer from Foundation Fund Income from Investments Account	482 14 6
4173 17 6		3813 2 6
97 15 8	,, Revenue Account	194 17 3
£4271 13 2		£4007 19 9

The Textile Institute—Crompton Prize Fund Scheme: Competitions.
Dr. Income and Expenditure Account for Year ended 31st December 1931 Cr.

1930 £ s. d.	EXPENDITURE.	£ s. d.
57 15 11	To Printing and Stationery	32 15 11
40 15 9	,, Purchase of Specimens	30 11 10
9 2 6	,, Mounting of Specimens	5 4 6
146 15 6	,, Prize Awards and Expenses	167 4 6
3 18 5½	,, Postages and Carriage	8 6 3
20 0 0	,, Administration Expenses	20 0 0
278 8 1½		264 3 0
63 1 10	,, Balance carried forward	69 9 10
£341 9 11½		£333 12 10

1930 £ s. d.	INCOME.	£ s. d.	£ s. d.
112 9 7½	By Balance brought forward		63 1 10
135 16 7	,, Albums Subscriptions		132 15 0
7 15 0	,, Competition Entrance Fees		6 16 0
50 0 0	,, Dividend on £1000 5% War Stock	50 0 0	
35 8 9	,, Dividend on £1125 4% L.M.S. Railway Stock	34 17 6	84 17 6
	,, Income Tax repaid in respect of 1926-27; 1927-28; 1928-29; 1929-30 and 1930-31		46 2 6
£341 9 11½			£333 12 10

Audited and found correct,
16th March, 1932
37 York Street, Manchester.

ARTHUR E. PIGGOTT, SON & SOUTHWORTH,
Incorporated Accountants, Auditors.

Dr. The Textile Institute—Foundation Fund Income from Investment Account for Year ended 31st December 1931 Cr.

1931	EXPENDITURE.	£ s. d.	£ s. d.	1931	INCOME.	£ s. d.
May 1	To Mather Lecture	... ...	25 0 0	Feb. 1	By Dividend £1242 10s. 4% Consolidated Stock *less* tax	19 5 3
Dec. 31	,, Interest on £844 9 2 5% War Stock (Diplomas) transferred	42 4 6		May 1	,, ,, £1000 4% Funding Loan 1960-90 *less* tax	15 10 0
,, 31	,, Interest on £102 5 0 5% War Stock (Life Members) transferred	5 2 3		June 1	,, ,, £15939 18s. 10d. 5% War Stock, 1929-47	398 9 11
,, 31	,, Interest on £99 1 6 5% War Stock (Perpetual Members) transferred	4 19 1		Aug. 1	,, ,, £1242 10s. 4% Consolidated Stock *less* Tax	19 5 3
,, 31	,, Interest on £240 0 0 5% War Stock (London Section) transferred	12 0 0		Nov. 1	,, ,, £1000 4% Funding Loan 1960-90 *less* tax	14 10 0
,, 31	,, Interest on £4870 0 0 5% War Stock (Scholarship) transferred	243 10 0		Dec. 1	,, ,, £15939 18s. 10d. 5% War Stock 1929-47	398 9 11
,, 31	,, Interest on £1000 0 0 5% War Stock (Crompton) transferred	50 0 0	357 15 10			
,, 31	,, *Journal* Account	... ...	482 14 6			
			£865 10 4			£865 10 4

Dr. The Textile Institute—Scholarship Scheme Income and Expenditure Account for Year ended 31st December 1931 Cr.

1931	EXPENDITURE.	£ s. d.	£ s. d.	1930	INCOME.	£ s. d.
Dec. 31	To Scholarship Holders' Maintenance Allowances.— Alan Ratcliffe	102 0 0		Dec. 31	By Balance brought forward	441 7 4
	William Graham	27 0 0	129 0 0	1931		
,, 31	,, College Fees	... ...	131 5 6	Sept.26	,, Refund of Breakage Deposit: College of Technology	1 1 0
,, 31	,, Printing and Advertising	... ...	14 9 10	Dec. 31	,, Interest on £4870 5% War Stock, 1929-47	243 10 0
,, 31	,, Balance carried forward	... ...	274 15 4			
			411 3 0			
			£685 18 4			£685 18 4

Audited and found correct,
16*th March*, 1932
37 York Street, Manchester.

ARTHUR E. PIGGOTT, SON & SOUTHWORTH,
Incorporated Accountants, Auditors.

INSTITUTE FOUNDATION AND OTHER FUNDS

SCHEDULE OF INVESTMENTS

(at Cost or Value at original date of gift) **as on 31st December 1931**

Foundation Fund—							£	s.	d.	£	s. d.
£3737	14	9	5% War Stock, 1929-47	...	...		3503	7	0		
£4789	9	5	5% War Stock 1929-47	...	...		4789	9	5		
£ 48	16	3	5% War Stock 1929-47	...	...		49	14	1		
£ 105	5	3	5% War Stock 1929-47	...	...		106	14	0		
£ 102	17	6	5% War Stock 1929-47	...							
£4870	0	0	5% War Stock 1929-47 (Scholarship Scheme)				5355	0	0		
£ 240	0	0	5% War Stock 1929-47 (London Section)								
£ 650	0	0	5% War Stock 1929-47 (Diplomas)		...		661	9	6		
£ 194	9	2	5% War Stock 1929-47 (Diplomas)		...		200	0	0		
£1000	0	0	4% Funding Loan 1960-90	...	...		800	0	0		
£1242	10	0	4% Consolidated Stock	...	...		1050	0	0	16515	14 0
Crompton Prize Fund—											
£1000	0	0	5% War Stock 1929-47	...	...		1000	0	0		
£1125	0	0	4% L.M.S. Railway Preference Stock		...		1500	0	0	2500	0 0
Life Membership Account—											
£ 52	5	0	5% War Stock 1929-47	...	...		53	14	6		
£ 50	0	0	5% War Stock 1929-47	...	...		51	5	6	105	0 0
Perpetual Membership Account—											
£ 99	1	6	5% War Stock 1929-47	...	...		...		...	97	10 0
										£19218	4 0

(Securities at National Provincial Bank Ltd.)

Audited and found correct,
16th March, 1932
37 York Street, Manchester. ARTHUR E. PIGGOTT, SON & SOUTHWORTH,
Incorporated Accountants, Auditors.

ELECTION OF PRESIDENT

Mr. F. Nasmith, Hon. Secretary, moved the re-election of Mr. George Garnett as President of the Institute for the coming year. Mr. Garnett, he said, served a very excellent apprenticeship as a pioneer of the Institute. He had been a really hard worker, both as Chairman of the Council and also as President. It was noteworthy that the Institute Presidents always seemed to find that during their period of office they undertook a particular job of work. They had at the present moment two large tasks in hand which they thought would advance the status of the Institute and of the industry. The Textile Information Bureau which they had undertaken was an important piece of work. Mr. Garnett had set his hand to make it a success and he was sure that under his guidance and his encouragement the work they had before them would make rapid strides before he went out of office. The Information Bureau was going to be of immense use to the industry and a great service to the textile industries throughout the world. He had great pleasure in asking them to re-elect Mr. Garnett as President for the coming year.

Mr. Lishman, in seconding, said he thought they had had a very fine President in Mr. Garnett. He was always tactful and had a keen interest in the work of the Institute which he had very much at heart. The Institute must prosper on business lines and must not be allowed to slack and in Mr. Garnett they had the right man in the right place. The resolution was carried with acclamation.

Replying to the motion re-electing him president, Mr. Garnett said :

I very much appreciate re-election to the Presidency of this Institute It is a distinguished honour and privilege to occupy such a position, as the status of the Institute is now fully recognised throughout the length and breadth of the Textile Trades.

One cannot close one's eyes to the responsibilities also of such a position, as the work that it is undertaking to-day grows in importance and magnitude, but given reasonable health and strength my best service will be at the disposal of the Institute during the current year.

Whilst loss in actual membership of the Institute is easily accounted for by the serious industrial depression through which we are passing and which affects us all proportionately in exactly the same way, it is a matter of great lament that we have to record the loss by death of many valued members of the Institute.

Last month we lost one of our late Presidents, Sir William Priestley, who had been in indifferent health for some time. Sir William was a splendid citizen and served his country as well as his city with conspicuous ability, and he has sacrificed all the time. He took a keen interest in the advancement of technical education and was a strong supporter of the Bradford Technical College. It was because of this interest that we were able to persuade him to accept the office of President from 1913 to 1915, during which time we found his influence a marked advantage to the Institute.

During the last few days we had also lost Mr. F. Anderson of Belfast and Mr. Oscar Hall of Bury. With regard to both these men, the Institute had a very warm place. They both believed in its influence and value, and in the passing away of these friends the Institute has lost some of its best supporters.

It can be truly said to-day that the Institute is realising the dreams of its earlier founders and builders, Lord Rotherham, Sir Frank Warner and Sir William Mather. Other Presidents have each year contributed to its prestige and helped its forward growth to build bigger on the spirit and vision of its earlier pioneers.

Looking backward gives us a most interesting retrospect. Each President has contributed his emphasis to what was the dominant educational theme of his time, and each has done much to lift the Textile Industries on to a more scientific basis of structure.

In the earlier years education for the trades, fundamental and supplementary, was urged and much good result has been the outcome. The prominence that we, as an Institute, gave to this subject, the co-ordinance of interests in the Textile trade, the gathering into membership of all the heads of our University and Municipal Technical Colleges, and through them an annual increase in membership of the men under their tuition, has further widened the recognition of the Institute's position.

Research work, scientific and technological, was started by the Institute only to be handed over to the great Research Associations as each industry could secure larger financial support for its continuation and the maintenance and expansion of each major industry be more fully realised. It is gratifying to find that we are definitely and officially linked to these great Research Institutions and that the *Journal* is accepted as a medium for the publication of inventions, records of progress and abstracts in the technology and economics of Textiles.

Closely associated also with this aspect of our work is the increased interest taken in the annual competition for the Crompton Prizes. The best men in our Technical Colleges, all over the land, recognise their value by competing for them, and the results show a genius and adaptability to beautiful creations in materials, weaves and colours, that must help to keep us well in front of world competition.

The Royal Charter has secured to the Institute a new and larger meaning and purpose, and as a direct evidence of the value of the Diplomas, the Industries are calling for and giving preference to these men who have passed the exactions of a Board of Examiners and Assessors, who fully realise the demands that are being made to-day on the leaders of our industries for both internal and external administrators and designers. The gentlemen who form this Board are giving through the Institute a great national service which we are much too slow in appreciating

These are the influences which are bringing us new life and the best type of men into membership, and in this and many other ways we are proving our value, nay, necessity to the Textile Trades, and justifying our sphere of activity.

The latest recommendation to form an Information Bureau and a comprehensive collection of yarns and fabrics, will throw upon the Institute and staff a large amount of additional work and expense, but the more I consider the scope of this work, the more am I satisfied of its essential necessity and if we can get the support of the Trade Associations, many of whom we know already are sympathetic to this undertaking, we shall show what unique advantage all this information can be, not only to our members and supporters, but such a compilation that will merit the support of government Departments, municipal, and other public bodies. This work would in no way infringe upon that of a similar character now being done by Research Associations, Testing or Conditioning Houses, who each have their own special spheres of activity. It will take perhaps some years to establish this scheme effectively, but the earnestness of the Committee pledged to see that the foundations are well and truly laid, foreshadows success.

Last year I ventured to lay some stress on the more definite recognition of Art in textiles. I find since that some of our colleges are including in their courses a specific number of lectures on this most important aspect. Recent exhibitions have shown to the world a marvellous display of colour combination in all weights of fabrics Those who visited the recent B I F in London, must have been struck with the variety and beauty of these collections.

The cotton trade evidently is convinced that it was an unique opportunity to advertise its capacity to make any type of fabric needed for any market in the world, in attractive colourings, and we sincerely hope that their faith may have full reward in the near future.

The wool fabric trade is conducted on rather more conservative lines, and apart from being probably a good medium of advertising, doubts are expressed on all sides as to the effectiveness of the exhibition as a means of selling more goods. This trade has exhibited freely and extensively on many former occasions, but no great volume of business can be traced to this considerable outlay of money. It may be that we have been slow to appreciate its educative value on the public mind, and that as an element in advertising it had advantages that we were somewhat slow to appreciate. We doubt whether this trade lends itself to such open display of design and colouring as does the cotton or the artificial silk trades.

As the maintenance of the life and activity of the Institute must largely depend upon young men whose interests we are so much fostering and encouraging at the present time, I would like to urge them to still continue to prosecute their studies and qualify for the Institute Diplomas and Fellowships, in spite of the terrible trade depression through which we are passing.

Many of these, I know, feel disheartened because they either cannot get berths or cannot get the remuneration which their talent and genius merit. Undoubtedly it must

mean a considerable sacrifice of time and money for which there seems to be no adequate return, but this condition of affairs cannot continue indefinitely, and I have confidence that those at the head of the Government to-day are as capable to handle these delicate situations as those are in any foreign countries, and if we realise that it is only by co-operation with similar minds of other nations that this crisis can be ultimately satisfactorily handled, we shall yet come into a new era of prosperity and general trade revival, when the ability of all those men should be adequately recognised.

Reparations, war debts, exchange restrictions, currency questions and the unsound fiscal policies of many nations have all played their part in bringing about the present crisis and the collapse of values In my judgment, only international action can remedy this situation.

Private foreign loans have not always been wisely made or wisely spent. Too few conditions have been attached that they should be used for revenue-making schemes.

As international traders we cannot alone regulate our own sterling exchange basis. We are vitally influenced by the supply and demand of world products, and this situation must be finally the arbiter of this financial factor.

I think one of the brightest features in the Budget read last night was the decision to raise the fund of £150,000,000 in order to counteract as far as possible money withdrawals and money transactions both with this and from other countries, which has had tremendous effect on money values in days gone by and particularly this last two years.

The crisis of 1931, as in the words of Sir Arthur Salter in his new book, " Recovery," revealed as never before the anatomy of the world's economic structure. In an excellent review of this book in the " Economist " last week the editor states that Sir Arthur's proposals for coping with these difficulties, and for initiating a more liberal tendency in Europe follow broadly the lines of the report of the Conference of Economic Experts of August last The following are among the conditions which he lays down. There is a case for asking non-European countries to concur in special arrangements for the European nations. Even a limited Customs Union—still less one for Europe as a whole—could not be achieved at one step, but the declared object of any plan should be to reduce and finally remove the barriers between the participating States. Between these States the most-favoured-nation clause should apply, and the reductions should aim at making any " intermediate " tariffs more level. Groups must be open to the admission of other countries and not create new and exclusive groups. There must be no increase of protection against non-participating states, and other countries whose general tariffs are equal to the lowest in the group should be given the advantage of the lower rates without having to increase their tariffs against the rest of the world. Such a plan, which clearly can only hope to succeed if tariffs are simplified and cleared of their present excessive complexities, would create a lower tariff regime between certain countries and would tend to encourage its extension by offering inducements to other countries to conform to its clearly defined conditions.

This problem, however, like all the others which he discusses, forcefully illustrates what may almost be described as the main thesis of Sir Arthur Salter's book, namely, the striking contrast between the avowed opinion of the nations of the world as a whole and the action of its individual members. While all agree that barriers must be removed, everyone adds a new tier to his tariff wall While all agree that, if the world is to be saved from a reversion to barbarism, civilised nations must disarm and live in peace, everyone polishes up his weapons of war Even now, with the whole world in the toils, is it not yet for collective wisdom to prevail over individual folly ? Lausanne will give one more opportunity for the statesmen to answer this challenging question. Because the world has shown such unsuspected power of resistance to the effects of credit collapse, suspension of contractual obligations, diminution of production and the slaughtering of trade, we cannot assume that the strain can be indefinitely prolonged without disaster. Nor is it enough to prop up a corner here or repair a crack there when a whole building is in danger of collapse. It will be high time in June to take a general look round and see what must be done in every direction—and not in the limited field of reparations alone—to restore the shattered economic structure of the world.

It is beyond the scope of the Institute to do anything in this situation beyond perhaps giving facilities in its *Journal* for the ventilation of some of these great economic causes. This, I think, might be done with great profit to our younger members, as some day they must take their part in the management of these affairs.

I think the Institute must continue to confine itself largely to educative work more directly associated with our industries, but if the wider outlook can be extended as we have opportunity and finance, I feel it should increase the prestige that we already have secured.

Before closing these observations, I should like to pay a tribute of appreciation and thanks to the members of the various committees, who have so loyally carried out the work of the Institute during the last year. They have spared neither time nor effort in its interests to make its work effective and influential, and they have given ungrudgingly whatever demand has been made upon their time to further the general interests of this great institution.

It is by such effort that this Institute has become what it is to-day, and is by this same spirit that it must continue to grow, and if our younger members are catching the spirit of those who have gone before us, we shall still justify our existence as one of the foremost educative movements of the present time.

Again allow me to thank you most sincerely for the honour you have done me in asking me to accept this position for another year.

Mr. H. Binns, Chairman of the Council, moving the re-election of Messrs. J. Crompton, H. P. Greg, and J. H. Lester as Vice-Presidents, made a brief reference to the national certificate movement of the Board of Education. It seemed to him that having there such gentlemen at the head of the list an active co-operation would help them enormously in attaining that high standing which was required by the Board of Education. They were a combination of practical men, technologists and scientists, and such a happy combination was of enormous value to the Institute.

Mr. F. Wright, Vice-Chairman of Council, seconding, made an appeal for the young people of this country. He was convinced that the Institute had got to succeed on the basis of its learning and scientific attainments and it was to the youths who were growing up that they would have to look to build up the Institute. The older members had not had the opportunities for education such as were now provided but he thought there was a missing link with the employers and that was the interest taken by the old employer to get into touch with the younger people. If they gave youth all the encouragement they could the Institute and trade would succeed.

The President, supporting, said the men proposed as Vice-Presidents were the type of men they wanted in the Institute and in the affairs of the country. They were deeply grateful to them for the services they had given in the past.

The resolution being carried, Mr. John Crompton responded on behalf of the other Vice-Presidents and himself.

The ballot for the election of ten members of the Council resulted in the following being elected :—Messrs. H. G. Greg (Manchester), H. Richardson (Bradford), R. J. H. Beanland (Bradford), F. P. Slater (Manchester), J. Read (Salford), J. B. Speakman (Leeds), H. Binns (Bradford), G. H. Thompson (Oldham), T. F. Robinson (Manchester), and T. S. Stott (Manchester).

Messrs. Arthur E. Piggott, Son & Southworth, were re-elected auditors.

The proceedings concluded with a vote of thanks to the chairman.

Lancashire Section

At a meeting held at the Harris Technical Institute, Preston, on the evening of the 5th February, Mr. C. A. Harrington presiding, a paper was read by Mr. James H. Yates, A.T.I., on " Efficiency in Manufacture." Mr. Yates said that he could not accept the complacent attitude which regarded our textile manufacturing efficiency as incapable of further advancement. In winding and beaming, particularly, old methods remained in practice to a most undesirable extent. There was abundant room for the modernisation of weaving sheds and provision of adequate space for effective modern practice. It was significant that in the spinning section there was a greater proportion of new machinery than in the weaving section. Mr. Yates dealt with many aspects of production arrangements and offered considerable criticism.

In discussion which followed, Mr. Fletcher Chadwick said that the contributor of the paper missed many opportunities of presenting useful information by over-indulgence in criticism and censure.

Meeting at the Institute, Manchester, Friday, 22nd January, 1932; Mr. T. E. Mitchell in the Chair.

FASHION AND COLOUR IN TEXTILES

The lecture on this occasion was delivered by Mr. Robert F. Wilson, General Manager and Secretary of the British Colour Council. The early part of his address dealt with the relationship between the colours, forms, and sounds employed by artists during successive periods in the world's history and the " spirit of the age " in which they lived. The more wide-spread the appreciation of art in any nation, the healthier the nation, was postulated by the lecturer. He then reviewed briefly the history of design and colour as a preliminary to consideration of where this country stood in regard to the application of colour and design to textiles. The historical outline given by Mr. Wilson was illustrated by a series of lantern slides.

The lecturer said he hoped the outline of the history of decorative textiles would enable his audience to realise that design was symbolic, often connected directly with religion ; that scanty and slow means of communication resulted in the slow spread of ideas between nation and nation ; and that the rise and decline of prosperity seems to have been moving from East to West.

Slides were then shown illustrative of the designs in vogue to-day which, the lecturer claimed, typified speed and mechanism, and these he suggested were symbolic of the spirit of the present age. The lecturer briefly surveyed the present world position as indicative of changes rapidly experienced and to be yet experienced at perhaps an even more rapid rate. Such changes counted in moulding national character and this again had its effect directly upon the arts and crafts of the nation. He then proceeded to discuss the present day position in regard to colour. He said, " Until this year Paris has, generally speaking, set the fashion in colour, although America, by reason of the Textile Colour Card Association, inaugurated fifteen years ago, has had a great effect upon colour decision, not only in this country, but also on the Continent and in our Dominions. The fetish concerning Paris has been considerably assisted by the attitudes of many firms to whom the latest knowledge of fashion colours is absolutely essential, also by the Press and by the British public themselves. When we had world markets which we held to a great extent undisputed, this looking to the Continent for colour inspiration did not, to any great extent, matter very much, but world affairs have made it essential that we should now create and not follow, otherwise we are not only in danger of losing our prestige, but also of creating a greater army of unemployed, which can only result in financial distress."

Mr. Wilson then outlined the activities of the British Colour Council which had only been in active work for some nine months and terminated his address with an appeal for the co-operation of Manchester and Lancashire.

The Chairman, Mr. T. E. Mitchell, said that he had enjoyed Mr. Wilson's lecture, which had been delivered in an interesting and charming manner. He called upon Mr. C. M. Whittaker and Mr. W. Scott-Taggart to propose and second a vote of thanks.

Mr. C. M. Whittaker said that it was a pleasing task for him to propose a vote of thanks. He had been connected with the colour industry for 32 years and he was a member of the British Colour Council. He added that in the interests of British industries it was the best thing possible to get the British Colour Council known and he had great pleasure in proposing a vote of thanks to Mr. Wilson for lecturing on such an interesting subject.

Mr. W. Scott-Taggart, in seconding, said that he was just a little disappointed that the slides shown to illustrate designs had not been in colour. One saw so many drab shades that it was excellent to know that at last England was taking a leading place in deciding colours.

A hearty vote of thanks was accorded to Mr. Wilson.

Yorkshire Section

Address by Sir H. McGowan, at Bradford.

At a Luncheon Meeting promoted by the Yorkshire Section of the Textile Institute, and held at the New Victoria Restaurant at Bradford, on the 25th February, Sir Harry McGowan, K.B.E., Chairman of Imperial Chemical Industries, Ltd., and a director of the Midland Bank, Ltd., gave an address on the industrial situation.

Mr. Wilfred Turner, J.P., presided and, in calling upon the speaker, said we were beginning to realise not only the interdependence of nations but the interdependence of industries. Confronted with many difficult problems, they were glad to grasp the opportunity of hearing the views of one so eminent in industrial control.

Sir Harry McGowan, K.B.E., at the outset said that they were all deeply concerned with methods calculated to bring back prosperity to our industries. The Macmillan Committee on Banking had indicated two ways of escape from world depression, reflation or the raising of the international price level; or deflation, the re-adjustment downwards of all items of money incomes. The Committee had favoured reflation. Unfortunately there was no agreement upon the precise machinery for this process of restoring the price level. Effective action called for great measures of international co-operation. How far the world was from such agreement needed no emphasis. Industrialists, realising that such international co-operation was receding from practical politics rather than becoming more real, had to turn to the second remedy pointed out by the Macmillan Committee. In addition to never-ceasing endeavours to achieve every possible economy in manufacturing costs, they have had to seek relief by way of wage reductions. So long as wage falls do not lead to a further decrease in the price level they promise some alleviation of the industrial position. But we need most the development of fresh activities, new manufactures, improved processes, so as to be able to set more men to work. Unless, however, profit can be shown, new ventures will not be undertaken and old ventures will be abandoned. From the handicap of adherence to the Gold Standard we had been recently rescued. We can now look for a rise in price level. It was misleading and unwise to argue that government and monetary policy must be directed towards preventing such upward movement. Misleading because prices in many industries in this country had been forced down by unfair foreign competition. A tariff would rescue us from such subsidised competition. It was unwise because fresh industrial activities could be undertaken if we could see promise of a profit.

Sir Harry said he welcomed the reversal in our old fiscal tradition and was satisfied with the cautious and considered manner in which it was being made. Precipitate and ill-advised fiscal action might have done more harm than good. He believed that, despite all obstacles, foreign trade would continue and expand but only under proper regulation. To-day we were suffering from unbalanced production; over production that is in certain specific fields. It was doubtful whether the world could stand the shocks of a number of international commodities falling in price through excess of supplies. Such a process spread like a disease: the remedy was a better control of aggregate world production. This could only be achieved by co-operation between the principal producing countries which must each be represented by men who could speak for the industry of their own country. Industry in each country must therefore be organised not only in such a way as to permit of representative views being expressed but also to admit of decisions being put into effective operation. The world was burdened by many excess stocks. The key was industrial and financial co-operation. Sir Harry then referred briefly to such examples of co-operation on broad lines as were already available. He instanced the national

electricity grid scheme, shipbuilding co-operation, the Lancashire cotton schemes, and the chemical industry in this country and the sugar industry, the copper producers and others abroad.

There was ample evidence, the speaker continued, that foreign industrialists were viewing the British market and British competitive power in foreign markets with new respect. In handling the forthcoming commercial treaties, our representatives would have to be supported by British industrialists. One industry must speak with one voice and could only do so if organised not only for speaking but for action. Fiscal changes to the textile industries were not quite of the same moment as to many other industries. For the textile trade, however, to export will be a vital necessity. To hold the British position more and more organisation will be imperative. The unit of size-efficiency might not need expansion but groupings of hitherto independent mills with resulting improvement in efficiency of finance and selling would probably prove necessary. As communication transport developed the world became smaller and international co-operation more essential. The nineteenth century was an age of manufacturing individualism; the twentieth century must be one of controlled production and organised distribution; of co-operation or disaster. Prosperity could only be regained by co-operation and organisation joined with high technical efficiency and artistic originality. Because he was so passionately interested in the prosperity of the Textile industries he had ventured to speak directly and vigorously.

A vote of thanks was accorded Sir Harry McGowan on the motion of Sir Henry Sutcliffe Smith, seconded by Mr. William Hunter. The latter said that exchange restrictions to-day formed a great barrier in regard to export trading. He believed there was room for better recognition of individuals responsible for improvements effected in industrial operations. Sufficient was not known of the work going on behind the scenes in regard to textile production and many excellent ideas were not adopted owing to the low price levels obtaining. He considered that the Textile Institute could do more than they had done in honouring inventors.

Moved by Professor Barker, seconded by Mr. Edford Priestley, the Chairman was also thanked for his services.

London Section

Meeting at the Clothworkers' Hall, Mincing Lane, London, Tuesday, 12th January, 1932. Mr. E. Wigglesworth in the Chair.

SCOTCH TWEEDS

The lecturer, Mr. J. Macpherson Brown, Fellow, was introduced by the Chairman, who said that the meeting was first to have a lecture and then a film, after which questions could be asked.

Mr. Brown first described the origin of the Scotch tweed trade in the southern counties of Scotland which had been famed for centuries for the production of fine woollen cloths. He then took his audience through a description of all that took place from the receipt of an order for goods to the finished article. He described in turn the cloth analysis, fleece sorting, wool or yarn dyeing, carding, scribbling, clearing, condensing, spinning, seasoning, beaming and weaving. The various methods of finishing the woven goods were indicated and the advantage enjoyed in Scotland of ample soft water was referred to. Fulling stocks were still used though even yet the still earlier method of treading cloth persisted in certain districts.

A film was then shown depicting the processes through which the wool passed in the making of Scotch tweed from the time the wool left the sheep's back until the cloth was made and ready for dispatching.

The Chairman said they were all indebted to the Lecturer for his address and for the interesting and informative film. After one or two questions, Mr. A. Mason, Fellow, proposed and Mr. Hardman seconded a vote of thanks to Mr. Macpherson Brown, which was heartily accorded.

Irish Section

Meeting at the Municipal College of Technology, Belfast, on Thursday, 11th February, 1932; Dr. W. H. Gibson presiding.

STUDIES ON LINEN SCOURING

This lecture was contributed by Mr. E. Butterworth, Fellow, who said that the present work* had been undertaken with the twofold object of examining the reaction of the linen cellulose complex with alkali in the scouring operation and determining the effect of unremoved impurity in the various standard tests for cellulose. The primary object was the examination of partially and fully scoured material by viscosity in cuprammonium hydroxide in relation to the standardisation of the test for commercial purposes. After a number of interesting demonstrations a discussion followed and on the proposition of Professor F. Bradbury, seconded by Mr. W. J. Cowden, a vote of thanks to Mr. Butterworth was passed with acclamation.

The 6th Annual Meeting of Members of the Irish Section was held at the Municipal College of Technology, Belfast, on Thursday, 7th April, 1932; Present: Professor Bradbury, Messrs. W. Cowden, J Kirkwood, J. McClenaghan, G. R. Beatty, E. Butterworth, and F. J. W. Shannon (Hon. Sec.). Professor Bradbury was voted to the Chair.

A note of apology for absence was received from the Section Chairman (Mr. W. H. Webb), who had just left for America.

The minutes of the 5th Annual Meeting (27th March, 1931) were read and approved.

The Hon. Sec. presented the Annual Report and it was agreed to record as follows:—

"During the past session two meetings were held at which the following papers were contributed:—

1. 16th December, 1931: 'Monetary Leadership—Plan for an Empire Currency,' by J. F. Darling, Esq., C.B.E. (Director, Midland Bank, Ltd.).
2. 11th February, 1932: 'Studies on Linen Scouring,' by E. Butterworth, M.Sc. (Tech.), F.Inst.P., F.T.I.

Both meetings proved very successful and Mr. Darling's lecture drew the largest audience secured at an Irish Section meeting.

The membership of the Section now stands at 33, showing a decrease of 4. This is the first time we have had to record a decrease in membership since the Section was re-organised in 1926.

It is with great regret that we record the loss of three members, by death:—Mr. R. Garrett Campbell, Belfast, a life member of the Institute and one who always took a keen interest in our work; Mr. J. W. F. McClean, Dunmurry, who joined the Institute about two seasons ago; Mr. F. Anderson, Portadown, a Vice-President of the Institute and a member of the Irish Section Committee.

Mr. Anderson did much to further the interests of the Institute and was held in exceptional esteem by a wide circle of members both at home and across the Channel.

With regard to our meetings, we wish to thank Mr. Darling and Mr. Butterworth for the contribution of papers, and Professor Earls for continued facilities so graciously afforded for the holding of meetings at the College.

On the proposition of Mr. McClenaghan, seconded by Mr. Beatty, the report was adopted.

* It is hoped to print this contribution in full in a subsequent issue.

It was decided to put forward the following nominations to be recommended to Council for election for the ensuing year:—Chairman: Mr. W. H. Webb (Randalstown); Hon. Secretary: Mr. F. J. W. Shannon; Committee: Dr. Gibson, Professor Bradbury, Messrs. W. Cowden, J. McClenaghan, and G. R. Beatty.

The Hon. Sec. read a letter from Mr. H. L. Robinson, extending an invitation for an Irish representative to serve on a Special Committee to deal with the forming of a Textile Institute Information Bureau. It was decided to send forward Mr. E. Butterworth's name for this Committee.

A discussion then took place regarding lectures for the following session, and it was decided that a number of names should be sent forward to Mr. Athey, who could perhaps make some arrangements or suggestions.

Scottish Section

Annual Meeting

The Annual Meeting of the Scottish Section of the Institute was held in the North British Station Hotel, Edinburgh, on Saturday, 16th April, 1932, when Mr. T. M. Lees (Galashiels), presided over a representative attendance of Members.

After intimating apologies for absence from Messrs. W. Black, H. Cook, W. B. Robertson and Jas. Ross, the Hon. Secretary read the Minutes of the previous Annual Meeting as printed in the Journal and already circulated.

The Chairman welcomed those present, and said that the past session had provided a satisfactory record. He hoped the Committee would be able to present at least equally interesting arrangements for the ensuing year. He congratulated Dr. Stevenson (Galashiels) on his election to Fellowship, and Messrs. J. Callander (Paisley), E. Y. Johnston (Alva) and C. J. Wright (Paisley) on their election as Associates of the Institute.

The Hon. Secretary (Mr. A. W. Blair) submitted a short report of the proceedings during the past twelve months and stated that the Membership at 29th February was 89, being an increase of 6 on the previous year. Eight Members had been lost through resignation and transfer to other Sections, while there were twelve new Members and two transferred from other Sections. The membership was distributed as follows:—East and Midlands, 30; West and South-west, 29; Border district, including Carlisle, 27; North, 3.

In addition to the Annual Meeting, two other Section Meetings had been held at Greenock and Galashiels.

The Hon. Secretary submitted a financial statement showing the total expenses of the Section, and pointed out that the expenditure amounted to 1/11½ per Member. The principal items were for hire of rooms for the various meetings during the year.

On the motion of Mr. J. Macpherson Brown, seconded by Mr. J. P. Beveridge, the report and financial statement were approved, and Mr. Blair was warmly thanked for his services as Hon. Secretary.

The following Members were elected, subject to acceptance by Council, to form the Section Committee:—Messrs. A. W. Blair, J. Macpherson Brown, A. R. Geary, T. M. Lees, A. Smith, and Dr. Stevenson.

The Chairman pointed out that Mr. J. P. Beveridge remained on the Committee, *ex officio*, until due to retire from Council in 1933.

The Chairman welcomed Mr. J. D. Athey (General Secretary) who was in attendance, and in response to a request, Mr. Athey gratefully acknowledged the welcome. He congratulated the Section on their efforts, which had been particularly satisfactory having regard to the long distances involved in attendance at the meetings. Referring to the forthcoming Annual Conference at Leamington Spa, he was glad to observe that the Section would be represented.

After adjourning for luncheon, the meeting was resumed, when Mr. D. A. Watson, A.T.I. (Paisley) contributed a short paper on "The Fastness of Colours."

There was an interesting discussion, and, in the absence of Mr. J. Macpherson Brown (Chairman of Section Committee), Mr. J. P. Beveridge expressed the thanks of the Committee to Mr. Watson for his excellent paper.

The meeting terminated with a hearty vote of thanks to the Chairman.

Midlands Section

Meeting at Hinckley and District Technical College, Wednesday, 20th January, 1932.

WORKS ORGANISATION AND MANAGEMENT

A discussion on this subject was opened by Mr. S. E. Ward, of J. B. Lewis and Sons, Ltd., who dealt first with the meaning of the word " Organisation," and the inference to be drawn from the definition offered. He then dealt with the main types of organisation possible in the Hosiery factory and the reasons which govern the choice or utilisation of each type. Minor points arising were discussed such as lay-out of buildings, transport systems, conveyor systems, and power and light installations.

Mr. J. K. Ebblewhite, of Livesey & Crowther, Ltd., who was the second speaker, dealt with the automatic control of heating, and of humidity in hosiery mills.

In the discussion, Mr. P. A. Bentley emphasised the importance of these points from the point of view of machine builder and Col. C. E. Atkins referred to them from the manufacturer's standpoint. Other speakers contributed to an interesting discussion.

NOTES AND NOTICES

National Certificates and Diplomas in Textiles

The Council of this Institute, at its meeting on the 20th April, considered a recommendation from the Selection Committee in favour of taking steps towards the promotion of a scheme for the award of National Certificates and Diplomas in Textiles. The Selection Committee was authorised to enter into negotiation with the Board of Education on the whole matter. The proposed scheme represents a movement of real importance. National Certificates and Diplomas are now available to technical students of Mechanical and Electrical Engineering, Chemistry, Naval Architecture, and Building, and the possibility of providing textile students with similar national recognition is to be thoroughly explored. In the case of existing schemes, the Board of Education is associated in every instance with a professional institution of high standing and, to quote from a report, " students concerned are aiming at acquiring a knowledge of principles rather than skill in a craft or occupation." National Certificates and Diplomas are issued jointly by the Board of Education and the professional institutions. It is fully appreciated that the promotion of a scheme related to textiles will involve a considerable measure of negotiation and possibly a good deal of consultation with various bodies. A highly important point about National Certificates procedure lies in the consideration that it is intended to bring the technical schools into closer association with the professsional institutions representing the industries for which the students are being trained.

Institute Examination

At the last meeting (6th April) of the Selection Committee of the Institute it was reported that several applications had been received for permission to take the Institute's examination in General Textile Technology quite apart from application for the Associateship. Under these circumstances, it appears to be again necessary to point out that the Institute examination is available only to applicants for the Associateship whose applications have been approved for reference to the examination. The Institute examination is conducted

exclusively in relation to the Associateship, and all applicants for the Associateship must have completed at least six months of membership of the Institute.

Death of Sir William Priestley

President of the Institute for the years 1913-14 and 1914-15, Sir William E. B. Priestley, whose death took place at his residence at Bradford, on the 25th of last month (March), was one of the earliest and most earnest supporters of our organisation. For many years subsequent to his presidency, he maintained the warmest interest in the affairs of the Institute, joining heartily in the efforts of the late Sir William Mather and the late Sir Frank Warner to promote the establishment of the Foundation Fund. Sir William Priestley contributed substantially to the Fund, the annual revenue from which has permitted various enterprises, including more particularly development in connection with the publication of the *Journal* of the Institute. Sir William was a warm supporter of technical education and was closely identified with the municipalisation of Bradford Technical College in 1899. He was a Member of Parliament from 1906 to 1918. Sir William is survived by Lady Priestley and two married daughters.

Obituary Notice

The Institute has suffered severely by the death of several prominent members in recent months. The passing of Mr. Oscar S. Hall, of Bury, during the present month removed one of the keenest of supporters of our institution. In the early years he contributed substantially to committee work, became a member of Council and also a Vice-President. Mr. Hall was head of the firm of Messrs. Robert Hall & Sons (Bury) Ltd. and took a most active interest in both the technical and commercial aspects of the industry. He contributed several papers at the Institute and other meetings, and, in addition to his devotion to the interests of the Textile Industry, he took an active part in affairs of local government. He had travelled considerably and was a capable linguist. The interment took place at Bury on the afternoon of the 20th April at which time the annual Meeting of the Institute was taking place at Manchester, which prevented many members and officials from attending. At the Council meeting on the same day fitting reference was made to the deaths of Mr. Hall, Sir Wm. E. B. Priestley (Past-President), Mr. Mark Sutton (Rio de Janeiro) and Mr. Frank Anderson (Portadown).

Textile Institute Diplomas

Elections to Fellowship and Associateship have been completed since the appearance of the previous list (March issue of this *Journal*) as follow—

FELLOWSHIP

SMITH, Harold de Witt (Bayonne, U.S.A.).
WHITAKER, George (Bradford).

ASSOCIATESHIP

CHARAP, Myer Martin (S. America).
KENDALL, Frank (Shipley).
SOUTHERN, Edward George (S. America).
ULLAL, Narain Venktappa (Bombay, India).

Institute Membership

At the April meeting of Council, the following were elected to Membership of the Institute :—G. Akroyd, 33 Sandhurst Place, Harehills, Leeds (Head of Testing Department, Montague Burton Ltd., Leeds) ; H. S. Butterworth, Highlands House, Shaw, Lancs. (Cotton Mill Manager) ; T. E. Ericsson, Sven Erikssonsgatan 30, Boras, Sweden (Correspondent, etc., Technical Dept., Boras Wasveri Aktiebolag) ; Dr. E. Franz, c/o Kammgarnspinnerei Stohr & Co., Aktien-Gesellschaft, Leipzig W.31, Germany (Manager of Laboratory) ; S. D. Garg, 14 Duncan Road, Longsight, Manchester (Student) ; D. Hunter, c/o Wm.

Cunningham & Co., 52a Bow Lane, Cheapside, London, E.C.4. (Assistant Linen Agent and Merchant); E. J. Kerfoot, 62 Sunfield Road, Oldham (Salesman in training at Platt Bros. Ltd.); N. G. McCulloch, Calico Printers' Association, St. James' Buildings, Oxford Street, Manchester (Director); G. E. Morgan, 39 Oakfield Drive, Ferniehurst Park, Baildon, Yorks. (in charge of Testing Laboratory, Samuel Rushforth Ltd., Frizinghall); F. D. Vandemeulebroucke, Potiaulaan 22, St. Gillis, Dendermonde, Belgium (Student). E. Tillotson, Prospect Villas, Cleckheaton, Yorks. (Asbestos Works Manager), was elected to Life Membership.

GENERAL ITEMS AND REVIEWS

MEMORANDUM ON TEXTILE EDUCATION IN GERMANY*

1. Throughout Germany, except in Bavaria, the law requires children to attend school from the age of 6 to 14. In Bavaria, the limits are 6 to 13. Boys and girls leaving elementary schools are required to attend compulsory continuation schools between the school-leaving age and the age of 18. In fact, the law does not appear to be universally enforced, and it is unlikely that all the children, who are legally liable, attend for the whole of the four years. These continuation schools are supposed to be held in the " day " time but a good many of them are held from 6 to 8 in the evening. The young people are supposed to attend from 6 to 8 hours a week. Some of them get exemption from attending compulsory continuation schools in view of attendance at other schools, e.g., Trade Schools (Fachschule) during the day or evening.

2. **Smaller Trade Schools.**

These schools are intended to provide training for boys and girls of about 14 who are to be skilled workers in industry and the crafts. The curriculum is usually dictated by the particular work for which the students are preparing. There appear to be about 35 such institutions "attached" to the Textile Industries including:—

Municipal Trade Schools for the Textile Industries.
State Trade Schools for Spinning and Weaving
Schools for Weaving (Webschule)
Schools of Finishing (Appreturschule).

The normal provision of "Trade Schools" includes

(*a*) Day courses (full-time) giving practical courses of instruction lasting six months, one year or a number of years according to the needs of the student. The fees vary from £4 to £10 per annum.

(*b*) Evening courses. The schools are normally supported and controlled by the State or Municipality, but there are one or two under the direction of an industrial association and one or two privately owned institutions. These latter appear to be attached to the works of a particular firm. In some schools " apprenticeship courses " of from six to ten hours weekly in the day-time are provided for about three years for young people who have shown sufficient merit to be allowed to attend a Trade School instead of a compulsory continuation school

3. **Higher Trade Schools.**

The aim of these schools is to train manufacturers, works managers, foremen, designers and merchants for the German textile industries. The three largest schools are at Aachen, Cottbus (Lausitz) and Reutlingen (Wurtemburg). In addition there are nine Higher Trade Schools in the textile area of Saxony, one at Munchen-Gladbach, one at Krefeld and three others at Barmen, Berlin and Lambrecht in Rheinfalz. Generally speaking, the worsted trade in Germany has not been developed to such an extent as the woollen trade, and this situation is reflected in the provision made for technical education. In particular there would appear to be no Higher Trade School with so comprehensive and up-to-date

*A copy of this Memorandum, issued by the Yorkshire Council for Further Education, has been received at the Institute and is summarised above.

an equipment for worsted spinning, weaving and finishing as the equipment for the woollen industry (see para. 9) provided at the Cottbus school. At the same time it should be said that complete full-time courses in worsted yarn manufacture and the production of worsted and " half-woollen " cloth are established at Aachen, Krefeld and Munchen-Gladbach.

Each school serves a wide area, the students coming to live near the school for the period of their course. In the Higher Trade School for the Textile Industry at Chemnitz there were 353 day students in 1927-28 and at the Technical School for the Textile Industry at Reutlingen (mainly cotton) about 400 day students.

In the Higher Trade School at Cottbus the number of students was, in 1929-30, day students 321, evening students 451.

Provision is made both for full-time and part-time day students and for evening students. A complete full-time course in a single branch of textiles, spinning, weaving or finishing, usually lasts for about 21 weeks, and, as a rule, each course is held twice a year. It is, therefore, possible for a full-time student to complete a reasonably thorough training in textiles in $1\frac{1}{2}$ or 2 years, taking the three main subjects successively. At Cottbus the course in dyeing is exceptional in that it may last one or even two years. Specialised courses for designers and merchants are also held.

The qualifications for entry to the larger schools are :

(1) the leaving certificate of the Mittelschule (Secondary School taking pupils from 11-16) *and*

(2) practical experience in a works of one or two years.

The school Prospectuses strongly recommend students to have at least one year's practical experience in the industry before entering the school. The age of admission is usually 16 to 17 years. With many of the schools a public textile research and testing laboratory is combined.

4. **Technical High Schools.**

The highest form of technical education in Germany is carried on in the " Technical High Schools " and in certain Universities. The deputation which visited these schools from the Manchester Education Committee were deeply impressed with the impressive and magnificent buildings and the generous equipment at Charlottenburg (Berlin), Dresden and Munchen. There are ten Technical High Schools in Germany with a total of 22,500 matriculated students, and the work is of University rank. They appear, in the main, to confine themselves to the various forms of Engineering, Building, Architecture, Mining, Metallurgy and Chemistry. In 1930, there were students studying Textile Technology at Charlottenburg, and a Department of Textile Engineering at Dresden. There is also a Department of Textiles at Köln University. Nevertheless it would appear that the " Technical High Schools " and Universities of Germany have not, up to the present, developed textile departments on quite the same scale as those for other industries.

5 **The cost of Textile Education.**

It is the duty of the municipality to provide the greater part of the money required to establish and maintain a Higher Trade School. In addition a grant-in-aid is paid by the state, which must be consulted before a new school is established. Thus, from the legal point of view, the municipality and the State are together liable for the upkeep of the school. In practice, however, it is usual for the municipality to APPLY to local industrial concerns and organisations for contributions in consideration of the training provided for their operatives and for the use of the Research Department which, as has been said, is often attached to the school. Voluntary contributions by industrial associations are, in fact, very considerable and may go some way to explain the comparative superiority of buildings and equipment in Germany. For instance, the Textile Associations and individual firms have borne the whole expense of equipping and maintaining

the very expensive laboratory at the Higher Trade School for the Textile Industries at Karlsruhe. The amount of the contribution and the objects to which it is applied vary from school to school and are treated as confidential matters, but it may be said that ordinary running expenses are materially assisted as well as extensions and improvements involving capital expenditure.

The Technical High Schools are provided by the State, but, here again, the industries are asked for voluntary contributions towards the provision of buildings and equipment and their response has been generous. At one time the Universities and Technical High Schools conferred honorary degrees on large contributors, provided that they had certain other qualifications and had deserved well of the industry, but it is understood that this practice is to be discontinued.

6. To give an indication of the general organisation of the work at a Higher Trade School, specimen full-time courses from the schools at Aachen, Cottbus and Greiz were appended to the report. Except in special cases, each course lasts for 21 weeks (*i.e.*, one half year, allowing for ten weeks annual holiday).

7. In addition to the full-time courses the Trade Schools conduct evening and other part-time classes for those actually in the trade. Generally speaking, however, these evening courses do not appear to be so long or so systematised as the corresponding courses in this country, a situation which is, perhaps, natural in view of the large volume of day training.

8. **Fees.**

The normal fee for a full-time course of 21 weeks is 110 R.M. (£5 10s.), and for a corresponding evening course, 15 to 25 R.M. (15s. to £1 5s.). The fees for foreign students are about five times as much.

9. **Premises.**

There is little doubt that the buildings of the larger trade schools in Germany are their most striking feature in contra-distinction to certain institutions of a similar nature in this country. At Aachen, Munchen-Gladbach, Cottbus and Reutlingen, the workshops are laid out on generous factory lines. The school-house containing the class rooms, assembly hall, etc., is, at least, in these instances, a striking and dignified building, and serves to prevent the business-like appearance of the workshops making the institution appear nothing more than the replica of a factory.

10. **Equipment.**

It has been possible to obtain particulars of the equipment at Cottbus, which are summarised in an Appendix to the Report. The school is noted for the thorough way in which it has been equipped to serve the WOOLLEN trade of the Lausitz district.

Hydrogen Ions. By H. T. S. Britton. Published by Chapman & Hall, London. Second Edition, 1932 (xvi-589 pp., with 124 figures. (Price, 25/-.)

There is no need to acclaim this as a very valuable work, since the first edition of June, 1929, has been sold out. The accurate control of acidity or alkalinity is now recognised as of immense importance in industry, and this new enlarged edition is to be heartily welcomed with its 74 additional pages.

The chief new feature of this addition is the inclusion of a chapter on the conception of " activity coefficients "—to take account of the increasing acceptance of the Debye-Hückel-Lewis Theory of Electrolytes. This has been contributed by Dr. R. A. Robinson. As Dr. Britton points out, however, it must be remembered that the explanation of the origin of the potential differences observed, in no way affects the great usefulness of the measurements in industrial control. It would be interesting to know how Professor H. E. Armstrong would write the subject matter of this book without recourse to the conception of ions and the mathematics involved.

Only six to seven pages are devoted to the textile and dyeing industries, but there must necessarily be much selection in a book which has already reached 500 pages, but it would probably require two volumes to deal adequately with all the applications of *p*H measurements. The best way out of the difficulty would

perhaps be for the author to elicit and edit contributions from industrial chemists. If only one book on the subject is to be purchased this is obviously the volume to choose. F.C.W.

Modern *p*H and Chlorine Control. W. A. Taylor & Co., 872, Linden Avenue, Baltimore, M.D., U.S.A. 50 pages.

This trade booklet gives an account of the Company's comparators for the colorimetric determination of *p*H. The first half of the brochure gives an excellent account of the meaning of *p*H, its determination by indicators, and its industrial applications. F.C.W.

Annual Report of the Society of Chemical Industry on the Progress of Applied Chemistry, 1931. Published by the Society of Chemical Industry, Finsbury Square, London. (12s. 6d. nett).

This report on the Progress of Applied Chemistry, which maintains the high standard of previous years, is especially valuable to the chemist who specialises in a particular section of chemical industry in affording a convenient summary of information on current work on various subjects, any or all of which may have a useful bearing on his own, yet which it is impossible for him to survey adequately through the ordinary literature channels.

The selection of matter most worthy of inclusion is perforce left to the judgment of the compilers and can be relied upon from these recognised experts in their respective subjects.

The Chemist associated with Textile Industry will find not only that the sections immediately concerned with Textiles and Textile processing are valuable summaries of recent progress, but also that the great majority of the 24 subjects reviewed will provide him with suggestions and hints significant with regard to Textiles.

The Report should be in the hands of every Textile Chemist and Engineer who is desirous of maintaining an up-to-date acquaintance with the contributions of Applied Chemistry to his own work. A.T.K.

Costing Problems in the Artificial Silk Industry. (In German). By Dr. H. Wilbert. Published by Julius Springer, Berlin, 1932. (105 pages. Price, 10 RM.)

In the introduction a short account of the history of artificial silk is given, dealing with nitrate, cupra, viscose and acetate artificial silk. This is followed by a few remarks on the economics of the artificial silk industry.

Section 1 deals with the basic principles of the costing problem in the artificial silk industry. A short account of the methods of production of viscose, cupra, acetate and nitrate artificial silk is given, followed by remarks on management and on methods of price calculation. This is followed by a discussion of the products of the artificial silk industry, the finished product, the by-products and the products recovered and the waste, also the methods of finishing, e.g., twisting, etc.

Section 2 deals with the general methods of costing taking into account all raw materials and accessories, including non-productive wages, etc. This is followed by the calculation on reckoning of the cost in detail, taking into account all fixed charges. In this part attempts are made to introduce mathematical methods of calculating the cost. In so far that certain items may be regarded as fixed charges, while other items obviously depend on production and denier, there is scope for the truly mathematical methods in dealing with spinning, twisting, and reeling. It is also clear that costs depending on the human element will not confirm to mathematical calculation, although good management should reduce the variability of cost due to the human element to a minimum. A considerable amount of detail is given in order to deal with methods of reducing the cost of manufacture of artificial silk. The possible methods of reducing the cost are considered such as selecting raw materials of suitable quality at a lower price, increasing the yield of finished product, reducing the time needed for processing, accelerating the velocity of machinery and shortening the pauses in working operations. In this section the increased power utilised when centrifuges are speeded up is taken into account. Finally, the possibilities of reducing the power costs are considered. While the mathematical treatment appears complicated, it is not really so, it is only the mass of detail which makes it appear complicated. The book should be valuable to all who have interest in the economical manufacture of artificial silk. W.H.

THE JOURNAL OF THE
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PROCEEDINGS

Annual Conference of the Institute

LEAMINGTON SPA, WEDNESDAY, THURSDAY, AND FRIDAY, 18th, 19th, and 20th MAY, 1932

Mayoral Reception, Wednesday, 18th May

The Annual Conference, held this year at Royal Leamington Spa, opened with a reception accorded to Members attending the proceedings by the Mayor, Alderman R F Bury, M R C S (Eng), L R C P (Lond), and Mrs Bury The Royal Pump Rooms were used for the event and afforded an opportunity for inspection of the baths for which Leamington is notable Refreshments and music were provided and contributed to an enjoyable evening

The Mayor, welcoming Members of the Institute to Leamington, expressed pleasure that the Spa had been chosen for the occasion and confidence that the beauties of the town and district would increase the pleasure and benefit to be derived from the visit

Replying on behalf of the Textile Institute, the President, Mr George Garnett, J P, said he was sure that Members, though assembled for a serious conference, were aware of the possibilities for pleasure and benefit to health which were associated with the town of Leamington Spa, the ladies, in particular, would undoubtedly be glad of the opportunity to see the places of beauty and interest with which the district abounded The Council of the Institute was sure that good work could be done in such delightful surroundings.

Mr Frank Nasmith, Honorary Secretary, who supported the President in thanking the Mayor for his welcome to Leamington, reminded those present of the references to the town made by Dickens, and added that he was sure that Members of the Institute would fully appreciate not only the visit, but also the cordial welcome extended by the Mayor.

Conference Proceedings, Thursday, 19th May.

This opened on Thursday morning, in the Town Hall, where two rooms were placed at the disposal of the Institute to accommodate a very full and comprehensive programme of papers on "The Testing of Textiles" The papers* read and discussed the first day were as follows :—

* The papers and discussions arising therefrom will appear in extenso in subsequent issues of the *Journal.*

ROOM 1 (10 a.m. to 12.45 p.m.).

(*a*) " An Instrument for the Measurement of Fibre Length," by W. Sever, M.Sc. (Department of Textile Industries, The University, Leeds). *Chairman :* Professor E. Midgley.

(*b*) " The Testing of Yarns for Levelness and Counts," by G. R. Stanbury, B.Sc., A.R.C.Sc., F.Inst.P. (Wool Industries Research Association). *Chairman :* Professor W. E. Morton.

(*c*) " The Testing of Yarns and Fabrics," by W. E. King, A.T.I. (The Technical College, Bradford). *Chairman :* Mr. J. H. Lester.

ROOM 2 (10 a.m. to 12.45 p.m.).

(*a*) " Apparatus for the Testing of Air Porosity," by Guy Barr, B.A., D.Sc. (National Physical Laboratory). *Chairman :* Mr. J. H. Lester.

(*b*) " Quantitative Determination of Cotton, Wool, Silk, and Artificial Silks in Mixed Textiles," by Professor Dr. P. Krais* (Deutsches Forschungsinstitut für Textilindustrie, Dresden). *Chairman:* Dr. J. C. Withers.

(*c*) " The Strength of Textile Fabrics and their satisfaction-giving Qualities in Conditions of Normal Use," by J. G. Williams, B.Sc. (Lond.), A.I.C. (Selfridge & Co., Ltd). *Chairman :* Mr. Henry Binns.

Excursion and Visits, Thursday, 19th May.

In the afternoon of the Thursday, Members went by motor coach to Coventry, where visits to works were made. Invitations to visit their establishments had been issued by Messrs. J. & J. Cash, Kingfield Works ; by the General Electric Co., Telephone Works ; by the Humber Motor Co., and by the Quinton Hosiery Co., and different groups of Members were conveyed to each. Tea was provided and the hospitality extended was much appreciated. The return journey was made via Warwick and a brief visit made to the historic Castle ; this part of the outing was unavoidably shortened as the preceding visits took longer than anticipated.

Dinner at Regent Hotel, Thursday evening.

Exactly one hundred Members, Ladies, and Guests sat down to a dinner held at the Regent Hotel. Among the guests were the Mayor and Mayoress, and the Town Clerk of Leamington Spa ; Sir William Noble (General Electric Company), and Dr. S. G. Barker, representing the Institute of Physics. After dinner, and interspersed between the Toasts, songs were contributed by Miss Dorothy Megeney (soprano), and Mr. Harry Whetter (tenor), both being accompanied by Mrs. F. Webster.

After proposing the Royal Toast, the President called on Mr. Henry Binns, Chairman of Council, to propose the Toast of " Our Guests." In doing so, Mr. Binns referred to the fact that Alderman Bury had been Mayor of Royal Leamington Spa for three successive years. He also welcomed Sir William Noble, who had that afternoon personally conducted a party over the works of which he was Managing-Director, and also Dr. S. G. Barker, who was so well-known in Yorkshire for his work as Director of the Wool Industries Research Association.

Replies to the Toast were made by the Mayor, who expressed his pleasure at being present and hoped that the event would be both enjoyable and profitable, and by Sir William Noble, who made reference to the present industrial position and expressed his confidence in a not-to-far-distant recovery of trade. He also said that he hoped the Textile Industries would secure their fair share of any improvement made.

Dr. S. G. Barker (Wool Industries Research Association), representing the Institute of Physics, proposed the Toast of " The Textile Institute," with which

* In the absence of Dr. Krais, this paper was introduced by the Chairman.

he coupled the names of the President, Mr. George Garnett, and those of the General Secretary, Mr. J. D. Athey, and the Editor, Mr. H. L. Robinson. In doing so, he said he felt that he comprised a glorious trinity of interests in that he fulfilled the threefold function of Physicist, Fellow of the Textile Institute, and also had the honour to be associated with the Wool Industries Research Association, all branches of textile and scientific activity which lay close to the heart and object of their common aims and existence.

On that occasion he deemed it a special honour to represent his own professional Institute, The Institute of Physics, from whom he brought cordial greetings and good wishes as from one member of the scientific family to another. His capacity therefore was that of " diplomatic relations," in that his personal pleasure was subordinated to his official duties.

" In the realm of textiles," continued Dr. Barker, " a field of investigation where almost every manipulation and process has a physical significance, there is unlimited scope for the science of physics. The achievements of Astbury and his colleagues in revealing the details of the intimate structure of textile fibres by means of X-ray analysis are of profound importance to us all, whilst I can say from inside knowledge, that the work of Stanbury and Marsh in our own laboratories, upon the more practical applications of physics to wool processes are not only of the highest scientific value but also of immediate practical utility to the industry.

" There are those in this country who ascribe limitations to textile activity within the world of wool, cotton, linen, silk and rayon, forgetting the wider issues embraced by jute, sisal, hemp, coir, and other coarser fibres, which I am sorry to say have been sadly neglected as regards scientific development and research. The Textile Institute would do well to remember this, for these more " democratic fibres " are of great economic importance to the British Empire and they meet definite requirements and needs of to-day. When one contemplates that every bit of wool is baled in jute (often we would like to forget it), and the many domestic uses of coir, etc., we should not pass lightly over their demands for consideration in a scientific manner. I therefore feel it permissible to draw your attention to achievements of physical and electrical science in the realm of fibres outside the usual run.

" Perhaps a little less recognised is the fact that in cocoanut fibre we have a commodity which is almost perfectly resistant to bacterial attack or to the ravages and deteriorations by exposure to seawater, atmospheric influences, or immersion in water or water-logged soil. In times past, its uses have been restricted by its characteristic brittleness, harshness, coarseness, and the difficulty of its extraction during long periods of retting. A recent discovery is of great importance in this regard. Not only can the retting period be reduced from months to hours, but the product, whilst maintaining or even enhancing the resistant powers of deterioration and the good colour of the fibre, is so softened that it can be handled upon slightly modified jute spinning and weaving machinery for manufacture into softer fabrics, capable of easy manipulation in the lapping for the protection of underground pipes against erosion, or of cables, etc., which undergo the attacks of deleterious influences in the course of their ordinary function. The process is as yet commercially undeveloped, but I have had the privilege of playing my part in its realisation along with a London colleague.

" Let us again consider another new discovery of the physicist which as yet has not attracted great attention but to my mind may do so ultimately. The recent issue of the Proceedings of the Physical Society records experiments in investigation of a phenomenon observed by a London Physicist, namely that drops of one electrolyte in another when subjected to the action of an electric field

exhibit the phenomenon of lateral spreading. A purely scientific piece of work, seemingly a far cry from textile application. Yet recently I have seen drops of viscose and of cellulose acetate, when subjected to similar treatment, attenuated into filaments up to six inches long and of fine denier, the contour of which is rough and uneven, thus rendering it more suitable than usual for admixture with wool. I would state, clearly, that it cannot equal wool nor is it even a passable imitation thereof, but it opens out a new phase in rayon manufacture. These were but typical examples of the scope of the physicist along paths which may seem unfrequented and unusual, but exemplify the truth that none can say what textile application and where or how it can be made, will follow even a remote discovery in physical science. In the wool industries you are already familiar with its achievements and it is not my intention to recapitulate what you are hearing in the excellent series of papers presented to this Conference. I want, however, to place before you to-night one or two ideas of the more general relationship of science to industry and incidentally to indicate the role of the Textile Institute in this regard.

" One often hears the statement that science knows neither nationalities nor geographical boundaries. This is true but in the world to-day, with industrial competition as it is, it would seem that applied science has, of necessity, adopted the slogan ' Love your neighbour, but don't cut the dividing hedge too low !" Be this as it may, the work of the Textile Institute is largely, at any rate, upon occasions of this sort, to invite us all to come out of our garden gates into the wide open spaces of knowledge, and to confer together upon a basis of scientific fraternity and equality in the search for truth.

" One is often asked to state the precise achievements of the Textile Institute or of scientific research in textiles, and in a more general way to enumerate the concrete benefits accruing from the introduction of science into our industries. It is a difficult poser to answer effectively, for much of the work up to date has been of a pioneer character and it must be remembered that good foundations, once well and truly laid, are rarely seen again. This, to me, sums up, much of the position of science in textiles as we find it to-day. We all realise that we are living in, we hope, abnormal times and although recognising that fundamental research will, in the long run, produce the best and biggest results, yet when our industries are calling out for immediate tangible aid in their present acute state of depression, an industrial laboratory such as that of the Wool Industries Research Association, or an Institute such as this connected with textiles, must pull its weight more definitely upon the side of immediate practical issues and concern itself more with the solution of the practical problems of the present in order to safeguard the future. These urgent needs of our Industry present the scientist with a formidable task which cannot be leisurely performed, for the call is immediate and urgent. It is said that the steepest ladder makes the shortest climb, and it seems to me that this is the lot of the industrial scientist under the present conditions of industrial development. If, therefore, we who are engaged in the application of scientific principles for the elucidation of industrial problems, in common with our fellow textile workers in the mills, are perforce of circumstances, having to aim at a realisation of what is immediately possible rather than what is ultimately ideal, we must not forget the latter in our anxiety for the successful accomplishment of the former. Patience and patents must ever be viewed in their proper perspective, for the exercise of the former, results in the speedier realisation of the latter. Let us, however, for a moment contemplate the world of science as a whole.

" The realm of physics, it will be admitted, has extended its boundaries in the last decade beyond the wildest dreams of imagination. To the ordinary individual, it has led perhaps to a sense of mental confusion and the establishment

of an inferiority complex as regards the understanding of science. This is a very disquieting feature of modern life and industry. Experts and experimenters in many fields, forming but an insignificant numerical minority of the world's population, are seemingly possessors of vast new knowledge, which is almost unintelligible to the great majority of people at the other end of the scale, who have neither the scientific training nor the time to grasp the full significance of the discoveries which are being made. We often forget that the world is mainly made up of ordinary people. We tend, therefore, to put our modern scientist on a pedestal, consider him as a Merlin of old, and accept his dicta almost as Holy Writ in an effort to save ourselves the trouble of thinking.

" Yet science is only a simple truth, which has a significance or application for each and every one of us, each new fact presenting a potential amenity for mankind which even the discoverer himself most often fails to recognise. It is the old story, the hen that lays the egg would never recognise the omelette made therefrom, nor would it be a good judge thereof. The omelette, however, is a success or a failure according to the skill and experience of the cook who makes it. Hence when the scientist is asked for a statement of the practical significance of his work he is being asked to prophesy what posterity may or may not do with his results.

" Nevertheless, the scientist is to-day faced with intensely practical issues for immediate solution and he must be ready and willing to essay an attempt to deliver a concrete consignment of goods now, and to use a current phrase, in a plain van, or in other words without frills and ceremony and not in instalments when vital commercial issues are at stake. In many phases of ordinary life we have got the instalment complex, but in handing out scientific results to industry, a single concrete fact now is valued more than a plethora of abstruse knowledge for future application. We must, therefore, aim at rendering immediate and definite help to our industries in their time of depression, so that when prosperity returns, opportunity will be given to us to promote those long distance fundamental researches, the results of which we fondly hope to realise.

" Where is science in industry to-day, and what is its influence upon the trend of modern social and industrial conditions ? C. E. M. Joad recently summarised his view of it effectively when he wrote ' nothing in modern civilisation is more remarkable than the disparity between our mechanical skill and our social wisdom, between our power over nature and the mentality which dictates its employment. Science has won for us powers fit for the gods.'

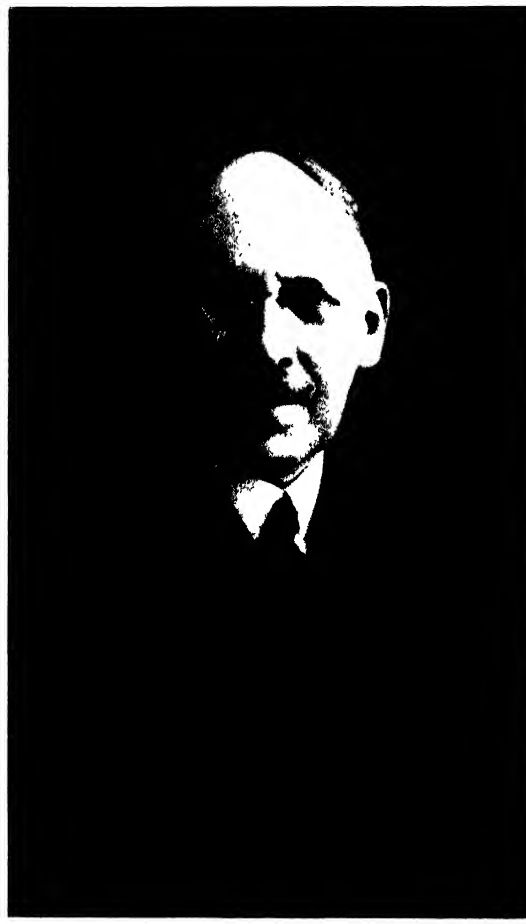
" What a challenge to us to seek to bring to their use an outlook and intelligence of commensurate breadth and status. Julian Huxley recently referred to ' that paradoxical modern situation, namely, the outrunning by science of all the rest of human nature.' We hear upon all sides of poverty of the individual in a world of plenty It would seem as though increased efficiency in applied science has led to over-production and yet this process of discovery goes on, and is going on, in the natural course of world evolution. Much of the trend of modern applied science dates its origin from the war period, and much, therefore, may be attributed to the aftermath of the war. Instead of swords being beaten into ploughshares, our chemists were concerned with rendering cordite and other cellulose derivatives into camisoles. If wool could be made explosive would it have received more attention ? It almost has seemed as though the world had one eye upon industrial development and the other on the possibility of some future world conflagration, for science and destruction almost became wedded during the war. Thus we find ourselves to-day in a world crying out for succour, seeking a correct diagnosis of its malady and expecting the scientist,

who did so well in devising powers of destruction, to show equal constructive ability in the prescription of a quick and effective remedy.

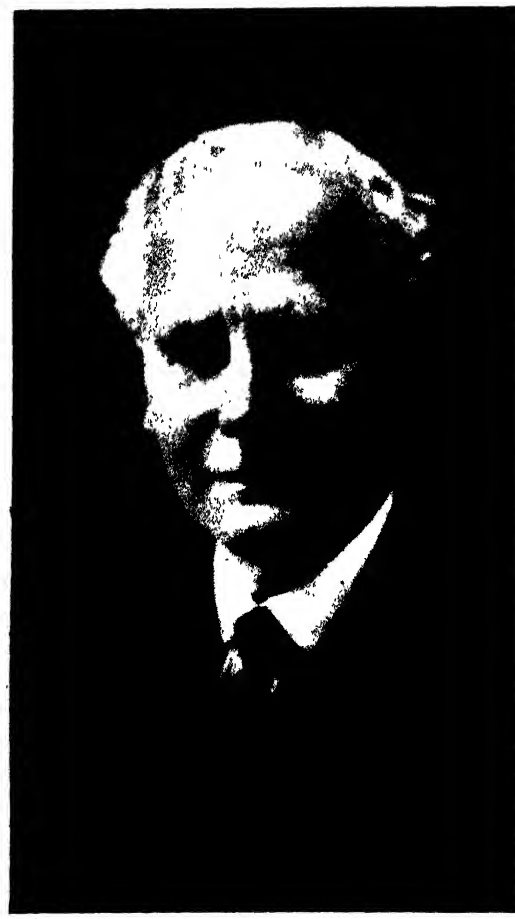
" The present state of affairs is glibly styled by some as the ' Golden opportunity of Science,' fondly hoping that science has not, as the result of post-war troubles, gone off the gold standard like everything else. We are face to face with the fact that a tired and weary world seeks, for its salvation in its bewilderment, men with powers it cannot define or comprehend. A world whose people are groping in the darkness of depression for someone to lead them to the light of prosperity, someone whom they can trust, hence they turn to the scientist in their quest, earnestly looking for guidance and direction to those who, at any rate, seek after the truth in nature.

" We are told by the croakers of this era, that our youth is on the decline, that the spirit of adventure is dead, and that the romance of discovery is a thing of the past. Little do they realise that the spirit which prompted our forefathers to set out on their voyages into lands unknown, returning with new amenities for mankind, has its modern counterpart in the spirit of restlessness and enquiry for the youths who to-day crowd our research laboratories, once more setting out upon voyages of discovery into the unknown realms of nature, returning as of old with new amenities for mankind and completing the work of their forbears by exploring to the full the potentialities of the raw materials, the presentation of which seems so wonderful in days gone by.

" ' An important fraction of the romanticism of to-day,' says Huxley, ' the spirit of rebellion against things as they are, is now canalised into pure scientific research.' This is the spirit of modern science and industry to-day, thus maintaining the old traditions of romance and adventure to the full The real application of science to industry, however, is by no means a simple matter, often presenting great difficulty, and great expenditure both of time and money before a successful bulk issue is obtained after satisfactory laboratory achievement. The investigator in applied science realises to the full the dictum of our friend the hiker, that ' when you have gone 19 miles out of the 20, you are about half-way.' It is the last mile that means so much, just as it is the last straw that hides the needle in the stack of knowledge. If science is to be successfully applied to industry, therefore, it is largely to the man in the mill that we must look for its complete accomplishment and adaptation, for we need his practical knowledge of processing and the handling of bulk materials. This being so, then it is essential that there should be workers in our factories capable of completing the tasks that science is setting before them. The provision of such men and women for the textile industries, and the creation of facilities for their training, is to me the paramount function of the Textile Institute, and further they should be assured of due recognition of their professional status, in other words, the corporate membership of the Institute should become a matter of greater practical significance. Thus the Institute has perhaps to preach to the personnel of our industries the doctrine of conversion to a more scientific outlook, for it is surely to such organisations as this that we look for such service. Tactful methods must be employed for such propaganda for it is recorded that an effort in this direction, made with the best of intentions, was met by the remark ' Convert us to a scientific outlook ! Conversion indeed ! What do you think we are, War Savings Certificates ? ' One other point to be remembered in the modern textile industry is that it should be emphasised that ' art ' must be wedded to ' science ' for possibly to-day the greatest attribute of a fabric is its aesthetic appeal. The Textile Institute must not forget this, for in the past the ' art ' of textile manufacture, in other words, the human element, was of paramount importance and its union with science must not mean degeneration of craftsman-



Mr WILFRED KERSHAW,
Awarded the Textile Institute Medal, May, 1932



SIR MICHAEL E. SADLER, K.C.S.I.
DELIVERED ANNUAL "MATHER" LECTURE, MAY, 1932.

ship or of the artistry of old, but the creation of a progeny which will be economic, utilitarian, artistic, and scientific.

" If science is to penetrate into our industries then the function of organisations like the Textile Institute is surely well defined, for a type of worker will inevitably be required, capable of that sense of scientific appreciation and application which is essential to progress. What a vista of useful work for the country is thus opened out to us in promoting the educational side of our meetings. Let us not fail to discharge our obligations in the matter, for to me, we have here presented to us opportunities for patriotic social service such as was outlined by H.R.H. The Prince of Wales, in his stirring call to the youth of the nation.

" There is one other point which I wish to commend to your attention, namely, I feel that if science is to be embraced into our industries, then we must see to it that the teachers in our technical schools have adequate recognition of professional status. I suggest that the Board of Education should be asked to recognise corporate membership of the Institute as a graduate qualification under the Burnham salary scale. Such an approach has already been made by the Institute of Physics and I see no reason why a similar procedure should not be tried for textiles.

" In a gathering such as represented here to-night, we meet as co-workers in industries possessing a wealth of tradition, bordering perhaps upon conservatism, which may prove either a deterrent or an incentive for future development, according to our method of utilisation of the vast pool of practical knowledge, born of experience, which has been accumulated in the industries themselves.

" We have got to face the future, whatever it may bring forth. Let us do so cheerfully by cultivation of a spirit of scientific appreciation and receptiveness, and whilst drawing upon the vast store of practical experience for our navigating skill in piloting the ship of textile industry through the more or less placid water of normal times, let us be ready for voyages of adventure into uncharted oceans, let us be prepared for sudden squalls and troublous seas of economic depression, and finally let us be ever watchful for unexpected tornadoes which may arise from unexpected quarters, shaking the very foundation timbers of the barque of our Industry, by utilising to the full the wider and new knowledge of industrial navigation which science so bountifully provides."

The President (Mr. George Garnett) replied. He was a colleague of Dr. Barker's at the Wool Industries Research Association, and was glad indeed to hear from him the heartfelt expression of what men of extremely scientific outlook really felt when they were up against the industrial situation, and who were believing that science could help industry. Perhaps the more quickly a favourable attitude was adopted to their proposals the better it would be for the industry. Dr. Barker had made eulogistic remarks regarding the position of the Institute in relation to science. Twenty-one years ago its founders believed that the Institute could render services to the trade that were needed and some of them had been deeply interested in research and investigatory problems. When these got too costly for them they transferred them to the new industrial Research Organisations dealing with these specific researches. They did not claim to have originated the Research Associations but they claimed to have applied stimulation in that particular direction, and so they believed, with Dr. Barker, that many foundations well and truly laid were underneath and only seen on rare occasions.

" The Institute's function to-day," continued the President, " is firstly the stimulation of self-education. Secondly, it tries to deal with the development of industry in its sounder and more scientific construction, and thirdly, it has given not only to the industry, but to the nation, a tremendous amount of valuable work entirely wrought by the self-sacrifice of those who associate themselves with the different committees of the Institute. In this way we are securing

recognition, but it is rather on the educative and technical sides we are developing than the scientific.

" The papers that we have heard to-day and shall hear to-morrow, are precisely of the type that we wish to be associated with an Institute Conference. They are strengthening our individual usefulness to the industry by helping us to make more perfect, more saleable textiles and incidentally, as the author of one of the papers this morning pointed out, we are enabling the trade to recognise intrinsic merits and saleable qualities. The salesman of such fabrics may tell his customer over the counter that these goods are really reliable. That is not only good morality, it is good business."

" We are claiming," he continued, " to play a definite part in the mental as well as in the technical reconstruction of our Textile industries and that we are contributing something that no other society is doing. It is indispensable to the welfare of the trades we serve that we gather around us collaborators who are generous in outlook, giving freely and willingly everything of their best. In this way we shall continue to grow, and grow in a manner that will make us more and more valuable. We know that we have a great deal of very hard work still in front of us to convert our colleagues who are heads of industry to accept the point of view that we emphasize so much, and it is with that view in mind that we decided to establish an important new branch of Institute function : the work of the Information Bureau, in which we shall hope to get the hearty co-operation of the Industry's leaders.

" Finally, I have a great belief and confidence in the mind and purpose of Britishers. I do not think any nation recovers more quickly, as circumstances permit, than what we do. I believe that as profits of industries can be secured the workers shall have a reasonable share of them, but they must also take reasonable responsibility. If we inculcate sound principles of science in industry, which is, after all, the greatest thing in the country, the Textile Institute will have a great part to play. It will play that part because of the voluntary service which is being offered freely—if that spirit is maintained it will live and serve a useful purpose."

Presentation of the Institute Medal.

After the completion of the Toast list, described above, the ceremony of presentation of the Medal of the Institute to Mr. W. Kershaw (Fellow), of the Bleachers' Association, took place.

Dr. J. C. Withers, introducing Mr. Kershaw, said that at the age of 22 he was already a works manager which fact redounded to his credit. He was what they called in the West country an exceedingly knowledgeable man. There was scarcely a question in textiles that was up-to-date about which Mr. Kershaw was not already informed ; he had found that through some years of acquaintance with him. He would suggest that he set among workers in textiles a notable example. Mr. Kershaw was a great student of technical literature. He did not let anything pass. He had won for himself in his own field a very prominent position and his advice was sought by many departments in our Textile Institute Councils and he also served on Advisory Committees of the British Cotton Industries' Research Association. He was on the Committee of the Manchester Municipal Technical College, and advised the City and Guilds of London Institute, but the work for which they honoured him that evening was the work he had done and was doing for the Textile Institute. He had been for many years a member of the Competitions Committee and had done great service there. He had been a member of the Library Committee since its formation, and of the Finance Committee, and at present was chairman of what was perhaps the most vital committee of all, the Publications Committee. He could personally testify to the great work

that Mr. Kershaw had done as Chairman of that committee, having had some personal experience of the work of the committee and having served on the committee under his guidance for some time. It was not only at Institute headquarters that Mr. Kershaw had helped them, but he had made pilgrimages to the branches and local sections and had done great service indeed for the Institute in pleading those things the members of the council felt most closely and felt should be pleaded most—that was the maintenance of the Institute as a scientific textile body.

The President, handing the Institute Medal to Mr. Kershaw, said: "We ask you to accept this as some token of our high regard for you in appreciation of the services you have rendered us from time to time. May you live long to enjoy it."

The President then handed the medal to the recipient who thanked him and the Council of the Institute, saying :—

"Mr. President, Ladies and Gentlemen: Please allow me to offer my very warmest thanks for this evidence of the Institute's appreciation of the services of a Member. I value the award all the more because it has come quite unexpectedly. It has always been a peculiar pleasure to take some part in the activities of the Institute and thereby to participate in the great volume of voluntary effort ungrudgingly given by so many of its Members. This spirit of unselfish service has always been, and will I hope continue to be, a most important factor in the success of the Institute. No small part of the value which I shall attach to this award will refer to the fact of the association of my name with those of other medal holders who have so eminently merited the award.

"Of my many activities on behalf of the Institute I am particularly interested in the work of the Competitions Committee and the Publications Committee. It must be very gratifying to Mr. John Crompton, who set such a notable example, to see the interest that is taken in the prize scheme. We are hoping for an extension to the scheme and this year, for the first time prizes will be given for knitted fabrics. Let us hope that the efforts of our Yorkshire members, who have the matter under consideration, will result in a substantial addition to the prize fund.

"I make no apology for referring here to the work of the Publications Committee. As Chairman of this Committee I sometimes feel a heavy responsibility. The production of the *Journal* to meet the requirements of all sections of the Industry, and all shades of opinion, is a heavy task. The work done by this Committee is of the utmost importance, and it is essential that the standard of the *Journal* should be a high one. To my mind there is no Textile Journal in the world which comes near the standard set up by the *Textile Institute Journal*. I read textile literature most comprehensively, and am confident that my statement is correct. You are familiar with its format—General Proceedings, Transactions and Abstracts.

"The results of fundamental research, published in the Transactions section, are of extreme importance, and before they are submitted for publication they have been criticised and refereed by acknowledged authorities.

"The Abstracts section is also a valuable feature, being in essence a world survey of textile work, and if used in an intelligent manner, keeps one fully acquainted with the progress and developments taking place in all sections of the textile industry throughout the world which is necessary alike to the student, technologist, administrator, and research worker. The General Proceedings section is under review at the moment and it is hoped to make this section of still greater interest."

He emphasised this important voluntary service which was a distinct service to the textile industry, and in particular a help to those commencing their careers—who would one day take up leading positions.

Conference Resumed on Friday, 20th May.

The Town Hall was again used for the reading and discussion of papers* as follow :—

ROOM 1 (10 a.m. to 12.45 p.m.).

(*a*) " Detection and Estimation of Chemical Damage in Wool," by Professor Dr. P. Krais** (Deutsches Forschungsinstitut für Textilindustrie, Dresden). *Chairman :* Dr. J. B. Speakman.

(*b*) " Chemical Tests in the Wool Industries," by E. Hill, F.I.C., A.R.C.Sc. (Wool Industries Research Association). *Chairman :* Dr. J. B. Speakman.

(*c*) " Testing of Linen Fabrics from the point of view of their Uses," by J. A. Matthew, M.Sc., A.R.C.Sc. (to be read by W. H. Gibson, O.B.E., D.Sc., Linen Industry Research Association). *Chairman :* Mr. W. Kershaw.

ROOM 2 (10 a.m. to 12.45 p.m.).

(*a*) " The Significance of Results in Textile Testing," by F. P. Slater, M.A., M.Sc. (Research Department, Fine Cotton Spinners' and Doublers' Association). *Chairman :* Dr. A. J. Turner.

(*b*) " The Testing of Laundered Fabrics," by R. E. V. Hampson, D.Sc. (British Launderers' Research Association). *Chairman :* Dr. W. H. Gibson.

(*c*) " Faults in Piece Dyed Woollen and Worsted Materials," by L. L. Lloyd, Ph.D. (Bern), F.I.C. (The Technical College, Bradford). *Chairman :* Mr. F. Kendall.

After lunch the conference was resumed and the following papers read and discussed :—

ROOM 1 (2 p.m. to 3 p.m.).

(*d*) " The Standardisation of Testing of Hosiery Yarns and Knitted Fabrics," by J. Lomax, F.I.C. (Testing House, University of Nottingham). *Chairman :* Dr. A. W. Stevenson.

ROOM 2 (2 p.m. to 3 p.m.).

(*e*) " Commercial Strength Standards for Linen Yarn and Fabrics," by W. J. Cowden, F.T.I. (City and County Borough of Belfast Public Testing House). *Chairman :* Mr. H. C. Barnes.

Annual Mather Lecture, Friday, 20th May.

This lecture was delivered by Sir Michael E. Sadler, K.C.S.I., Master of University College, Oxford, in the Council Chamber of the Town Hall. The President, presiding, at the meeting, welcomed the lecturer and expressed on behalf of the Institute the warmest appreciation that Sir Michael had consented to deliver the " Mather " lecture of the Institute. The lecture was then delivered as follows :—

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* To appear *in extenso* in subsequent issues.

** Presented by title in the absence of the author.

LIBERAL EDUCATION AND MODERN BUSINESS

By Sir Michael Sadler, K.C.S.I.
(Master of University College, Oxford.)

I

If you take up an old book which describes the course of a liberal education and tells the reader what good effects may be expected from it in later life, you find that the writer has in view a small number of professions towards the needs of which his plan of school and college instruction is exclusively directed. He thinks of the sacred ministry : he thinks of the law : he thinks, generally, though not always, of the medical profession : he thinks invariably of the affluent gentleman with his home in the country and some touch with the town : he thinks of the soldier : he thinks of the statesman : and, with a flourish in the final chapter, of the education of a prince. But he has nothing to say about the boy or young man who is going into business as a merchant or as a tradesman or as an employer of manual labour.

If one had asked him why he left these callings out of account, he would have been puzzled. Already in the Seventeenth Century, many younger sons of county families were going into business. In the Eighteenth Century, trade and commerce had demonstrably become the backbone of English prosperity. And in 1808, when Richard Lovell Edgeworth wrote his *Essays on Professional Education*, the Industrial Revolution was already in full swing. But in almost all the books about liberal education, business was ignored. There were two reasons for this. Business as such had not yet claimed its share in a liberal education. And the writers of the books followed convention in leaving business out.

To this convention there were three outstanding exceptions. John Locke, in 1692, wrote a book about education " suited to our English gentry." " If his mistaken parents," he wrote (page 550) " frightened with the disgraceful name of trade, shall have an aversion to anything of this kind in their children, yet there is one thing relating to trade which, when they consider, they will think absolutely necessary for their sons to learn. . . . I would advise all gentlemen to learn perfectly merchants' accounts and not to think it is a skill that belongs not to them because it has received its name from men of traffic."

In 1760, Joseph Priestley wrote : " It seems to be a defect in our present system of public education that a proper course of studies is not provided for gentlemen who are designed to fill the principal stations of active life, distinct from those which are adapted to the learned professions. We have hardly any medium between an education for the counting house, consisting of writing, arithmetic and merchants-accounts, and a method of institution in the abstract sciences : so that we have nothing liberal, that is worth the attention of gentlemen, whose views neither of these two opposite plans may suit." He set himself therefore to plan and to give at Warrington " A course of liberal education for civil and active life "—for those, among others, who " in the business of merchandise " would " look beyond the servile drudgery of the warehouse or counting-house."

Locke, when he wrote on education, was living in Holland. And in Holland, he saw how valuable in commercial life is a wide and generous education. And Priestley, a nonconformist, wrote with direct experience of the culture of many men of business who had been excluded by religious tests from the then narrow conventions of an English university education.

The third writer whose eyes had been opened to the claims of business to a share in liberal education was headmaster of Tonbridge School, which owes much to the Skinners Company in London. In 1781 Vicesimus Knox prefaces his book

on " Liberal Education, a practical treatise on the methods of acquiring useful and polite learning " with a significant tribute. " To the honour of the commercial orders in the community," he wrote, " it must be remarked that, amidst the avocations of lucrative pursuits, they have usually paid attention to the state of literature, and have greatly contributed to the diffusion of polite learning, by expending the superfluity of their opulence in literary establishments. . . . The many instances of the English citizen's generosity in building and enriching schools and colleges, and in affording exhibitions for the maintenance of studious youth at the universities, seem to prove the error of an opinion very generally received that a laborious attention to trade renders the sentiments mean and narrow."

The men, who more than any others in England, brought many English business families into the main stream of liberal education were the Hills of Birmingham and their contemporary, Thomas Arnold of Rugby. But the old convention, which confined the idea of a liberal education to certain privileged callings, continued strong. It left its mark on two of the best English books on educational aims : on the *Essays on a Liberal Education*, edited by F. W. Farrar, in 1868, with contributions from Henry Sidgwick, Edward Bowen of Harrow and W. Johnson of Eton, and on Henry Latham's book published in 1877, *On the Action of Examinations considered as a Means of Selection*. And the Dictionary of National Biography is more generous in its recognition of clergymen, lawyers, medical men, schoolmasters and writers than of men eminent in commerce and industry.

II

But during the last sixty years, business careers have risen rapidly in social prestige. The change is world-wide—conspicuous in the United States, in Great Britain, in Western and Central Europe, and significant in India and Japan. The change is due to applied science, to rapidity of communication and to the growing urgency of economic questions in national policy and in international affairs. Along with this change, the age of entry into business has risen and the qualifications for employment have become more exacting. Consequently, the requirements of a business life now exert a potent influence upon every grade of school and also upon universities. This change has affected our ideas of a liberal education. The old meaning of the word has been expanded. A liberal education is now designed not only as a specific preparation for a limited number of learned professions, but also as a training for various forms of business life. Its aim is to give the mind freedom. But this freedom can only be achieved through an exacting discipline—both of the body and of the understanding.

In these Islands, the connection between a liberal education and business life became strong in Scotland sooner than in England. In Europe as a whole, Germany led the way. And all Western European countries, though France less than the others, have felt the influence of educational movements in the United States.

Thus a change in the traditional conception of a liberal education has accompanied a great change in social outlook and social conditions. This has happened three times before in European history. It happened in the time of Aristotle : it happened in the early middle ages : it happened in the time of Humanism. And it is happening now. As always, the change is slow. There are spots of rapid change, but the movement as a whole is gradual. Education, by its nature, is largely and solidly conservative—conservative with bright streaks of adventurous experiment. It changes under a mask of continuity. One reason why the old order persists far into new conditions is that many parents think—not inexcusably—of the advantage their sons will enjoy by becoming

members of schools which deservedly enjoy a high social reputation. Another reason is that an ancient educational tradition has well-tried tools which have been shaped by centuries of experience and are not equally at the command of those who justly advocate the educational claims of new subjects. In England, and to some extent in Scotland and Ireland, and markedly in France and in Germany, the growth of the Government Services has indirectly helped in maintaining the hold of the older educational tradition. In France and Germany for more than 100 years, in Great Britain for more than half a century, the public services have been recruited by some form of examination based upon established school curricula. For nearly two generations up to the War, the public services became, for the middle and upper middle classes, the career which competed for brains with business. The tests for admission, different as they were in Great Britain, in France and in Germany, gave preference in all cases to candidates who had been trained on the authorised and more traditional lines. The tests were designed to secure what was believed to be, and truly was, an intellectual élite. But the élite which these tests secured and rewarded was not exactly the same élite which the leaders of business would have taken for their own service.

III

These, however, are but temporary retardations of a strong current which has set towards change. Something fundamental in the readjustment of our ideas about a liberal education is indicated by the drift of thought and by the pressure of events. The thunder of an educational revolution is rumbling in the distance, and we can see two storms coming up from opposite quarters of the heavens.

First let us take the revolutionary ideas of D. H. Lawrence. They are clearly, passionately, stated in his *Fantasia of the Unconscious* (1923) :

> " Knowledge must be put into its true place in the living activity of man. . . . So a new conception of the meaning of education. Education means leading out the individual nature in each man and woman to its true fullness You can't do that by stimulating the mind. That which sublimates from the dynamic consciousness into the mental consciousness has alone any value. This, in most individuals, is very little indeed. So that most individuals, under a wise government, would be most carefully protected from all vicious attempts to inject extraneous ideas into them. Every extraneous idea, which has no inherent root in the dynamic consciousness, is as dangerous as a nail driven into a young tree For the mass of people, knowledge must be symbolical, mythical, dynamic. This means you must have a higher, responsible, conscious class : and then in varying degrees the lower classes, varying in their degree of consciousness.
>
> " General education should be suppressed as soon as possible. We have fallen into a state of fixed, deadly will. . . . To save the children as far as possible, elementary education should be stopped at once. No child should be sent to any sort of public institution before the age of ten years. If I could but advise, I would advise that this notice should be sent through the length and breadth of the land.
>
> " Parents, the State can no longer be responsible for the mind and character of your children. From the first day of the coming year, all schools will be closed for an indefinite period. Fathers, see that your boys are trained to be men. Mothers, see that your daughters are trained to be women.
>
> " All schools will shortly be converted into workshops or gymnasia. No child will be admitted into the workshops under ten years of age. Active training in primitive modes of fighting and gymnastics will be compulsory for all boys over ten years of age.
>
> " All girls over ten years of age must attend at one domestic workshop. They may, in addition, attend at one workshop of skilled labour, or of technical industry, or of art.
>
> " All boys over ten years of age must attend at one workshop of domestic crafts, and at one workshop of skilled labour, or of art. A boy may choose, with his parents' consent, his school of labour, or technical industry or art, but the directors reserve the right to transfer him to a more suitable department, if necessary, after a three months' probation.

> " It is the intention of this State to form a body of active energetic citizens. The danger of a helpless, presumptuous, newspaper-reading population is universally recognised.
>
> " All elementary education is left in the hands of the parents, save such as is necessary to the different branches of industry.
>
> " Schools of mental culture are free to all individuals over fourteen years of age.
>
> " Universities are free to all who obtain the first culture degree.
>
> " Our process of universal education is to-day the most terrible menace to the existence of our race. We seize hold of our children and by parrot compulsion we force into them a set of mental tricks. . . . Instead of living from the spontaneous centres, we live from the head.
>
> " Why should we cram the mind of a child with facts which have nothing to do with his own experiences and have no relation to his own dynamic activity Every idea which is introduced from outside into a man's mind and which does not correspond to his own dynamic nature, is a fatal stumbling block and is a cause of arrest for his true individual activity and a derangement to his physic being.
>
> " Let us substitute action, all kinds of action, for the mass of people, in place of mental activity. Even twelve hours' work a day is better than a newspaper at 4 in the afternoon and a grievance for the rest of the evening.
>
> " With the boys, first and foremost, establish a rule over them—a proud, harsh, manly rule. Make them know that at every moment they are in the shadow of a proud, strong, adult authority. Let them be soldiers, but as individuals, not machine units. There are wars in the future, great wars, which not machines will finally decide, but the free, indomitable life spirit. . . . Wars in the strength of individual men. And then, pure individualistic training to fight, and preparation for a whole new way of life, a new society. Put money into its place, and science, and industry. When the leaders assume responsibility, they relieve the followers for ever of the burden of finding a way. Relieved of this hateful incubus of responsibility for general affairs, the populace can again become free and happy and spontaneous, leaving matters to their superiors. No newspapers—the mass of the people never learning to read. The evolving once more of the great spontaneous gestures of life.
>
> " We can't go on as we are. The secret is to commit into the hands of the sacred few the responsibility which now lies like torture on the mass. Let the few, the leaders, be increasingly responsible for the whole. Leaders—this is what mankind is craving for. Let the mass be free—save for the choice of leaders. But men must be prepared to obey, body and soul, once they have chosen the leaders.
>
> " We can't go on as we are—poor nerve-worn creatures, fretting our lives away."

There is authentic passion in this. But also the frenzy of a disordered judgment. What Lawrence wrote in this book about the future of education is cloudy, but ominous. That he should have written it, that he should have felt so strongly with his experience of his boyhood in the English midlands in his mind, is a presage of coming storm. His psychology, the psychology on which his argument seems to rest, is weird, incomplete, not subtle enough for the facts of life. His political outlook is confused. Leaders, Yes. But who shall elect the leaders ? The people. And how elect ? To what verdict of the public would such violent factions submit ? And how shall the leaders enforce the obedience which Lawrence regards as the fundamental necessity ? And what new order of society shall men obey ? Lawrence, like Thoreau, looks back on a golden age which never was. He writes with a mirage in his mind. He misreads human nature. He does not analyse freedom or discipline. He stakes everything on a kind of goodness which exists indeed in most human beings, but would quickly be trampled under foot in the cruel struggles of coercive and predatory revolution. He does not provide for the curbing of the recalcitrant ; for the discipline of the refractory. His mind flickers between a hope for human peace and anticipation of constant war. And when he elaborates his educational programme he proposes something which would, for its effective realisation and maintenance, cost far more than the present system of primary and secondary

education. He glosses over the difficulties, the ambiguities, of his solution. But he wrote with intense reality of passion, and with an overwhelming disbelief in the smooth fallacies of mere educational veneer. He sees that somehow or other intellectualism is in itself no remedy for the discontents of man.

In the meantime, in the opposite quarter of the heavens, another storm brews. Mr. H. G. Wells in *The Work, Wealth and Happiness of Mankind* (1932)—a thrilling, glamorous book—has little good to say of education as, in the main, now organised and given. "We have to restore unifying power to education," he writes (page 731). "We seek a new education to achieve the synthesis of the new world community. But if we are seeking to frame out a new education in view of the new ways of living that open before us, we are thereby and at the same time starting religion anew. . . . Our world is now launched upon a perpetual investigation and innovation. The ideal of education is no longer the establishment of a *static* ideology but the creation of a receptive and co-operative alertness."

His view of what may be and should be, in its stress on the value of intellectual generalisation, is the converse of D. H. Lawrence's. "Reading and writing," Wells writes, "involved the penetration of general ideas into a majority of minds that had hitherto been untouched by them. Instead of certain instructed and privileged classes, the whole community is now accessible to wide general ideas and capable of incalculable interventions in the economic and political organisation." What Lawrence loathed and would stamp out, Wells welcomes and would diffuse. "The broadest ideology may appear now in action at any level in the social body. The educated persona which dominates the public services more and more, which has permeated even into the militant services, is now infecting and changing both the entrepreneur and the worker. The sense of service is spreading; it is becoming an ingredient in a growing proportion of personas. We are visibly moving towards an entirely literate and disciplined world, more and more clearly informed about its origins and its destinies. The civilised world-state of the future will develop and can only develop in correlation with that spread of the educated persona. . . . The motive of service must replace the motives of profit and privilege altogether" (page 718).

The excitement with which one reads Mr. Well's book is the excitement of hope. He has the gift of encouragement. And one feels exhilaration at the wide range of the facts and forces which he brings into his vivid picture of the labour and conquests of mankind. The education in which he sees the hope of the world is a jet of stimulus and detergence behind which is the vast pressure of aeons of growth, struggle and achievement. All the past is focussed in what he would have education become. All that he can divine of the future defines its aim. But when one thinks next morning over the glowing picture which entranced one in his pages the night before, a cold shadow of fear passes over one's thoughts and one finds oneself questioning whether Mr. Wells does not foreshorten his perspective, and under-estimate the weight and viscous resistance of national habits and customary preoccupations. Mr. Wells admits the need for stringent discipline—but he is very sanguine about its remedial effects. He allows for recalcitrancy but is very hopeful about individual lasting reformation. On one point he differs fundamentally from D. H. Lawrence. But a sentence in Mr. Wells' book (page 755) makes me pause before I touch on it. "Nothing is more amazing," he writes, "to the enquiring and intelligent humble than the realisation of the intellectual sloppiness and defensiveness of the academic dignitary." It is not a *tu quoque*, I hope, if I suggest that when some very intellectual people look out on the world they are prone to see in every kind of men and women, of whatever type, race and colour, a reflection of their own tastes and interests and predilections—rudimentally undeveloped perhaps, but fundamentally identical. I doubt whether the average man is naturally so

predisposed to the intellectual relish of life as Mr. Wells assumes. And I doubt whether ideals, if healthily come by, are as deleterious as Mr. Lawrence declares to the morale and mentality of the average man.

But a liberal education in its content and spirit is always coloured by the presuppositions and expectancies prevailing in the social order out of which it springs. It is also sensitive to every change. And if either Mr. Lawrence's prognostications are sound or Mr. Wells' blue print designs feasible and practically prophetic, the practical inference is that we English will be wise not to go too quickly at present in fundamental educational reorganisation. The forecasts are too conflicting.

IV

And even more menacing than the vision of Mr. D. H. Lawrence is that of Mr. Middleton Murry. He scouts Mr. Wells' internationalism because it is " bourgeois underneath." In *The Necessity of Communism* (1932) he declares (page 70) that " a world of efficient capitalism, which is what Mr. Wells desires, is a contradiction in terms." It would lead to another and vaster catastrophe. " The world to-day has reached a climacteric. . . . Communism is a religion. It demands all we have, and all we are. And because it dares to demand this, it is invincible." " In my heart," he says, " I believe that England is capable of such sacrifice as the world has never known in a nation. But no one dares to demand it. . . . The immediate aim of the conscious Communist is to make the impulse to resistance, which is the impulse to revolution, conscious in those in whom it is instinctive. . . . The real meaning of the revolution, which must come, is nothing less than a complete economic change—the complete extirpation of the system of individualistic capitalism."

" It is quite conceivable that we intellectuals will not survive. It cannot be helped. There is only one way to endow ourselves with survival value—to be ready to sacrifice our all.

" To cling to the past is forbidden. That of the past which lives is living in ourselves. The past to which we feel the need to cling as to something other and more solid than ourselves is the dead past. No matter how noble or precious it appears we shall find that in so far as it serves to hold us back from complete surrender of ourselves to the communist ideal of utter disinterestedness, it is the mask of interest not the vehicle of value."

In Mr. Middleton Murry's book there is fire : the fire of a new kind of religious enthusiasm. He flames out against capitalism and the bourgeoisie as the Covenanters flamed out at the Pope. Feeling respect for this intensity of his belief, I for one regard its political aim as misguided and misleading. And I have no wish to change my religion for his.

But he is not alone. The dominant regime in Russia has acted on his principles. And our judgment of what liberal education should aim at—most of all liberal education for those engaged in or entering upon business life—depends on our attitude of mind towards this communist ideal and policy. " In a capitalistic society," writes Kautsky, " the proletariat cannot achieve equality or social liberty. As a consequence it ought to assume a hostile attitude towards the existing state of society and to be bent on the reorganisation of society as a whole. In other words it is bound to be revolutionary. It is for this reason that the proletariat demands a complete and definite theory of human society so that it may determine how to reorganise every social institution. The necessity to base oneself on the authority of a theory—a necessity which has disappeared among the bourgeoise ever since the bourgeoisie became reactionary—is affirming itself more and more strongly among the proletariat as a direct consequence of the proletariat's special position as the revolutionary class." How this doctrine

has affected Russian architecture is shown by the programmes of the architectural groups quoted by Mr. B. Lubetkin in this month's *Architectural Review* on the Russian Scene. The doctrine challenges the family, individual freedom of thought, institutional religions of the older types, and the still prevailing conceptions of a liberal education. It is ferocious but, I believe, built on an imperfect foundation and doomed, in the long run, to failure, disillusionment, and collapse.

We in England are right, therefore, as I conceive the situation, in sticking steadily to the middle way in our educational policy. We listen to the arguments shot at us from the two extremes on either side of us. We are ready to learn from each. But we feel our way along a middle road, unconvinced by the extreme theories which are pressed upon our attention, not deaf to them nor unobservant, but prudent and unrattled. The present outcome of English liberal education as we know it is *steadiness of mind.* This is the best cement we can have in an age of temporary disintegration. Our judgment is sensitively empirical. No one can wisely ask for more. We value doggedness. " It's dogged that does it." A liberal education is an education for liberty. And the liberty we enjoy we are ready to give to others. We do not want in England an atmosphere of espionage.

V

In England during the last thirty years there has been a wider extension of opportunity for a liberal education than in any like period in our history. And the change has been in accordance with social requirement, psychological thought and economic need. We think of a liberal education as something that may in the end be so widely diffused as to become a general possession. We no longer regard it as a deposit of culture guarded by a limited number of favoured beneficiaries. Oldnotions of its being in the main a class privilege have faded. We think of it as an atmosphere in which all the relationships of life may take on a deeper meaning and lose much of the monotony or staleness of routine.

A liberal education is not a veneer of culture. It gives a heightened awareness of truth, of beauty, of the connexion between things seemingly discrete, of the significance of human life and of its swift eclipse, of the deep undertones of duty and of the unfathomable reality in simple things. Its best outcome, as Mr. John Cowper Powys says in his excellent book, *The Meaning of Culture* (p. 293) is a " sweet-natured, considerate, courteous, and compassionate disposition" and it never forgets that these qualities may " co-exist with the most rudimentary education."

And in respect of knowledge its aim is, as Locke wisely said, " not to perfect a learner in all or any one of the sciences, but to give his mind that freedom, that disposition, and those habits that may enable him to attain any part of knowledge he shall apply himself to, or stand in need of, in the future course of his life."

Therefore a liberal education begins in infancy and can be carried on into old age. It is a discipline of body, mind, and spirit: a discipline which is not individual only but also communal. Its presence is not signified solely by any label, certificate, or academic degree. It does not mean the absorption of inert ideas as necessary for an examination. It is evinced in an attitude of mind liberated both from apathy and from self-will, in an attitude of mind towards work, duty, and the realities of belief. Therefore there are blended in it freedom and strict discipline; drudgery and diligence; the education of the body and the education of the mind; training by others and self-training; science and letters; questioning and awe; preparation for livelihood and for leisure.

Thirteen years ago when I was in India as President of the Calcutta University Commission, my colleagues asked me to write a description of the earlier stages of a liberal education and were so good as to accept what I wrote, though they wisely added to it an allusion, suggested by Sir Philip Hartog, to what he called " the intellectual conscience." What I wrote, with that addition, is the following :

" A liberal education should be given under conditions favorable to health. The body should be developed and trained by systematic and vigorous exercise. The eyes should be trained to see, the ears to hear, with quick and sure discrimination. The sense of beauty should be awakened. The hands should be trained to skilful use. The will should be kindled by an ideal and hardened by a discipline enjoining self-control. The pupil should learn to express himself accurately and simply in his mother tongue. Through mathematics he should learn the relations of forms and of numbers. Through history and literature he should learn something of the records of the past ; what the human race (and not least his fellow-countrymen) have achieved ; and how the great poets and sages have interpreted the experience of life. His education should further demand from him some study of nature and should set him in the way of realizing both the amount and the quality of evidence which a valid induction requires. Besides this it should open windows in his mind, so that he may see wide perspectives of history and of human thought. It should also, by the enforcement of accuracy and steady work, teach him by what toil and patience men have to make their way along the road to truth. Above all, a liberal education should endeavor to give, by such methods and influences as it is free to use, a sure hold upon the principles of right and wrong. It should arouse and enlighten the conscience, the intellectual conscience and the moral. It should give experience in bearing responsibility, in organization, and in working with others for public ends, whether in leadership or in submission to the common will."

This view of the realities of a liberal education implies that its most critical stage lie in the earlier years of a pupil's training and that we are right not to have remained content with the old meagre notions of an elementary education. In the training of young children, all the elements of a liberal education are in solution.

This definition also stresses the paramount necessity of inculcating the habit of hard work, of requiring accuracy, and of training children and young people to bear hard things.

Also it leads up to the conviction that a liberal education cannot be completed at school or college but is a discipline of life and is carried on by study and through the stimulus of varied experience in adult years.

It is also in accordance with the temper of a free self-governing nation. As Ruskin said, " I believe every man in a Christian Kingdom ought to be equally well educated." This paradox does not mean that he thinks all men equally gifted or equally educable. The opposite was his belief. But he has a vision of a liberal education in which all may share, of a fountain to which all may come. " I believe every man in a Christian Kingdom ought to be equally well educated. But I would have his education to purpose ; stern, practical, in moral habits, in bodily strength and beauty, in all the faculties of mind capable of being developed under the circumstances of the individual, and especially in the technical knowledge of his own business ; but yet infinitely various in its effort, directed to make one youth humble and another confident ; to tranquillize this mind, to put some spark of ambition into that ; now to urge and now to restrain."

A liberal education of this kind would enhance the qualities which leading British men of business indicated as being valuable in their recruits when they

gave their opinions to Mr. R. B. Dunwoody, and allowed him to publish them in *Youth's Opportunity* in 1928: Hard work and perseverance; tactful handling of men; keenness and concentration; the power of exercising the mind; and above all character. It is the fashion to undervalue Samuel Smiles's book on *Self-Help*. But in his final chapter on Character he goes to the root of the matter and states truths which no changes in the economic outlook or in the political atmosphere can make obsolete.

There are four pitfalls the way, in four things which may delay or foil the fruition of these hopes. First, a failure more fully and scientifically to integrate the training of the body with the training of the mind. We need, as Robert Bridges said in "The Testament of Beauty":

"Grace and ease of health alike in body and mind."

Happily we in England have not neglected the physical side of education. We have not induced intellectual overstrain. But much more remains to be done in *integrating* the exercise and development of the physical and mental powers. A second pitfall is the danger of maladjustment of examinations to education. Here again we are on the alert. The remedy lies not in the abolition of examinations (we need them for audit, for incentive, and as a guarantee of vertical mobility in English life), but in making examinations subordinate to good teaching, and not too narrow in their incidence to attest the possession of a number of qualities of will, temperament, and disposition which are of high value in the discharge of the practical duties of life. A third peril is the possibility of there being a serious shortage in the number of men and women endowed with a natural gift for teaching and capable of developing it as an art in accordance with the changing needs of the time. No one can say whether this indispensable supply—the demand for which is certain to increase—will rise in accordance with our needs. But it is remarkable how human ability adapts itself to the requirements of successive generations; and as education is now clearly one of the fundamental needs of the world, it is not improbable this ability will flower in response to the call for its services. The fourth peril is finance. Of this, I will only say one word. Of all the services public and private in the modern world, none is more essential than good and wise and strict education. And in supplying the effort, devotion, and care necessary to this end it is possible for parent and employers themselves to do much by personal service to lighten the general burden. The responsibility for certain parts and sides of education—and I do not mean here the direct financial responsibility—lies with each one of us and should not be transferred to others.

For my own part I believe that to spread widely and opportunely the essentials of a liberal education for boys and girls, for men and women, should be the distinctive aim of educational policy in a modern community like ours.

And I am happy to think that this view commended itself to the man in whose memory this lecture was established. Sir William Mather had a deep and reasoned belief in the value of a liberal education. He saw it in wide and generous perspective. Year by year he did his best to encourage the training of teachers for young children in order that the foundation of a liberal education might be truly laid. He welcomed the growth of secondary schools in England because they give opportunity for a liberal education to thousands who would otherwise be shut out from it. And he favoured an intimate connexion between the Universities and civic life because he believed that each of the two gains from this contact and that a liberal education is enriched by the fusion of scholarship with experience of affairs.

The Conference concluded with Afternoon Tea served in the Cadena Café.

NOTES AND NOTICES

Federation of Textile Societies

The movement whereby the various textile Societies and kindred organisations became Federated a few years ago appears to have made quite satisfactory progress and the Annual Conference which took place at Bradford, Saturday, May 7th, by invitation of the Bradford Textile Society, the largest organisation of its kind, was distinctly successful. An excellent programme had been arranged, embracing three visits to textile works in the neighbourhood. There was an attendance of about seventy delegates from societies in Yorkshire, Lancashire, and the Midlands. Mr. Edford Priestley, as President of the Bradford Society, entertained the delegates to luncheon, whilst later in the day, Mr. Foster Pickles, Chairman of the Executive Committee of the same Society, gave tea to the delegates. The Lord Mayor of the City, Alderman George Walker, J.P., attended the proceedings and offered a cordial welcome to all the visitors. Mr. W. Munn Rankin, M.Sc., the Principal of the Municipal College at Burnley, was elected President of the Federation for the ensuing year. A record of the proceedings will appear in our next issue and the next meeting of representatives of societies in membership of the Federation is to take place at the Textile Institute, Manchester, on the afternoon of Saturday, 28th May, when syllabus arrangements will be considered. The Oldham Technical Association has invited the Federation to hold its next Annual Meeting and Conference at Oldham, when the event will honour the coming-of-age of the Oldham Association.

Institute Diplomas: Regulations

The printed Regulations governing awards of Associateship and Fellowship of the Textile Institute have undergone revision by the Regulations Sub-Committee of the Selection Committee and are now available in the revised form. Several important modifications in the provisions have been introduced as a result of experience in the conduct of the Scheme on the part of the Selection Committee. The Institute's Examination of Applicants approved for admission thereto has been reconstructed and is presented in two parts—Part I (Auxiliary Subjects), Part II (General Textile Technology). The revised regulations, having been approved by the Council of the Institute, are now in operation. Copies have been forwarded to the various technical training institutions and to Education Authorities in textile areas both in this country and abroad. Copies are supplied at a charge of one shilling each and may be obtained on application to the Institute. To date, the Fellowships awarded to members of the Institute number 172, and Associateships 235.

Institute Employment Register

The following entries from the Register of Members whose services are available for vacant posts are recorded. Employers may obtain full particulars on application to the Institute :—

No. 69. Technical Adviser or analyst; A.T.I.; accustomed to all types of woollens and worsteds; full technical and practical training; prefer near London. Age 23.

No. 73. Inside weaving-manager seeks post; age 40; married. First-class experience in West Riding mills.

No. 74. Weaving manager (abroad) for 13 years, open for similar post or as assistant in this country.

No. 75. Analyst or salesman seeks post in wholesale merchanting business. Excellent references (London).

No. 76. Young man seeks employment as assistant to works manager, or in a department, at hosiery underwear factory.

No. 77. Engagement required in Design Department (weaving). In charge for 6 years ; married ; age 29. Well qualified ; part-time lecturer. Accustomed to control and to cloth production by various kinds of looms.

No. 78. B.Sc. in Textiles offers services. Practical experience in works and also as technical representative and salesman.

No. 79. Age 26. Assistant-manager of textile mill or assistant designer. Ten years' mill experience. First prize in Textile Inst. "A" Competition ; City & Guilds Diploma.

No. 80. Weaving Manager, expert in Winding, Warping, Sizing, and Weaving of Silk, Artificial Silk and Crêpes. Experience practical and unique. Made special study of scientific management as applied to textile works.

Textile Institute Diplomas

Elections to Associateship have been completed since the appearance of the previous list (April issue of this *Journal*) as follow: —

ASSOCIATESHIP

ASHWORTH, Milton Victor (Brazil, S. America).
BARON, Henry Lewis (Blackburn).
COOP, Frank (Rochdale).
HOLMES, Laurence (South Australia).

Scholarships in Technology

The Manchester City Council is again offering a number of Scholarships tenable in the Faculty of Technology of the University of Manchester. Successful candidates are required to follow a full-time course leading to the degree of Bachelor of Technical Science in the College of Technology and Matriculation, or its equivalent, is an essential qualification.

For students who have been engaged in industry, and who have attended part-time day or evening classes, the Scholarships are of the value of £100 per annum, while for students leaving Secondary or Central Schools, the value is £60. Both classes of Scholarships are tenable for three years. Applications, which can be made up to the middle of June, should be addressed to the Principal at the College of Technology.

London Section

The Annual Meeting of Members of the London Section took place at 104, Newgate Street, London, on Thursday, 28th April, 1932, when Mr. Frank Henley presided.

The record of proceedings of the previous annual meeting (1931) were presented and approved.

The Ninth Annual Report of the Section Committee, submitted by the Hon. Secretary (Mr. A. R. Down), stated that during 1931 the Section had lost, through resignations, transference, and other causes, 29 members. Of new members, 12 had been added and the total membership at 1st January, 1932, reached 136. The membership included 1 Honorary Fellow, 14 Fellows, and 10 Associates. Five public lectures had been held during the past session in the Clothworkers' Hall, by kind permission of the Clothworkers' Company, and three at the Barrett Street School of the London County Council. The Committee were keenly appreciative of the valuable facilities given to the Section both by the Worshipful Company named and by the London County Council. By the courtesy of Sir Sydney Skinner, a large party of members was enabled to visit the works of the Rayon Manufacturing Co., Ltd., at Ashtead, Surrey, when the various processes were demonstrated and explained. At the kind invitation of

Messrs. Liberty & Co., Ltd., a party of members and friends visited the printing works of the firm at Merton. Mr. Hilary Blackmore received the company and conducted members through the works, the hand block printing operations proving of great interest. At the conclusion the members were entertained to tea in the Sports Pavilion.

The Committee had given considerable attention to educational arrangements for textile distributors in the area of the Section. The Institute was represented on committees engaged in drawing up suitable courses and various bodies had asked for assistance. An Advisory Committee on Education for Textile Distributors was in course of formation by the Section, and it was hoped this would provide means of bringing the various authorities concerned into closer touch.

The Committee was pleased to report that arrangements as to premises and clerical assistance with the Drapers' Chamber of Trade and referred to in last report had proved most satisfactory. The Committee offered their sincere thanks to the President, Council and Secretary of the Chamber. The attention of members was now drawn to the facilities available at 104, Newgate Street—a well-equipped members' room, with telephone, writing, and reading room facilities.

The proposed visit of London Students to textile industrial establishments in the North had been deferred but the matter would be reconsidered at an early date. The co-operation offered by the Institute in respect of a visit to Manchester was greatly appreciated.

The Committee recorded their warmest thanks to their Chairman (Mr. Frank Henley). The past year had been a difficult period but success achieved in various directions had been largely due to Mr. Henley's enthusiasm.

The report was adopted.

On the motion of Mr. E. Wigglesworth, seconded by Mr. R. S. Meredith, Mr. Henley was re-elected Chairman. Mr. Henley said he greatly appreciated the honour but hoped that by another year a successor would be forthcoming, as he was convinced of the desirability of change from time to time.

Mr. A. E. Garrett moved and Mr. W. H. Matthews seconded the re-election of Mr. A. R. Down as Hon. Secretary and Mr. Albert Gowie as assistant. The motion was carried unanimously and both officers were warmly thanked for their services.

Mr. Down reported that nominations for membership of Committee did not exceed the number required, 20, and there was no ballot. The Committee was declared elected as follows:—Messrs. F. Henley, A. E. Garrett, J. Howard, P. J. Neate, E. Wigglesworth, A. B. Ball, C. H. Colton, C. W. James, W. H. Matthews, L. J. Mills, G. A. Rushton, H. J. Clarke, H. B. Heylin, A. Mason, R. S. Meredith, T. C. Petrie, S. A. Williams, W. C. Whittaker, A. R. Down and A. Gowie.

The meeting afterwards discussed various matters and the General Secretary (Mr. J. D. Athey) was invited to speak in reference to movements of development on the part of the Institute—particularly the development of the Information Bureau.

Mr. H. J. Clarke said he hoped that serious consideration might be given to the question of occasional publication of matter of interest to distributors in the *Journal* of the Institute.

The meeting concluded with a vote of thanks to the Chairman.

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PROCEEDINGS

Annual Conference of the Institute*

LEAMINGTON SPA, 18th, 19th, and 20th MAY, 1932

FAULTS IN PIECE-DYED WOOLLEN AND WORSTED MATERIALS

By L. L. LLOYD, PH.D., F.I.C.

(Head of the Dyeing Department, Bradford Technical College.)

Chairman : Mr. F. KENDALL.

Piece-dyed faults may be caused by the dyer in the woollen and worsted trade by faulty preparing, inefficient dyeing, or during heat treatments in the finishing operations. Similarly faults may be caused by textile operations such as spinning, twisting, setting of yarn, warping or weaving. In some cases faulty shades have been shown to be due to the nature of the raw material.

Worsted materials when piece-dyed occasionally show a skittery appearance, this is understood to be an effect produced when some of the fibres appear to be only partially dyed, the colour being mainly on the surface of the fibres.

With blues, navy blues, and blacks the overhand appearance is that of a grey effect. This defect has been proved to be caused by certain blends of wool, sometimes of too varied a thickness of fibre, but others of practically the same " quality " wool. Two cases of the latter on investigation have shown that the possible explanation of the cause of uneven dyeing is that of different micelle structure. The fibres that dye a paler and duller shade when viewed under the microscope in polarised light have been found to have a higher strain than those that dye evenly. The orientation of the micellular structure is consequently the cause of the varied colour adsorption.

Listing is a common fault with piece-dyed goods and the main cause of the defect appears to be that of crabbing. This fault occurs with all types of worsted fabrics that have to be set before submitting to wet processing. In the crabbing process it has been proved that the use of alkaline water in the crab-bowl is very dangerous because the alkaline water acts as a hydrolytic agent on the wool with modification of the dyeing properties of it. The boiling water of the crabb has readier access to the fabric from the selvedges towards the middle of the fabric and thus these portions have a higher degree of treatment by the alkaline solution than the body of the cloth. The tension under which the fabric is crabbed plays an important part in the degree of listing produced, too little tension giving listedness on dyeing much more than too high a tension. The acidification of the crabbing bowl liquor has not produced any improvement in diminishing listedness. The best results appear to be produced when a hard water, preferably permanent hardness, is used in the crabbing bowl.

* This issue contains certain of the Papers read at the Conference, *in extenso* with the discussions that ensued. Other papers will appear in subsequent issues.

Crabbing is often followed by wet-blowing, sometimes termed wet-decatising, in order thoroughly to set the fabric to prevent too high a degree of shrinkage during scouring and dyeing or to prevent distortion of design. In this process wet steam is blown through the fabric in roll form and should always be double treatment on two separate cans in order to give as even a heat treatment from end to end of the fabric as possible. The tension applied to the fabric during winding on the blowing cans is very important, too little tension leads to listedness and too high a tension tends to make the fabric too lustrous and have a thinner handle. Wet-blowing is often applied for a very short period with the result that the heat treatment is not uniform from end to end and also from selvedge to selvedge, the result is that the wool will have different colour adsorption properties and thus yield faulty dyed goods. If the fabric is made of wool that will not become too lustrous an extended time of wet-blowing is preferable to too short a treatment.

The author has found that with goods that invariably give listedness may be obtained of a satisfactory nature when the setting is done by dry-blowing or decatising. The drier the steam employed the more even is the result, and although it is a more expensive treatment it is economically better than other methods of setting. This method points to the view that highly twisted yarn that requires setting by steam, would be more evenly set by dry steam than by wet steam which is usually used for the setting of bobbins or pirns of yarn.

Barriness in fabrics is also a serious source of colour defect. The bars may run as sections through the length of the fabric or in bobbin widths in the weft direction. Both of these defects have a sharp line of demarcation and as such cannot be produced by the dyer because no machine is employed that could follow a direct thread of either warp or weft. These defects are produced when the nature of the material differs or are caused by tension effects. In the warp direction the defect may be produced by heavier or lower tension during section beaming, whereby one or more sections are under different tensions to the others and by light reflection will then appear of a different shade. Weft bars may also be caused by tension but the more common cause of this defect is that of uneven treatment of the cops or pirns, in some cases the defect is caused by setting by steam, in others through different moisture content (condition) of the cops. The damper the material the more readily will the yarn stretch during weaving and will then give a different light reflection as well as a greater resistance to colour absorption during the dyeing process. The two effects when combined produce a tremendous variation of shade, especially when viewed over-hand or on the table. Weft barriness is present in almost every piece-dyed worsted material but the degree of difference is often so small as to be practically unnoticeable. Probably the only method of overcoming this defect is the use of box looms whereby the weft of several cops becomes so intermingled that the colour appears even throughout the whole length of the fabric.

Piece-dyed faults are of common occurrence through the mixing of yarns of different runs, and are usually the result of carelessness in the weaving shed, although in some cases the spinner is responsible for such faults. The latter is also responsible for piece-dyed faults due to variation of the thickness of yarn, variation of counts and variation of twists.

Faults produced by the above-mentioned effects are very prominent with piece-dyed goods but are scarcely discernible in woven dyed styles. The reason of this is that the variation of the physical properties of the yarn affects the penetration of the dye-bath liquor, and consequently modifies the amount of colour absorption in the yarns of varied density and twist.

The dyer is occasionally responsible for listed pieces but in these cases the listing is not as even from selvedge towards the centre of the fabric as listedness produced through faulty crabbing or too hurriedly scouring the goods to produce the desired shrinkage. The dyer produces listed defects when the temperature

of the dye-bath is raised too quickly and also when the acidity of the bath is too high at the beginning of the dying operation. By vessel dyeing in rope form the lists have freer movement than the body of the cloth, and consequently absorb dyestuff more readily, the absorbed dyestuff then combines with the wool, the latter depending on the properties of the dyestuff.

In many cases level dyeing is finally produced through the interaction of Glauber's salt which by a cycle of reaction acts as stripping and dyeing assistant. There are, however, many acid dyestuffs, particularly the fast acid colours, that do not respond to this reaction and if once attached to the wool will remain fixed. These dyestuffs are rarely used on the majority of the Continental fabrics that are piece-dyed and on account of this rarely show listedness.

To find whether the listing is due to faulty dyeing or to faulty preparing a strip of the material is stripped and is re-dyed with a level dyeing colour, if the test piece gives a level dyed result then the source of the defect is that of dyeing. Listed pieces that have the defect caused by faulty preparing would again give the defect on re-dyeing. In many cases, where the difference of shade is not too heavy, the stripped test piece should be heavily wet blown, preferably between wrappers and then again dyed, this operation often corrects such faults and may be applied to the fabric.

Goods that are taken from the scouring machine before the excess of alkali has been removed by washing may lead to listed pieces, particularly if after scouring they are kept in cuttled form for a sufficient time, two or three days, before dyeing. The moisture evaporates from the goods, mainly from the selvedges, when in pile, and thus allows alkali to concentrate towards the selvedges. Such material will, when dyed by most dyestuffs, show a degree of listing. The alkali has the effect of mildly hydrolysing the wool and thus modifying the dyeing properties. In the woollen trade, where wet processing demands the treatment of the fabrics in a wet condition for some time, this type of fault is often produced. A good means of its prevention is the final washing off of the goods with hard water. The permanent hardness of the water reacts with the soda ash retained by the fabric with formation of calcium and magnesium carbonates, which do not cause hydrolysis of the wool and do not interfere with the dyeing operations.

Piece carbonising is also a source of dyeing defects, and since these faults are made apparent by the dyeing operation they are often attributed to the dyer. After the goods have been thoroughly wetted with sulphuric acid solution of 6°-8° Tw, the addition of a wetting agent such as Nekal or Perminol aiding this operation, squeezed off, cuttled and allow to stand for a short time for the acid liquor retained by the material to become evenly distributed over the fabric. The drying process is very important in that there is the possibility of migration of the acid towards the selvedges, because these positions will allow evaporation to take place more readily, thus giving a higher concentration of acid in these portions which by the heat of " baking " will modify the dyeing properties of the wool, in most cases increasing the combination of dyestuff with the wool and thus producing listedness.

Moderately slow drying is essential at first to again aid the level distribution of the acid solution followed by moderately rapid drying at the temperature employed for the acid to hydrolyse vegetable matter. The effect of excessive acid treatment is recognisable by microscopic examination, the wool scales being attacked with cleave of wool cells. In some cases the carbonised goods are not thoroughly neutralised by washing with alkali and if such pieces are dried before dyeing they often yield flecky and patchy dyeing. A sample of such faulty material when stripped and re-dyed again reproduces the same fault.

A common source of piece-dyed defect is that of priming of the boiler, which is caused by the solids that are in suspension in the boiler liquor being carried

with the steam and delivered into the dyeing vessel. The suspended solids of the boiler contain calcium, magnesium, and iron compounds. Of these the latter are the most important because they act as mordants and usually cause a heavy saddening effect with most mordant dyestuffs. These suspended solids are of such a finely divided condition that they are mechanically absorbed by the wool and with those dyestuffs that form lakes produce a permanent defect. These faults are usually of a blotchy nature and are recognised by determining the iron content of the ash of portions of the fabric that are faulty and portions that are unaffected. The relative amounts of the two must be considered, because practically all dyed wool will give an ash containing iron. In some cases the defect may be remedied by stripping or partial stripping with oxalic acid and bisulphite of soda followed by the addition of sulphuric acid before washing off and then re-dyeing.

Mordanting is also a source of listedness and is mainly produced where temporarily hard water has to be employed for this operation. The effect of the temporary hardness is that of precipitating calcium chromate on the fabric, formed from the calcium carbonate that is mechanically attached to the wool reacting with the bichromate of soda. Such waters should be used along with tartar or argol for this operation, the amount being sufficient to give faint acidity to the bath.

From the above it is evident that there are many types of faulty piece-dyed goods, among which the faults due to textile operations are capable of solution of the source of fault by textile testing method and others which are due to the dyer which may be solved by chemical or dyeing methods.

DISCUSSION

The Chairman, Mr. F. Kendall, said he had never ceased to wonder why it was that the dyer and finisher were always held responsible for defects in finished goods. Either the dyer or finisher had to accept responsibility or investigate the cause of the defects. He considered this was an injustice to the finishing section of the trade. Co-operation between the various sections was necessary in the investigation of defects. One of the most important problems affecting the textile trade was the production, setting and sizing of crêpe yarns. Synthetic yarns of similar quality, twist, count, strength, elongation and number of filaments were often found to possess entirely different crêping properties. Frequently these variations were not discovered until a large amount of yarn had been produced. Secrecy in regard to methods of manufacture was a hindrance to arriving at a solution in connection with this type of defect.

Replying to the Chairman, the Lecturer said that a very difficult problem of the finisher had been mentioned. The finisher was expected to produce the same effect in finished goods in which the crêping properties of the yarns varied considerably. He considered this was due to variations of the degree of setting the yarns and also to the length of time that such yarn was kept before weaving and finishing. The longer the material was stored the more permanent was the setting with the result that crêping was more difficult. For all types of crêpe yarns there should be a standard method of setting that would allow weaving to be done and at the same time would allow equal creping properties to be retained.

Mr. Garnett thanked Dr. Lloyd for his contribution. He assured him that his work for the industry with which they were both connected was known and appreciated. It was a pleasure to have Dr. Lloyd at this Conference. He would like to ask whether it was better to store goods in the greasy state or scoured.

Replying to Mr. Garnett, the Lecturer said he would favour the storing of the goods in the greasy state, provided that the spinning oil lubricant was one of a satisfactory nature. This should also be coupled with the nature of the residual soap left in the wool from the raw wool scouring operation. He had found olive oil of excellent quality to become sticky and somewhat difficult to remove, through the presence of cottonseed oil soap from the wool scouring operation. In such cases it was advisable to commence the scouring of the goods with a solvent scouring agent and soda ash solution, to work for about 15 to 20 minutes and lightly wash-off before commencing the making of the fabric in the dolly.

Dr. J. B. Speakman, referring to the scouring difficulties caused by the use of inferior oils in wool, stated that Dr. Lloyd had for many years advocated the use of mineral oil, freed from unsaturated compounds, in preference to vegetable oils. The only difficulty associated with mineral oil was that of ensuring complete removal in scouring, and this Dr. Lloyd had proposed to overcome by the use of soluble oils. There was, however, a simpler and more universal solution to the problem. As a result of a study of piece scouring from a fundamental standpoint, Dr. Speakman had been able to show that there were two main causes of difficult scouring (apart from oxidation of the oil): high interfacial tension between oil and water, and high adhesion of oil and wool. Mineral oil was difficult to scour for the former reason, other oils, such as oleyl alcohol, for the latter. Adhesion is the neglected factor in all studies of scouring, and from a consideration of the preceding two fundamental principles, a solution of the scouring difficulty in the case of mineral oil had been discovered. This has been made the subject of a patent application and full details would be published in due course.

In reply the Lecturer said that the removal of mineral oil was aided considerably by the use of acid ammonia soaps or acid ammonia soluble oils, either of these having been proved efficient agents for the emulsification of mineral oil. Where a small amount of mineral oil was present on the fibre addition of a specifically heavy solvent scouring agent was useful.

Mr. J. G. Williams referred to cases he had examined where streakiness had appeared in coloured goods of silk or wool after laundering. The streaks only developed as the fabric dried and they appeared on those portions which dried first. The effect was associated with the alkalinity of the soap liquor or alkalinity remaining even in well-rinsed fabrics for if, after washing and rinsing, the fabric was scoured in weak acid then the streaks did not appear. He asked Dr. Lloyd if this was a very common defect. The statement that foreign dyers did not face up the troubles of getting level dyeings when using fast acid dyestuffs was very interesting; the fact that British dyers did use the fast deystuffs was a selling point for British goods which should be made known to buyers for retail distribution.

Dr. Lloyd said Mr. Williams' query referred to the well-known water bleeding property of many dyestuffs. The defect occurred in all types of fabrics and the presence of alkali aided the capillary effect. One of the main differences of Continental and British piece-dyed fabrics was that of fastness to various agencies, light being the most important. Continental goods were mainly dyed with readily levelling dyestuffs which were not fast to light, whereas the home dyed goods had usually to be of guaranteed standard. For this purpose the fast acid colours were largely used which required very careful application to yield even results. There were fabrics—women's dress goods made of wool and viscose rayon—which were dyed in this country with readily levelling dyestuffs. These fabrics were not fast as a rule to warm water bleeding and showed colour defects when ironed or pressed in too damp a condition. The dyestuffs were selected of good fastness to light but were sensitive to perspiration. These dyestuffs had to be used because the fabrics would not withstand the longer dyeing process. They were, however, dyed as fast as was commercially possible.

THE TESTING OF TEXTILES—WITH SPECIAL REFERENCE TO THE INVESTIGATION OF DEFECTS IN YARNS AND FABRICS

By W. E. KING, A.T.I.
(The Technical College, Bradford)

Chairman: Mr. J. H. LESTER.

Defects in woven and knitted fabrics are responsible for serious losses to the textile trade as they involve allowances between Spinners, Manufacturers and Dyers and Finishers. In addition to this, they are a frequent source of annoyance to all concerned, as such disputes are one of the chief causes of friction between those engaged in the various sections of the industry. Many good customers have been lost through this cause. In the interests of all concerned therefore, it is essential to eliminate, or at least reduce to a minimum, the number of defects in textile fabrics.

If a piece contains only a few defects, these are " strung " and the merchant receives an allowance according to the number of " strings " which the piece contains. This of course means a reduced profit to the seller. If the piece contains numerous defects it may have to be " jobbed " or classed as a " second " which usually means that it has to be sold at an extremely low price. A reduction in the number of defects in fabrics is therefore an indirect means of increasing profits to the seller and at the same time creating a more harmonious relationship between buyer and seller, which is equally as important. From this point of view therefore this matter should receive most careful consideration.

Claims in respect of defective pieces are continually being made, some just and others unjust. These disputes must be settled either by Arbitration or in the Law Courts at great cost. If the parties concerned had been more conversant with the causes of defects in general, it might have been possible to settle the matter amicably between them. Recourse to the Law usually means a cessation of business between the parties concerned and although a particular case may be won it may eventually result in a loss of trade out of all comparison to the immediate gain.

That the number of defects in fabrics due to bad yarn and poor weaving is becoming more prevalent is evidenced by the number of burlers and menders in comparison with weavers at the present time, against a period of twenty years ago. In fact, during a prosperous time in the industry, it is not unusual for pieces to be held up for long periods on account of there being insufficient burlers and menders available. This may mean cancellation of orders through late delivery and also creates dead capital with consequent loss to the manufacturer.

Imperfections created in the early stages of manufacture may have very far reaching effects. Thus, due to a lack of testing facilities on the part of the spinner, a warp yarn of inferior weaving property for the type of cloth intended may be supplied. This will reduce output during weaving, owing to the breakages which occur necessitating a stoppage of the loom at frequent intervals. This creates dissatisfaction on the part of the operative as it reduces her earning capacity and in a period of good trade might easily mean the loss of a good weaver. Bad warps make discontented weavers, and create a desire to move to another establishment where more attention is paid to providing good work and consequent increased earning capacity. Further, a piece of cloth woven under these conditions with frequent stoppages will be more imperfect than one woven under normal conditions. This means increased burling and mending charges and even then the piece cannot be of such high quality. It follows therefore that an inferior quality piece may actually have cost more to produce than one in which no imperfections occur and if the piece has eventually to be " jobbed," the loss is accentuated.

Defective fabrics are and always will be to some extent disagreeable realities. As such, they should be faced in the spirit that " prevention is better than cure " and an effort made to trace every defect to its source so that a recurrence of the same defect is avoided. If every case in dispute were investigated by a responsible authority it would do much towards reducing the number of defects which are continually recurring. In dealing with disputes there is too great a tendency to ask " Whose fault is it ? " and when possible, make the guilty party pay and then forget it. In some cases the guilty party deliberately withholds relevant information with a view to the blame being fixed on an innocent party to the dispute.

Few of the defects which occur in textile fabrics, causing them to be rejected, can be remedied when once the material is in cloth form, and at this stage the bulk of the expense of its manufacture has been incurred. In some cases, the cloth may have been made up into garments before the defect develops and in this case the claims will be most serious to the party involved in settling them.

Another factor is that in recent years other countries have greatly increased their skill in cloth manufacture. This has made it more difficult to find new markets for British cloths and to hold many of our old established markets. Previously, British cloths found an entrance into practically all countries of the world, due to their outstanding standard of excellence. As the skill of our competitors increases, however, it is necessary for us to strive for a still higher standard of excellence and at a reduced cost. This can only be done by careful analysis of every process of manufacture so as to increase output and, at the same time, assist in reducing costs by producing a smaller quantity of defective goods which have eventually to be sold at a loss. As a means of reducing the number of defects in cloths and also assisting in increasing output of perfect goods, the systematic testing of all materials at each stage of manufacture cannot be too strongly stressed.

TYPES OF TESTING

The testing of textiles may be classified under two main heads—(*a*) The testing of the various materials during the process of manufacture so as to minimise the risks of faults occurring and (*b*) The investigation of the causes of defects to their source with a view to preventing their recurrence.

The former type is what might be described as " routine testing " and includes testing for counts, twist, strength and elongation, evenness, freedom from slubs, neps, etc., and is essentially the spinner's liability.

Qualifications—Routine Testing

The qualifications necessary for this type of work are a good education including technical training, strict accuracy and neatness in working. This may be carried out by a youth or girl—and the latter is particularly suitable, provided that the proper type be chosen. With a youth there is a suggestion of " blind alley " occupation, and a natural desire for advancement. With a girl this is not so evident and thus there are less frequent changes in personnel, which is of value in systematic working. Further, attention to detail seems to come more natural to the majority of girls than to boys.

The methods of testing, sampling, etc., and the evaluation of the results will of course be in the hands of a thoroughly practical, technically trained supervisor, with a good knowledge of preceding and succeeding processes. All results must be systematically and neatly recorded and filed in such a way that they are readily available at a moment's notice for comparison, otherwise much of their value will be lost. The card index system of recording results will be found particularly useful for this work.

Investigation of Defects

To carry out this branch of textile work successfully calls for the highest qualifications, and really requires an expert in every branch of manufacture,

from the raw material to the finished fabric. A very thorough practical training is absolutely necessary, supplemented by a sound scientific and technical training. It is obviously impossible for the investigator to trace a defect to its source without a good knowledge, both practical and scientific, of all processes from the raw material to the finished fabric. The qualifications necessary adequately to carry out this work are briefly:

(*a*) A thorough practical and technical knowledge of all processes, which includes raw materials and their conversion into yarns, cloth structure and analysis, processes involved in dyeing and finishing.

(*b*) An inquisitive turn of mind, coupled with an abundance of common sense.

(*c*) Accuracy and neatness in working, with strict attention to detail.

(*d*) Good personality, and popular with other staff, in order that relevant information may be obtained when necessary. The technical qualifications should include skill in microscopic work and a good working knowledge of photography. As a general rule, it will be found that a man trained on the manufacturing side of the industry will be preferable to one trained on the spinning side, although this will of course depend on circumstances. The reason for this is that it is impossible for a manufacturer successfully to conduct his business without a fairly extensive knowledge of qualities and raw materials, and their conversion into yarns. Further, it is essential that he should have a good knowledge of the dyeing and finishing of the cloths which he produces. The spinner, on the other hand, is seldom conversant with the intricacies of cloth structure or of dyeing and finishing processes.

NECESSITY FOR TEXTILE INVESTIGATOR

Although it is not absolutely essential that a firm should employ a textile investigator of defects on its permanent staff, it is undoubtedly an advantage. The person on the spot possesses a tremendous advantage in this work, as he can readily obtain the necessary information as to processes, treatments, etc., through which the defective material has passed. He also has the opportunity of examining machines and discussing with operatives, any features of the work necessary. An outside investigator has not the same facilities in this respect and it is often most difficult to obtain even the most necessary information. It cannot of course be expected that his report will always be accepted by the other party to any dispute which may arise unless the evidence is overwhelming. It will, however, save trouble and expense of having a defect investigated by an outside investigator where he is convinced that his own firm is at fault. He will also be able to substantiate or otherwise, reports on defective pieces carried out by other investigators in which his particular firm may be concerned. Usually, however, it will be found necessary to submit disputes of a serious nature to an outside authority, so as to obtain an unbiased report as to the cause of the defect. This outside authority may be either a Testing or a Conditioning House, Research Association, Technical College or a private textile expert.

PUBLIC AND PRIVATE TESTING AUTHORITIES

The investigation of defects in cases of dispute by a private individual working for financial gain is obviously a most difficult matter as there must always be a tendency of bias towards the firm providing the work and who is responsible for payment of the account.

With public authorities—research associations, testing houses, technical colleges, etc., this factor is non-existent and an absolutely unbiased judgment can be relied upon. Further as some of these authorities are equipped with the latest machinery of all types upon which defects may be reproduced when necessary it can be considered a very great advantage to have this work carried out in such an institution. Technical colleges have many advantages in this

respect, especially the larger institutions, as in addition to being well equipped they usually employ upon their staff experts in each branch of the industry—spinning, weaving and dyeing and finishing, with whom the investigator may confer when necessary. In addition to this, departments of botany, physics, chemistry, etc., are usually included, so that problems of this nature may be submitted to them as the occasion arises.

SETTLEMENT OF DISPUTES

The ideal method of settling disputes and claims, amicably, would be one in which the investigation would be carried out by a public testing authority in conjunction with the local Chamber of Commerce. The final arbitration and apportionment of the blame and amount to be paid would be decided by a permanent committee elected by the Chamber and remunerated by them. This permanent committee would include highly qualified representatives from all branches of the industry who would adjudicate on the evidence put forward by the parties concerned, having in mind the report submitted by the authority who had carried out the work of investigation.

The recourse to law for settling purely textile claims as distinct from breaches of contract, etc., is seldom satisfactory to either side and cannot be compared to arbitration by a committee of experts who each have a unique knowledge of some particular branch of the industry. In this way also, many firms who disagree and eventually cease trading together might still remain good friends to their mutual advantage. The huge piling up of costs which one side or the other has eventually to pay would also be avoided.

TESTING OF TEXTILES.

It is beyond the scope of this paper to go fully into the details of the various tests which must be carried out under what is termed " routine testing." These may be found in almost any standard textile work. The variety of tests which a spinner will usually have to undertake in order that his yarns are up to the manufacturer's requirements are

1. Examination for quality of material, which includes types of material blended together, etc.
2. Testing for counts—average and variation on short lengths.
3. Testing for twist—average and variation on short lengths.
4. Testing for strength and elongation, or weaving property. Average strength and regularity in strength.
5. Testing for evenness in diameter.
6. Testing for moisture content or condition.
7. Testing for length.
8. Testing for freedom from neps, slubs, etc.

The tests which the manufacturer must be prepared to undertake in addition to those stated above include

9. Tensile Strength and elongation of cloths.
10. Bursting or perforation tests of cloths.
11. Colour fastness of dyed yarns.
12. Percentage of constituent materials for tariff purposes.
13. Shrinkage of wool goods.
14. Waterproof and showerproof properties.
15. Perspiration properties.
16. Weighting of silk and wool cloths.
17. Washing and laundering properties.
18. Fireproof properties of cotton cloths.

This list although including the chief items, by no means covers the complete range of tests which are possible on the various types of woven and knitted textures.

METHODS OF TESTING

Great attention will have to be paid to the method of selecting the samples to be tested if reliable results are to be obtained. Further, as the strength and elongation of practically all textile materials are influenced considerably by the relative humidity of the atmosphere in which the materials have been stored prior to testing, a controlled atmosphere is desirable. Where this cannot be provided, however, it is essential that the testing room should not be subject to frequent violent changes in the atmosphere. In all cases, the relative humidity of the atmosphere should be recorded at the time the tests are being carried out, as this may assist in explaining slight variations in strength of yarns and cloths which may occur from time to time.

INVESTIGATIONS OF DEFECTS IN FABRICS

The number of defects which may occur in woven and knitted fabrics is so varied that it is impossible adequately to deal with many of them in a paper of this kind. Further, it is most difficult to describe them in such a manner that the appearance of any particular defect may be appreciated, without actually examining the fabric concerned. This is probably the chief reason why this subject has never been thoroughly discussed in the literature, as many of the defects do not lend themselves to illustration by photographic or diagrammatic means.

The defects to be discussed later are chosen from over 2000 investigations carried out for the trade in the Textile Testing Laboratory of the Bradford Technical College in recent years. These results are completely recorded and thus provide most valuable information on the subject. It is only proposed to discuss some of the more uncommon types of defects which have been met with and the cloths containing these will be on exhibition during the Conference. The method of investigation of each particular defect and its peculiarities will also be more fully discussed at that time.

The following is a brief synopsis of the particular defects to be dealt with :

Defects due to Raw Materials

Example 1

Type of Cloth.—SUN CLOTH OR SHOT GABERDINE.

White worsted warp. Red cotton weft.

To be piece dyed for wool.

Defect.—Small red spots all over the face and back of the cloth.

Cause of defect.—Microscopical examination shows that the spots are caused by neps. Some of them are ordinary neps due to defective carding. Many of the spots are due to neps to which part of the husk of the cotton seed still adheres.

A carded cotton yarn is not suitable for this type of cloth.

Example 2

Type of yarn.—FOUR-FOLD CROSSBRED HOSIERY YARN.

Defect.—Looped fibres on surface of yarn at intervals.

Samples supplied.—Original Top A. Yarn from same.

Top B used for blending with original top in equal proportions.

Grey and dyed yarn from blended top.

Particulars supplied.—The original yarn is made from Top A of 46s quality. To reduce the price of the yarn the topmaker was asked to supply a cheaper top to blend with the original top in equal proportions. The top supplied was of 44s quality, Top B. The defect is supposed to be due to the blending in of the lower quality.

Method of Investigation.

1. Both tops were analysed on the Schlumberger Top-testing machine for length of fibres constituting each.

Result :—No appreciable difference in length sufficient to cause defect.

2. Tops examined microscopically to ascertain variation in diameter of fibres.

Result :—Both tops are very irregular in fibre diameter as might be expected from these qualities. Top B is slightly more irregular than Top A. Fibres vary between 1/500″ and 1/900″ in diameter.

Scouring Test.—Samples of the original yarn A and the blended yarn B were scoured in hank form. Both were very defective and full of looped fibres. Hanks of each yarn were again scoured after being previously " set " in boiling water. Neither of the samples developed the defect.

Cause of Defect.—The loops are caused by the variation in shrinking property of the fine and coarse fibres. The finer fibres shrink more readily than the coarse ones which adapt themselves to the reduced length by looping on the surface of the yarn. " Setting " the yarn prior to scouring and dyeing removes the tendency to irregular shrinkage by fixing the fibres in position. The defect is due to irregular fibre movement caused whenever low qualities are subjected to wet treatment without previously " setting " or " crabbing."

Example 3

Type of cloth.—MIXTURE WORSTED COATING.

Defect.—Uneven in shade.

Examination of piece.—The cloth is made with 2 threads light grey, 2 threads black botany in the warp crossed with a black weft. The piece is blotchy or uneven in shade and the defect counterchanges on the face and back of the cloth.

Weaving Particulars.

Warp	Weft
2/32s Black Worsted	2/32s Black
2/32s Grey Worsted	
70s quality	70s quality
4,400 threads	64 picks per inch
16s reed 4s	
69″ reed width	

8 shaft weave, $\frac{2\ 1\ 1}{2\ 1\ 1}$

Microscopical examination of weft yarn shows that the defect is due to fibres looping on the surface of the yarn, sometimes on the face, and at other times on the back of the cloth.

Examination of Weft Yarn.—The weft yarn is reputed to be of 70s quality botany. Microscopical examination shows that although containing much 70s quality fibre it also contains a good proportion of coarser fibre of approx.56/58s quality.

Cause of Defect.—The prime cause of the defect is the variation in diameter of the fibres employed in the weft yarn. This causes irregular fibre movement during wet finishing processes. A secondary cause is the oversetting of the warp—64 threads per inch of 2/32s yarn and the excessive width of 69 inches in reed for a slubbing-dyed yarn. The maximum sett for this weave is 60 threads per inch and the reed width 66 inches for a finished width of 57 inches. This is equivalent to a reduction in sett of 10 per cent. Had the quality been up to reputed standard, or if the width in reed had been normal, the defect would not have developed.

Example 4

Type of Cloth.—MOQUETTE—WARP PILE.
Piece dyed.

Defect.—Intermittent warp stripes, darker in shade and general warp streakiness.

Examination of Piece.—The cloth contains intermittent warp stripes at irregular intervals and not continuous throughout the length.

Particulars supplied.—The pile yarn is of 2/32s count and made from 46s quality material. Samples of yarn in hank and a thrum of the warp were supplied.

Microscopical Examination shows that where the stripes occur, the pile is less dense than in the perfect portion. The pile is arranged in plain order on alternate picks.

Counting the number of fibres per tuft of pile gives the following result :—

Perfect : 50, 41, 64, 47, 50, 45, 40, 50.
Stripe : 31, 32, 22, 33, 24, 25, 23, 24.
Average Perfect : 48 fibres per tuft.
Average Stripe : 27 fibres per tuft.
Counts of Yarn.—
Average count (2,880 yards) = 2/32·05s.
Variation in Count.—

80 yards tested	2/30·2s to 2/34·5s	= 14%
40 ,, ,,	2/29·0s to 2/34·75s	= 20%
3 ,, ,,	2/27·6s to 2/38·2s	= 38%

Number of Fibres.—
(*a*) Normal yarn Average 57.
(*b*) Thin places ,, 30.

Cause of Defect.—The yarn has been spun beyond the count limit for its quality, especially when employed in a cut pile cloth. This has resulted in the yarn being very irregular in diameter with a consequent variation in the number of fibres contained in thick and thin places. The dense pile causes light to be reflected from the cut ends of the fibres, whilst the less dense or thin pile allows light to be absorbed.

Example 5

Type of Cloth.—Tropical Suiting.

Defect.—Brown streaks weft way occurring in five separate bobbin widths in piece. The weft yarn is composed of white botany and natural brown cashmere blended together. The defect is supposed to be due to the cashmere fibres grouping at intervals in the yarn.

Microscopical Examination shows that where the defect occurs the wool fibres are brown as well as the cashmere and that the colour ceases abruptly.

Actual cause of defect.—The streaks are due to coffee stains on the outside layer of the weaving spool. This was eventually traced to an operative having spilled coffee on the lid of a skep containing the yarn when partaking of a meal.

Defects due to Yarn Structure

Example 6

Type of Cloth.—Knitted Jumper Cloth.

Defect.—Light coloured bar running across the piece and appearing less dense with light through.

Construction of Yarn.—The cloth is knitted from a fancy knop yarn. This is made from a two-fold botany worsted and a white viscose yarn twisted together with an excess delivery of viscose to form knops at regular intervals. This yarn is then bound with a white viscose thread twisted in the opposite direction to the original twist.

Cause of Defect.—The defect is due to the worsted yarn being single instead of two-fold at intervals.

Example 7

Type of Cloth.—Knitted Jumper Fabric.

Defect.—Dark bars across the piece with no difference in density when viewed with light through.

Construction of Yarn.—Fancy knop yarn made by twisting together a two-fold black botany worsted with an excess delivery of white viscose to form white knops at regular intervals. This yarn is then bound with a white viscose binding thread twisted in reverse direction to the original twist.

Test for Turns per inch and Take-up in twisting.

Perfect Yarn.—Binding twist 12·0 turns.

Take-up of binding thread.—10·5 inches of binder to 10 inches of yarn.

Turns per inch in Fancy knop yarn.—As spun 22 turns. After binding 10 turns.

Take up of Viscose Knop Yarn.—14·5 inches to make 10 inches of yarn.

Defective Yarn.—Binding twist 12·0 turns.

Take-up of binding thread.—10·5 inches to 10 inches of yarn.

Turns per inch in Fancy knop yarn.—As spun, 15·2 turns. After binding, 3·2 turns.

Take-up of Viscose knop yarn.—10¼ inches to make 10 inches of yarn.

Cause of Defect.—The defect is due to the tremendous difference in twist of the knop yarn before binding and the difference in take-up of the viscose knopping thread. In the perfect yarn, 14·5 inches of viscose are employed to make 10 inches of complete yarn. In the defective yarn, the take-up of the viscose and worsted threads are almost identical, producing an ordinary two colour twist.

Example 8

Type of Cloth.—Woollen Costume Coating.

Defect.—Indistinct weave structure.

Construction.—This cloth is made from woollen warp and weft and piece dyed to shade. Patterns of perfect and defective cloth supplied. Both are supposed to be made to identical particulars throughout. In perfect cloth the weave effect is plainly visible and adds life and character to the cloth. In the defective cloth the weave effect is hidden and the cloth has a felt-like appearance.

Method of Investigation.

1. Test for weight per square yard shows defective cloth to be 10 per cent. lighter in weight.
2. Test for picks per inch shows defective cloth to contain 3 per cent. fewer picks.
3. Test for counts of weft yarn shows defective cloth to be 8 per cent. finer in count.
4. Test for turns per inch shows defective cloth to contain 11 per cent. less twist.

Cause of Defect.—The defect is caused by the use of a weft yarn of finer count and with fewer turns per inch. This allows the fibres to move more easily during wet finishing processes and causes felting to take place more readily. This results in the obliteration of the weave effect and gives a " blind " surface to the cloth.

Example 9

Type of Cloth.—Schreinered Lining. Shadow Stripe.

Defect.—Indistinct stripes. The warp is made with 20 threads of ordinary and 20 threads of reverse twist to produce a " shadow " stripe. Sateen weave. Pattern of perfect cloth supplied for comparison.

Microscopical Examination shows that in the perfect cloth the schreiner angle and the twist angle are identical in the ordinary twist yarn and that the schreiner angle cuts the twist angle at 90° in the reverse twist yarn. This gives maximum lustre in one stripe and maximum dullness in the other stripe by comparison. In the defective cloth, it is found that the schreiner angle is cutting the twist angle in both the ordinary and reverse twist yarns and although this develops a highly lustrous finish on the surface of the cloth it does not accentuate the difference in lustre between the stripes composed of right and left twist yarns. This defect is illustrated by photographs of the perfect and defective cloths.

Example 10

Type of Cloth.—Viscose and Wool Fancy. Piece Dyed.

Defect.—Dark stripes at regular intervals running warp way.

Construction.—The warp is made throughout with 4 threads of botany and 4 threads of botany and white viscose twisted together. The stripes occur at regular intervals of $2\frac{5}{8}$ inches across the piece.

Method of Investigation.

1. Test for tension of warp threads shows no appreciable difference between stripe and perfect portions.
2. Test for counts of warp yarn shows no appreciable difference.
3. Test for turns per inch shows perfect to contain 14 per cent. more twist than defective threads.
4. The viscose yarn in the perfect portion is 150 Denier and contains 18 filaments. In the defective portion, the viscose although of same count, only contains 16 filaments.

Defects due to tension.

Example 11

Type of Cloth.—Viscose Poplin.

Defect.—Distortion of weave.

Construction of Cloth.—The cloth is woven with a fine viscose warp and a thick viscose weft in plain weave. Patterns of grey cloth from loom and finished cloth submitted. Both cloths are equally defective. Defect has the appearance of " water " marks of weird shapes which are exactly reversible on face and back of cloth. Piece is worse down one list.

Examination of weft yarn.—This shows that instead of the thick weft yarn being perfectly straight as is usual in warp rib structures, it is curved at irregular distances. When traced in the cloth it is found that the yarn is first prominent on the face and then on the back of the cloth for a short distance.

Tension of Warp Yarn.—At the side of the cloth where the defect is most prominent, it is found that the warp is slacker.

Cause of Defect.—Uneven tension of the fine warp threads allowing the thick weft to lie on the face and back alternately instead of remaining perfectly straight. This causes the ribs to be prominent, first on one side of the cloth and then on the other, and accounts for the defect being reversible.

Periodic Faults in Yarns

Example 12

Type of Cloth.—Fancy Woollen Coating.

Defect.—Weft stripes.

Construction of Cloth.—This cloth is made with 2 picks of ordinary woollen yarn and 1 pick of a fancy viscose knop yarn. The fancy yarn is composed of a woollen yarn as the ground thread with an excess delivery of white viscose. This compound yarn is then bound with a blue viscose binding thread. The defect only occurs on alternate picks of fancy yarn and is due to the white viscose yarn having been removed by cropping during finishing. The fancy yarn has been woven with two shuttles, pick and pick.

Examination of Defective Yarn.—When withdrawn from the cloth shows that the white viscose has been removed for a distance of 5 inches at regular intervals of 20 inches.

Cause of Defect.—A periodic fault in the yarn which occurs at regular intervals. This causes the white viscose portion of the fancy yarn to stand above the surface of the cloth where the defect occurs and be removed during cropping.

Example 13

Type of Cloth.—Worsted Suiting.

Defect.—Narrow bars weft way.

Cause of Defect.—A periodic fault consisting of a slight variation in twist at regular intervals due to winding.

Defects due to Conditioning

Numerous examples of defects due to the artificial and natural conditioning of weft yarns will be dealt with and the peculiarities of these faults explained. The examples will include worsted suitings and also rayons cloths.

DISCUSSION

The Chairman, Mr. J. H. Lester, pointed out that whether they were concerned with irregularity in mule yarn or with conditioning effects on the bobbin, they had to deal with an irregularity which occured at regular intervals. It was a simple matter to prepare a diagram showing the precise effect upon the fabric, due to the distance between the several irregularities and to the width of the cloth. The bars produced in the fabric would run at various angles to the warp and the minimum of " barriness " was obtained when these bars ran at right angles to the warp. He asked how Mr. King had identified the presence of coffee stains.

Mr. G. H. Thompson mentioned that whilst investigating faults known as " tramlines " in Ray-de-Chines and " rings " in stockings, the peroidicity was matched by dyeing the outside or full diameter bobbins. The information obtained was conveyed to the Shirley Institute who undertook further work on the problem.

Mr. H. C. Barnes asked if there was not also a geometric method of tracing defects arising from short faulty parts in yarn recurring at long periods by the kind of patterning in the uneven cloth. The lecturer had mentioned the significance of the pick length on a weft bobbin. He believed the Shirley Institute had gone much further and could explain certain cloth effects from the spinning, roving, and drawing processes knowing the drafts which had spaced out the faults, and the significant bobbin lengths, etc.

Replying to Mr. Lester, Mr. Thompson and Mr. Barnes, the Lecturer pointed out that diagrams illustrating the grouping of the defective portions in the yarn in geometric formation and cloths showing these defects were amongst the cards handed round for inspection.

The Chairman referred to the matter of public and private testing authorities. After quoting from Mr. King's paper, he commented that independent workers and even those working for financial gain—consulting chemists or technologists—had a useful place, indeed he was sure it was unfair to these men to say that their results were likely to be subject to bias. He scarcely liked to pass over that particular paragraph. He felt that they had a number of men occupying positions in the consulting profession who were extremely useful to the industry and who were out for the truth, the whole truth, and nothing but the truth.

Mr. F. Kendall said he had been informed that approximately 95 per cent. of the arbitration cases in textiles held at the Manchester Chamber of Commerce were now legal—employing a counsel. He thought that was a step in the wrong direction—cases were often fought on paper evidence rather than on material textile facts. At the Bradford Chamber of Commerce, a different principle obtained. Two competent men, with practical and technical knowledge covering the two sections of the trade involved, would be arbitrators, so that if a dyed cloth was in dispute a dyer and a manufacturer would be chosen. He did not agree with Mr. King regarding the work carried out by public institutions. They certainly were doing very valuable work but they could not be expected to keep abreast with the times, especially in relation to the development of synthetic products. For example, much experimenting was going on in the industry in the production of suede crêpe styles and other types of modified constructions, and changes in processings were necessary in order to comply with the ever-changing public taste. Such deviations in process were unknown to the public laboratories and therefore should they be asked to arbitrate on such matters they must of necessity be working in the dark.

In reply to remarks by the Chairman and Mr. Kendall in reference to public and private testing authorities, the Lecturer said that it was not suggested that a private investigator must necessarily be biassed towards the firm providing the work and being responsible for payment of the account. In his opinion, however, an investigator unconnected with any party to a dispute and whose remuneration did not come from either of them must be at an advantage in carrying out work of this type.

Dealing with Mr. Kendall's remark that approximately 95 per cent. of the Arbitration cases at the Manchester Chamber of Commerce were now legal and employed counsel, the Lecturer pointed out that this was fully dealt with under " settlement of disputes " where recourse to the law was deprecated. In a case of this nature it was evident that the experts who had reported on the defect for the opposing parties were not in agreement, otherwise there would not have been any case to go to the law. One of the experts must be wrong therefore, or, what is more probable, may only have reported on facts beneficial to the party he was representing and omitted material facts which were detrimental to his side. The case is analagous to a trial for murder between counsel for the Crown and defending counsel where the latter would only put forward facts calculated to assist in the acquittal of the accused.

He did not agree with Mr. Kendall that commercial research on disputes in which the firm doing the tests was one of the parties involved was unquestionably the best. One could not be both a witness for the prosecution and the defence and also the judge. Investigation by an impartial public or private authority was the only fair method to all the parties to the dispute. The remark by Mr. Kendall that public institutions could not be expected to keep abreast of the times could hardly be taken seriously in these days of Research Associations, etc.

Mr. Kendall disagreed with Mr. King and felt convinced that a public consultant would not sell his reputation to advance the interests of a man who had not the principle to accept responsibility for his own irregularities, and this particularly should be the case in private research laboratories in connection with the industry. Research work should not be affected by the financial gain or loss, the cause of the trouble being their goal. With this in view, commercial research in industry was unquestioningly the best.

Mr. G. Blackburn referring to competition from other nations and the suggestion that costs could be reduced by reducing the amount of defective cloth, maintained that competition would not allow them to put anything on the price for faults. The settlement of dispute through the local Chambers of Commerce was already in force, and was used on various occasions in different branches of the industry.

Replying to Mr. G. Blackburn, Mr. King said it was agreed that this would be difficult. It was pointed out, however, that the number of " seconds " produced would reduce profits at the year end and the firm concerned would either have to be content with reduced profits or adjust its costing for future trade.

The Lecturer also stated that he was fully aware many of the disputes were already settled by the local Chambers of Commerce, this system being fairly prevalent in Bradford. He pleaded, however, that all cases should be dealt with in this way and without recourse to the law unless the parties involved could settle the dispute amicably between them. If the method of settlement in Manchester mentioned by Mr. Kendall was correct, it was evident that this system was not universally applied and much money was being wasted in litigation to the detriment of all connected with the industry.

Mr. Lester said that from an experience of 17 years at the Manchester Testing House his feeling at the end was that in a large proportion of the cases, and so far as opposing sides were concerned, one would inevitably be satisfied and one dissatisfied.

THE TESTING OF LINEN FABRICS FROM THE POINT OF VIEW OF THEIR USES

By J. A. MATTHEW
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Chairman: Mr W. KERSHAW

A few years ago the term "testing" used in relation to a textile fabric would have signified the measurement of its tensile strength and the determination of such analytical details as its fibre composition, weight per unit area, and ends per inch. To-day, as the result of intensive scientific investigations, a very long list is required to include all the different kinds of tests which have been worked out and established for application to the different textile materials. This multiplication of test methods is very necessary and adds very materially to the value of the information which can be obtained from the test results. Unfortunately the mere diversity of these tests is rather terrifying to the layman, and to some extent holds him back from making greater use of them in his every-day work. Fortunately, it is by no means necessary for each sample of material to be tested by every one of the tests now in fairly general use; such a course would be a mere waste of time and energy. It must be remembered that the majority of textile test methods are not absolute, but are only comparative; usually they give a quantitative measure of some one property of the material when measured on a given apparatus under certain specified conditions. The actual service conditions of use cannot be accurately reproduced on any one machine, so these are studied to deduce what separate forces may be at work, and testing machines are then devised to measure these separate factors by themselves. Usually this is fairly simple, but the real difficulty is to be able to assess the relative importance to be given to each factor in order to simulate actual conditions. When in addition the great variety of textile products and the very varied uses to which they are put is remembered, it is very easy to account for the great variety of test methods necessary if the general field is to be covered at all adequately. It is probably only such institutions as the Research Associations and the Public Testing Houses, which need to be prepared to carry out the whole of these tests. In private laboratories, especially in those which mainly carry out certain definite duties of a routine character, only such tests as have a direct bearing on the usual product would be found.

These various tests may be used in a number of ways.

1. For routine check on regularity of manufacture or to certify compliance with a certain specification before sale.

2. To investigate and compare the probable behaviour of different materials under varied conditions.

3. To investigate the effects of changes in the manufacturing processes on the probable behaviour of the material.

Some tests are applicable with but slight modification to any of the textile fabrics, but in quite a number of cases, owing to the peculiar properties of some textiles, the tests have to be modified in some respect in order to be made suitable. It is also a fact which should be borne in mind, that oft-times erroneous conclusions can be drawn from test results by a person who is not intimately acquainted with the full details of the processes of manufacture of the material tested.

There appears to be perpetual scope for the development of new test methods. In some quarters this kind of work is regarded with some suspicion, as there is a tendency to believe or to fear that such new tests will be used ultimately to complicate specifications. This is not correct; new tests should be used to determine the superiority of one type or class of material over another for some particular purpose; the superior article can then usually be specified in terms

of structure and its delivery up to standard can in most cases be safeguarded by specification of some simple test such as for example a strength test.

Obviously the subject of testing is too wide to treat in all its bearings within the scope of this paper. An attempt will be made to summarise and discuss the chief tests found to be necessary and useful in investigations dealing with the manifold uses of linen fabrics. The Linen Industry Research Association places great importance on the determination and collection of data concerning the behaviour of linen fabrics in use and has done much investigation work in this connection. Tests on finished linen fabrics are carried out either with the object of testing the probable behaviour under some practical conditions or to estimate whether the material has been manufactured efficiently. On either account the tests are essentially tests of the " quality " of the material. Whilst some goods would be sold on this ground alone, many linen goods also owe their sale to some other characteristics, such as appearance and price. It is impossible to give a figure which expresses the appearance value of an article, nor can a real one be given for the overall quality per unit price. There is no doubt that testing can become of great assistance to the salesman, but not in giving an overall figure for " sales value " ; the conditions are much too varied and there is far too much compromise necessary between the optimum conditions for different factors required in any given article and cost.

Since the tests are either well-known or have been fully described in previous papers, it is not considered necessary to go into details here of the test methods, but only to refer to the original description.

SPECIFICATION TESTS

Specifications are in common use in Government Departments, railways, large institutions and business houses consuming large quantities of linen fabrics of all kinds varying from tent duck to the finest handkerchief linen or fine damask. They are used primarily as a safeguard to the consumer, but there is no doubt that they can be of service to the manufacturer, providing a constant check on the quality of his products. At present many manufacturers do not favour specifications, but this attitude is tending to change, as experience shows how the manufacturer is safeguarded in cases of dispute, and in time realises the value of the technical information indirectly gained regarding his processes.

In order to derive the optimum benefit from these advantages, the following considerations should be borne in mind when drawing up specifications :

1. The specification should be as complete as possible. In a great many cases, particularly in private businesses, they are far from complete, often inaccurate and sometimes specify impossible conditions. Such specifications are useless and only delay the general appreciation of the value of specifications.

2. The requirements of the user should be the first consideration.

3. The specification should be drawn up by some competent authority and only by persons intimately acquainted with the limitations of textiles in general and specially of the particular textile and also appreciating the personal factors involved in the use of many textile testing methods.

4. The specifications should contain only the clauses necessary for the purpose in view; every case should be considered on its own merits.

5. Where definite requirements are called for it is absolutely essential that full particulars of the test method to be employed should be described in an appendix.

6. It should be clearly stated whether the specified values are average, minimum or what plus and minus tolerance is allowed.

7. As far as possible all ambiguity should be prevented and nothing left to the discretion of the tester.

8. When employing testing machines, such as a strength testing machine, the type, capacity, and all conditions, such as size of specimen and rate of loading, should be fully stated.

Certain factors about textiles are incapable of direct measurement, or can only be measured by means of very expensive apparatus possibly requiring very skilled use. Such measurements would not be required in any ordinary specification, but only in some rare case where such property was of the utmost importance as regards the use of the material. In ordinary commercial work it is common to include a clause to cover such properties, which stipulates that the material must be similar to a sealed sample in respect of, say, quality, texture, design, shade or finish. Such a clause could be used very unfairly to reject goods otherwise up to specification, if dependence was only placed on vision or touch; as practically any property can be measured in some way, it should be stipulated that rejection under this clause could only follow on report of actual measurement by some competent body, confirming the suspicion or opinion of the inspector based on personal observation.

The results of many textile tests depend considerably on the moisture content of the material at the time, which in turn depends on the temperature and humidity of the air in which the material has been stored. It is difficult to allow for changes in moisture content by a correction. To overcome the difficulty it has become fairly common in strength testing to specify that the material should be soaked in cold water. This is simple in practice, but there are objections and some doubts as to the soundness of the method.[1] The really sound method is to specify a temperature and humidity at which the test should be carried out, after a fixed number of hours' storage. Where a controlled room is not available, the conditions can be very well fulfilled by using a controlled box for storage of the samples from which they can be quickly taken and placed on the testing machine.

TESTING METHODS. CLASSIFICATION AND REMARKS

Owing to the diversity of the kinds of linen fabric manufactured and the numerous different uses to which they are put, and the number of different kinds of tests which might be applied, a detailed list connecting uses and test for each kind of fabric is clearly impossible. The tests might be classified in groups depending on the branch of science chiefly involved such as botanical, chemical, physical, and mechanical, but it is possibly more instructive and more convenient to base the classification on a grouping of the tests according to the chief purpose of the test as follows.

1. Durability Tests.
2. Tests of Personal Appeal.
3. Tests of Body Comfort.
4. Miscellaneous Serviceability Tests.

The connection between individual tests and the particular uses of various fabrics may be then illustrated by the following detailed list for each group.

Durability Tests

Durability means the ability of the made-up article to withstand the stresses and strains imposed by the conditions of active use. There is a class of goods, containing a very large percentage of the total linen goods made, in which this property of durability is of supreme importance and entirely overshadows any minor considerations as to appearance and so on. Here are to be found the fabrics used in national defence, such as Admiralty canvas, sailcloth, aeroplane wing covers, tent duck, hangar canvas, haversacks, tape, and belts; in the preservation of life and property, e.g., hose pipes, fire escapes, life belt covers, water buckets; or in transport, for tarpaulins, waggon covers, mail bags and so on. In all these cases, failure of the goods may endanger life, either directly or indirectly and also may incur enormous monetary loss by damage to covered or contained articles. In most materials used for domestic purposes such as for sheets and pillow cases, table covering and napkins, towelling, mattress covers

and so on, durability is a very desirable property but not always of predominating importance, as the consumer may be willing to effect a compromise between durability and some other property necessary to fulfil the dictates of fashion. Articles of clothing made of linen may also be required to have a satisfactory durability, consistent possibly with some other property, e.g., uniform and school dresses, shirts, collars, shoes, and handkerchiefs.

Now this matter of durability evidently does not depend on any one particular property of the material, but on (*a*) the nature and soundness of the fibrous material itself; (*b*) the structure of the yarn and fabric; and (*c*) the method of finishing. No matter what the fabric or what the service conditions, three conditions must be fulfilled simultaneously if the goods are to be of the required quality: (1) the fibrous material must be pure flax or as specified, undiluted with cheaper fibre of a less resistance to wear, (2) the material must be sound, undamaged by any chemical used in course of its manufacture, (3) the material must be of correct structure, not, for example, lightened by the use of finer yarn or fewer than the proper ends per inch and perhaps loaded up by inert foreign matter which would be removed in the first wash or exposure to wet. In some cases durability may depend to a very great extent on the efficiency of the application of some particular finishing material. These belong more to specialised types than to the general goods now being considered and will be dealt with later.

To allow a fairly comprehensive test of durability alone, a specification would need to contain a selection of the following, according to the actual circumstances.

(*a*) *Fibre identification.* The presence of fibres other than flax, even in a fully bleached cloth can be detected and the proportion estimated by the drying twist test.[2]

(*b*) *Chemical tests.*

1. Alkali Solubility Number,[3] in case of goods made from unbleached fibre, to determine the thoroughness of the boiling treatment which has been given. It measures the amount of non-cellulosic impurities which remains in the yarn. This test is a much better criterion than an estimation of the actual loss in weight produced, because different yarns may lose very differently in weight in the same boiling treatment. It is important in case of liability to mildew attack in service.

2. Solubility Number[4] in case of bleached goods to determine whether the material has been damaged by chemical attack. Cellulose degraded by chemical attack is soluble in caustic soda. The Solubility Number is the percentage of the material soluble in caustic soda at 15° C under standard conditions. The test can serve as a means of differentiation between attack in manufacture or in service.

3. Viscosity.[4a] Undegraded cellulose forms a thick viscous solution when dissolved in cuprammonium. The measurement of the viscosity of a ½ to 2 per cent. solution of a cellulosic material in cuprammonium gives a valuable indication of the extent to which the cellulose has been degraded. The greater the degradation the lower the viscosity of the solution. The solubility number test and viscosity test are also used in conjunction to distinguish between acid tendering and oxidation.

4. Copper Number. Its determination gives an indication of the amount of non-cellulosic impurities plus modified or degraded cellulose present in the material. The main value of copper number is that it affords an indication of the degree to which a bleached material may be expected to become yellow in storage. Low copper number indicates little degradation, provided it is known that the material has received no treatment with alkalies subsequent to any treatment that may have caused degradation. Solubility number is increased only by chemical attack. Copper number may be increased by the growth of bacteria.

5. ACIDITY, to determine by spotting with suitable indicators presence of free acid left in material. May affect special finishing materials to be applied later, or in warm storage may cause development of tenderness.

6. ESTIMATION OF STARCH.[5] A weighed sample of fabric is boiled in dilute sulphuric acid which converts the starch into a sugar which in turn is capable of producing copper oxide from a standard copper solution which can then be measured and the amount of starch present originally found. This is much more accurate than removal of starch by successive boilings and determining the loss in weight.

7. ESTIMATION OF LOADING, by burning in a crucible and determining the ash content.

8. ESTIMATION OF FAT AND WAX, by extraction with chloroform in a soxhlet.

9. MERCERISATION.[6] Owing to the high natural lustre of flax, mercerisation does not always cause such an increase in lustre as to make the treatment obvious. A chemical test depending on the absorption of methylene blue is used.

(*c*) *Analysis of Structure.*

1. Determination of weight in ounces per sq. yard.
2. Determination of ends per inch.
3. Lea of yarns warp and weft.
4. Thickness, as an indication of the severity of finishing conditions.

(*d*) *Mechanical Tests.*

1. Tensile Strength.
2. Extension at break.
3. Impact Test, work to break.
4. Tear Strength.
5. Bursting Strength.
6. Resistance to Wear.[7]

Some type of mechanical strength test, usually that of tensile strength, is included in specifications as an indication that the material is up to a required standard of quality. This is not altogether reliable, unless at the same time certain other requirements are met, because the tensile strength may be affected by so many factors, and weakness due to chemical attack may not show till after some further treatment. Certainty of equivalence in quality is only assured when a satisfactory strength is accompanied by the correct structure and freedom from chemical deterioration.

In a recent paper[1] all these mechanical tests were compared on a set of linen fabrics. The tear test was concluded to depend on the yarn used, not on the cloth structure; the impact test and the bursting test depend on the strength and on the extensibility of the cloth. The tensile strength and the extension can be measured directly and moreover the stretch was shown to depend on the corrugations in the yarn, that is, on the cloth structure. Hence it was concluded that for general testing purposes there is no need to do more than take the tensile strength and check the structure by analysis. The resistance to wear as measured on the machine designed by the Linen Industry Research Association depends on the cloth structure in both directions and gives results which are not always in agreement with the tensile strength, being very sensitive to the effects of finishing processes. The impact and bursting tests have some advantages as regards ease of manipulation, and for some purposes they are to be preferred to the tensile strength.

Tests of Personal Appeal

Under this heading may be included the properties on which depend the personal appeal of certain articles to the user. Among these are characteristics which are appreciated by the eye, such as lustre, colour or whiteness, transparency and draping, or by the touch, such as softness, stiffness, thickness, smoothness. The fabrics chiefly concerned in these connections are any dyed or bleached goods, table linen, such as cloths, napkins, mats, etc., dress linen, handkerchiefs, curtain and upholstery fabrics.

Now no test has yet been devised which can measure the extent of the appeal of any article to a given human being. The object of the scientific tests is to measure in some way certain identifiable characteristics in terms of which different fabrics may be compared. It is true that the eye and hand can be trained to perform marvels in the way of carrying out such inspection work, but it is also true that they may be sometimes badly deceived. This matter has been briefly referred to in the previous section on specification tests, and in this case the personal inspection test is still very generally permitted. At the present time the greatest use of the tests available is in connection with investigation work which results, for example, in the determination of the comparative suitability of dyestuffs for different purposes or in the determination of process details in order to give various desired effects.

The varied tests which have been employed in these connections are as follows :—

(*a*) *Optical.*

1. Measurement of lustre,
2. Measurement of transparency.
3. Measurement of whiteness.
4. Measurement of colour.

These measurements are made with some form of optical photometer, specially arranged for the purpose. For the measurement of lustre and colour, there is an instrument[8] designed and manufactured by the Cambridge Scientific Instrument Co. in collaboration with the Linen Industry Research Association. It consists of an illuminating device and a comparison photometer, both of which move over a semi-circular travel bar. By moving the photometer it is possible to observe the fabric at any angle above or below the reflecting angle for any given angle of illumination. The movable source of light permits observations to be made at any angle of incidence. The fabric is kept flat and the necessity of cutting a sample for measurement obviated.

The photometer is also provided with a set of colour filters which enables the colour of a fabric to be measured in terms of a spectral reflection curve.

Another instrument is the Goerz Glarimeter, which measures only the light reflected at a fixed angle.

The Zeiss-Pulfrich Photometer can be used for the measurement of lustre and transparency, and by the addition of the Zeiss Colour Multiplicator, whiteness and colour can also be measured.

For other methods reference may be made to the works of Barker[9] and Cunliffe.[10]

Carrying out these tests on samples before and after exposure for varied times to different storage conditions, to real or artificial sunlight, or to other practical conditions of use such as laundering, permit estimation of the permanence of the appearance. Determination of the fastness to light of dyed fabrics is one of the most important and well-known aspects of these problems ; investigations have been much assisted by the introduction of apparatus embodying artificial sunlight lamps such as the " Fade-ometer " and " Fugitometer."

(*b*) *Chemical.*

1. Fastness of dyestuffs to washing. The following tests have been standardised :—

(i) One 10 minutes boil in two per cent. soap solution.
(ii) Ten 10 minutes boils in two per cent. soap solution.
(iii) One twenty minutes boil in two per cent. soap plus two per cent. soda ash solution.

(*c*) *Physical.*

1. Thickness.
2. Stiffness by bending test.

In addition the analysis of the structure of the fabric and various chemical tests as to the amount and nature of the finishing materials employed would possibly need to be carried out. The draping quality of a fabric is a complex property depending on several other properties such as thickness and stiffness, and has been very fully discussed by Peirce.[11]

Tests of Body Comfort

Under this heading are included a number of tests which are used purely for research work to investigate the relation between fabric structure and body comfort when the fabrics are used in close proximity to the body, as, for example, in the case of underclothes or outer coverings, or for bed clothing. In this section interpretation of results must be very difficult and controversial, and whatever the result there will always be a large number of people whose use of any particular fabric will be dictated by the decree of fashion or personal fancy, totally irrespective of considerations of real suitability or efficiency. Much has been published on the subject of which several résumés have been made recently,[12,13] but from a textile point of view a lot of it is useless owing to the totally insufficient descriptions of the materials used. On the physiological side the position appears to be more definite, and it is agreed[14] that for the body to feel comfortable, the skin must be maintained in a dry condition, and the temperature of the body should be maintained at normal body temperature, except for fluctuations within somewhat narrow limits, which have a distinct stimulating effect. Consider the conditions of a clothed human body situated, say, in a room. The body generates heat by the combustion of food and excess heat is dispersed by radiation and by the excretion of perspiration through the pores. If the body was covered by an impermeable covering sealed tight at all extremities, the body would quickly become surrounded by a layer of saturated air at body temperature ; the body could then lose no more heat so its temperature would rise, and the feeling of discomfort would increase as the heat loss decreased. On the other hand, if heat is lost by the body faster than it is generated, the body will cool with an ever-increasing discomfort. Hence the clothing must be so adjusted that heat can be lost at just the right rate. This right rate obviously depends on the circumstances and it would be impossible to lay down any hard and fast rule. Considering the general circumstances of fit and the properties of textile materials, various writers have connected the suitability of fabrics for clothing in terms of such specific properties of the material as :

1. Permeability to saturated vapour.[15]
2. Permeability to radiant heat.[16]
3. Permeability to air.[17]
4. Conductivity of heat.[18,19]
5. Heat retaining power.[14]
6. Absorbency.
7. Ease of drying.

As between fabrics made from different materials, there are other factors to consider, such as smoothness, softness, shrinkage in washing, and so on. Leaving these aside and considering only a fabric made from one particular kind of fibre, it is obvious, that of these seven measurable properties, some will predominate in some particular circumstances, and the relative importance of the properties will depend on whether the fabric is to be used as under or outer garments, whether the surrounding air is stationary or moving, whether the conditions are tropical, and on the shape and closeness of fit of the garment. During the last few years much work has been carried out on the measurement of these properties by Gregory,[15,16] Speakman,[18] Marsh[13,17,19] and also unpublished work has been done by the Linen Industry Research Association.

Our work on the permeability of fabrics to saturated vapour very largely confirms that of Gregory[15] in showing that fabrics differing very widely in material

and construction, show but little difference in vapour permeability under approximately still air conditions, although these same fabrics would differ very considerably in air permeability. This appears to indicate that this property cannot be of importance in a fabric used for clothing under normal conditions, not only because so little difference is observed but also because it is fairly obvious that openings have to be provided, and by the movements of the body, a flapping action will occur which will have the effect of creating air movements and in addition direct air ventilation may occur. The latter effects will be much more effective in removing saturated air vapour from the layer of air next the skin than any permeability effect through the fabric itself.

As regards the ability of the fabric to prevent loss of heat from the body, consideration shows that this may occur as evaporation of perspiration, radiation, convection (or by air currents over the skin), and by direct conduction by the fabric if in contact. Having regard to the prevailing conditions, the latter effect appears to be the least important from a practical standpoint and requires elaborate apparatus and considerable care in carrying out the measurements. It can be shown from the results of Rood[20] and has been shown independently by Speakman[18] that the conductivity of a fabric is related to its thickness and to its porosity or air content. The work carried out by the Linen Industry Research Association has followed the lines of that of Prof. L. Hill[14], using the fabrics as coverings to a Kata-thermometer ; the whole apparatus is very compact and arrangements were made to use it in an enclosure under controlled air conditions. Experiments have been made with fabric in contact with the bulb and with various air gaps, also with dry and damp fabrics in still and in moving air. The results show that the heat retaining power of the fabric covering is varied to a much greater extent by changes in the closeness of construction, in the air velocity, and in the moisture content of the cloth than by alteration of the material used in its construction. Thus the heat conductivity and heat retaining power are more dependent on the air content of the fabric than on the material of which it is composed. The latter, however, may become of importance by virtue of the dependence of the heat retaining power on the moisture content. For instance an undergarment may keep the skin dry very efficiently, if it is very absorbent by contact and can also dry very quickly, assuming intermittent contacts by the flapping movements already mentioned. The total moisture which can be absorbed, the rate of absorption, and the rate of drying are all properties capable of measurement. To some extent they vary with the fabric construction, but to a very much greater extent with the nature of the material and the way in which the material has been treated during manufacture. In both respects, it is very difficult to find anything which can beat well bleached linen. In passing it may be noted that these same properties of absorbency and ease of drying are of very great importance in connection with towellings of all kinds, for which purpose linen is universally recognised as the most suitable material.

As regards the uses of fabrics for clothing purely on account of efficiency, the conclusion indicated is that to a very great extent the nature of the material is of far less importance than the structure, and the latter needs variation to suit the particular circumstances. It is always an advantage to have the fabric maintained in a dry condition ; high absorbency and easy drying are also essential properties. The structure required on account of efficiency must also be presentable in appearance and pleasant to wear.

Miscellaneous Serviceability Tests

There are many other kinds of test which have been described to measure some property in a fairly restricted class of goods, so that any attempt at classification is impossible. The following are a few of the best known :—

1. *Resistance to Mildew Attack.*[21]

Many heavy ducks and canvases are exposed to wet in use, and they may be folded up and stored away without being properly dried. Under these circumstances mildew may grow and weaken the material. A method has been evolved whereby such growth may be brought about deliberately under repeatable and controlled conditions. The efficacy of various finishing materials as preventatives of such mildew attack may thus be tested.

2. *Water Percolation Test.*

In the case of many heavy fabrics used as coverings, either proofed or unproofed, such as for waggons or as tents, it is important that they should be able to prevent, during very heavy rain, direct penetration leading to a continual dripping of water from the under side. A test has been in use in which the material is folded like a filter paper into a cone placed inside a funnel and filled with a certain quantity of water, and the rate of leakage determined. There are several objections to such a method, and it is being replaced by a pressure test[22] in which a disc is subjected to a water pressure ; the result may be given as the pressure at which percolation occurs or as the time before percolation occurs when a constant pressure is applied.

3. *Waterproof Tests.*

In the case of fabrics very heavily coated with waterproofing material, for example waggon covers, tarpaulins, etc., a severe test such as the pressure test could be employed. Other fabrics intended for outer garments are showerproofed by special processes which do not obviously change the appearance. A showerproof test[23] is employed in such cases, water being allowed to drip at a certain rate from a fixed height till water appears on the under side.

4. *Bulging under Wind Pressure.*

In materials used for structures such as tents, wind screens, awnings and so on, or in aerial work for aeroplane wing covers, airship covers and the like, it is of importance to know to what extent the structure can be deformed by bulging owing to extension of the material under the influence of wind pressure. An apparatus called an Elasticity Meter[24] has been described in this connection by the Royal Aircraft Establishment, Farnborough.

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DISCUSSION

Owing to Mr. Matthew's indisposition a synopsis of his paper on " The Testing of Linen Fabrics from the point of view of their uses," was given by Dr. W. H. Gibson, O.B.E., Linen Industry Research Association.

The Chairman, Mr. W. Kershaw, said in connection with tests for the degradation of celluloses he would like Dr. Gibson's opinion as to the viscosity test and the solubility number. It is difficult from the literature to decide which test is preferred.

In reply, Dr. Gibson said that in general the viscosity test is to be preferred for indicating the extent of degradation of cellulose. The solubility number is more convenient in use, and particularly in the case of linen, may be relied upon if it is known that the material has not been degraded by acid. That is, a high solubility number always indicates extensive degradation, but a low solubility number does not necessarily indicate a small amount of degradation.

Professor W. E. Morton asked whether in work on the wearing properties of fabrics, any comparative tests of mercerised and unmercerised material had been made.

In reply to Professor Morton, the author states that some comparative tests on mercerised and unmercerised linen fabrics have been made. Fabrics were woven from 40's lea, $\frac{3}{4}$ white yarn in two settings; the fabrics from the first and closer setting were beetle-finished in the usual way and those from the more open settings were mercerised and shrunk, and then beetle-finished in the same way as the unmercerised to approximately the same width. Tests of the resistance to wear were then made on the L.I.R.A. cloth rubbing machine on warp and weft strips from the finished fabrics. The following results were obtained :—

Weave.	Unmercerised.				Mercerised.			
	Ends per inch		Rubs to Break		Ends per inch		Rubs to Break	
	Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft
Plain	54·2	50·7	446	370	51·2	47·7	334	287
2/2 mat.	54·3	53·0	346	291	52·0	46·0	345	234
4 leaf twill	55·0	51·8	337	306	52·0	44·0	334	225
Crêpe (4 end) ...	54·8	51·7	363	331	51·8	44·3	341	221
Oatmeal	55·0	51·0	379	265	52·3	44·7	318	201

The final settings of the two types of fabrics are not equal, paticularly in the weft. The resistance to wear varies considerably with the weave. It is difficult to make any correction for the difference in settings, as both the warp and weft settings will affect the result. It appears, however, so far as can be judged from these results, that in the plain weave, the mercerised is considerably less resistant than the unmercerised; in the other weaves there is not much difference in the case of warp strips but a slight decrease in the mercerised weft strips. The effect is evidently complicated and further investigation is required before any final conclusion can be drawn.

Mr. H. C. Barnes said that from the point of view of the user they were all admirers of linen fabrics, particularly in regard to lustre, whiteness, and crispness. They were supposed to become even more beautiful as they were handed from one generation to another. During the last 20 years or so linen seemed to have lost the reputation for beauty and durability which had been built up for it in the literature of the last 500 or 600 years. He asked whether it was not to the interest of the linen industry to ascertain whether this loss of reputation was due to modern methods and processes, to processes used in the laundry, or to marketings.

In reply to Mr. H. C. Barnes, Dr. Gibson said that he could not agree that present day linen was in any way inferior in beauty to that made in the past. As regards the durability of linen, this was a question on which very extensive investigations were being carried out by the Linen Industry Research Association. So far as manufacturing processes are concerned, there have been changes, more particularly as regards the bleaching process and the more extensive use of dyes. If these processes are carried out properly, and research is providing numerous methods for their control, the linen at present made should not be in any way inferior to that made long ago, if used in the same way. These remarks, of course, must be taken as applying to good quality, sound material. Owing to economic conditions in the last few years, there has been a demand for cheaper materials; these may be quite sound but made to a lighter weight, or they may be defective goods sold at scrap prices. In either case, the material will not be so durable as the better quality. The consumer should realise that in the long run, the better quality will be the cheaper. There has undoubtedly been a change in the conditions of use, viz., the change from home laundering to public laundering, with a consequent considerable increase in the severity of the process, owing to the use of chemic and the mechanical wear experienced in the rotary washing machines. The conditions vary considerably in different laundries, but even under the best conditions a rotary washing machine is severe on the materials laundered.

Mr. H. B. Heylin said that before the Research Associations came into being there were many official specifications which showed a lack of technical knowledge. When he joined the War Office service he found inconsistencies in different departments for drawing up textile specifications. Specifications should not be made out merely to safeguard the consumer. He believed in helping the manufacturer as much as possible by giving him all the essential details. Specifications should be helpful, and if they were drafted in a helpful way there would not be that antagonism mentioned by Mr. Matthew. He was sure the Research Associations would benefit by having more practical problems put before them. At the end of the War, the War Office investigated the failings of linen material. The work done at that time was of an exhaustive nature and involved the carrying out of over 45,000 tests. The problems were offered to the Linen and Cotton Industry Research Associations. In due course attention was given to these tests by the Linen Industry Research Association. Investigations were independently made and the government committee's work to ensure more durable supplies of linen duck was proved substantially correct. Since then a great deal of work had been done by the War Office and linen duck manufacturers in collaboration. Dr. Gibson had had a great deal to do with the completion of that work, and he hoped that this type of co-operation would be continued and developed in the future.

In reply to Mr. H. B. Heylin, the author is pleased to note his concurrence with the general notes on specifications. The Linen Industry Research Association always welcomes any practical problems which may be placed before them. In such investigations co-operation between the user and the manufacturer is essential, and can be very effectively obtained by the Research Associations.

CHEMICAL TESTS IN THE WOOL INDUSTRY

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Chairman: DR. J. B. SPEAKMAN

It is proposed in this paper to review briefly the various chemical tests relative to wool and its manufacture, these tests being employed in the laboratories of the Wool Industries Research Association.

In order to confine this paper within reasonable limits, I have added an appendix into which are placed details of tests mentioned.

If we begin with a consideration of raw wool, we find that it consists of :—

	Per cent.
Wool Fibre	15 to 72
Yolk (Grease and suint) ...	12 to 47
Vegetable matter, dirt, etc. ...	3 to 24
Moisture	4 to 24

The above constituents are tested for as follows :—

The wool is spread out in the humidity room kept at a standard humidity and after twenty-four hours is ready for sampling.

Moisture is determined in a specially designed bottle which is heated in an electric oven.

Grease is estimated by extracting 20 grams of dried wool with dry benzene in an all-glass soxhlet apparatus. The extracted grease is examined for traces of suint, which are removed by washing a petroleum ether solution of the extracted grease with 50 per cent. alcohol.

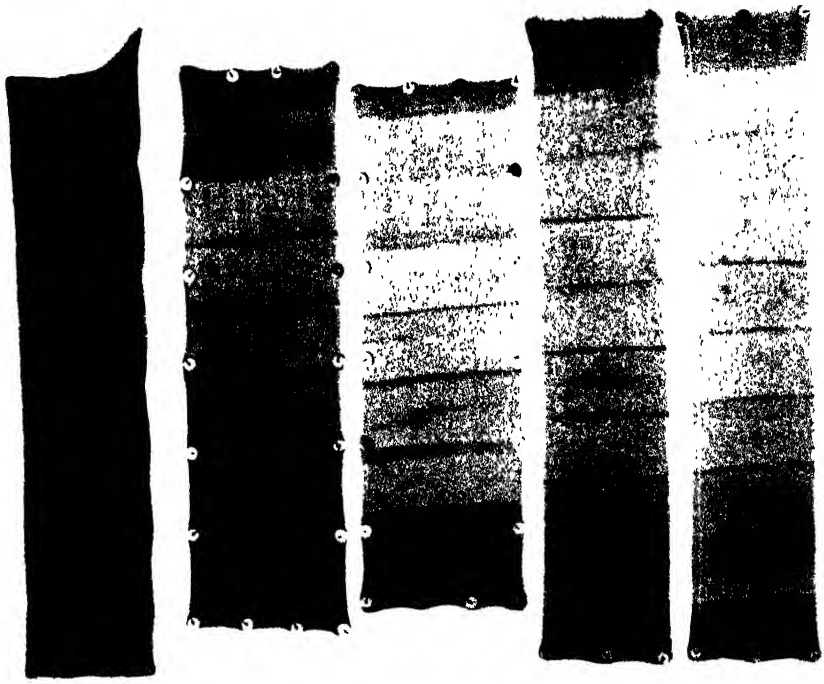
Suint is removed from the benzene extracted wool by soxhlet extraction with water, and the percentage of suint is determined from the dried aqueous extract plus the trace of suint obtained from the grease.

Wool and dirt. The extracted wool is dried and weighed, then washed in warm soapy water and finally in plenty of warm water to get rid of dirt, care being taken to avoid fibre loss. The vegetable matter is hand picked from the wool and the clean wool is then dried and weighed, the amount of dirt being estimated by difference.

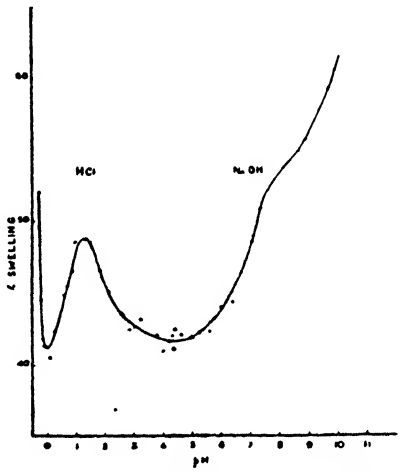
We have now arrived at the stage when it will be advisable to consider some properties of wool. Microscopic examination shows the wool fibres to consist of a thin external layer of scales adhering to a solid central cortex which constitutes the main body of the wool. Chemical analysis reveals wool to contain Carbon, Hydrogen, Oxygen, Nitrogen and Sulphur together with a small amount of inorganic matter. Wool protein or keratin is of a complex but unknown composition, but when it is treated with certain hydrolysing agents, which open up the protein molecule by the addition of water molecules, a number of substances result. The chemical constitution and quantity of these hydrolysis products is known. They are found to be amino acids which therefore possess amphoteric properties, i.e., uniting with acids in acid solution and with alkali in alkaline solution. Wool possesses amphoteric properties and the acid or alkali taken up by the wool has a great influence on its swelling, power of attracting moisture and its behaviour throughout the various processes from the raw material to the finished article. The following diagram shows the swelling curve of wool in acid and alkaline solution.

Estimation of Alkali in Wool

We are now in a position to consider the testing of wool for alkali taken up during Wool Washing, Scouring and Milling processes. On the basis of the amphoteric properties of wool, Hirst and King[1] have devised a method for the estimation of alkali in wool. Terephthalic acid, which is a stronger acid than soap acids but which has a very low solubility, is used (at 20° C., 1 litre of water dissolves only 0·0168 grams of this acid, less than 2/1000 per cent.) The sodium salt, however, is very soluble in water and is not decomposed by CO_2.



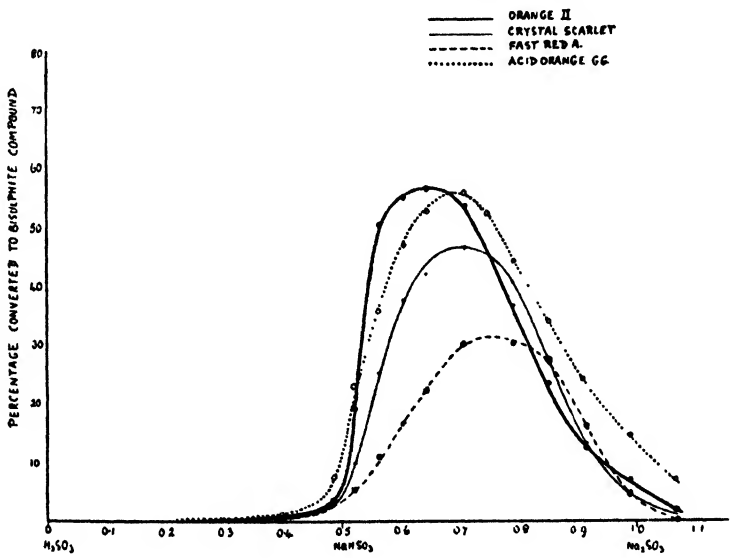
On adding excess of this acid to wool, the alkali present is converted into the soluble sodium salt of the acid; the wool becomes acid, and the sodium terephthalate is then free to diffuse through the solution. The terephthalic acid is used merely as a vehicle for the extraction of alkali from the wool and the amount of this acid taken does not enter into the calculation. Full details are given in the appendix.



(From *J. Soc. Leather Trades' Chemists*)

Indicators have been found to be very useful for the testing of cloth for alkalinity. King[2] utilised indicator-dyed cloth for the investigation of the migration of alkali to cuttle edges of pieces during the drying of moist cuttled piece goods and for uneven distribution of alkali in pieces, as shown in the photographs.

The presence of alkali in wood is found to have an effect on dyestuffs and King[3] showed that certain azo-dyes which normally are unaffected by sulphur dioxide in the presence of acid, are seriously affected if the wool or yarn dyed



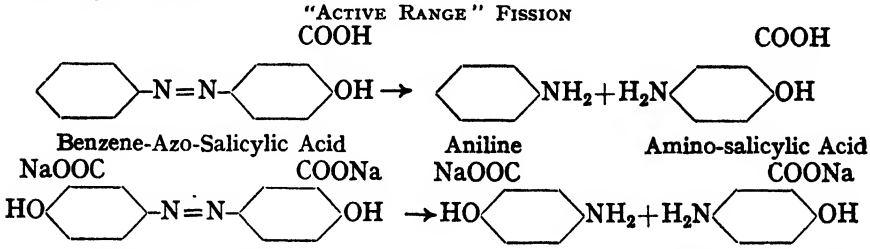
(From *J. Chem. Soc.*, 1927, **132**, 2641)

material is alkaline when finished. The extent of the change depends upon the amount of alkali in the wool since the more alkaline the wool, the greater is the amount of sodium hydrogen sulphite formed, with the consequent production of the bisulphite compound of the dye. The following graph indicates the percentage of dyestuff in N/50 solution.

With Sulphur Dioxide (H_2SO_3) alone there is no reaction in the acid range, but as the percentage of alkali increases, we see there is a range about *p*H7 where the maximum formation of the bisulphite compound occurs. These compounds possess a different shade from the original dyestuff, are more soluble and fade much more easily than the original dye.

A typical example of another chemical action involved with other types of dyes is given below.

"Active Range" Fission

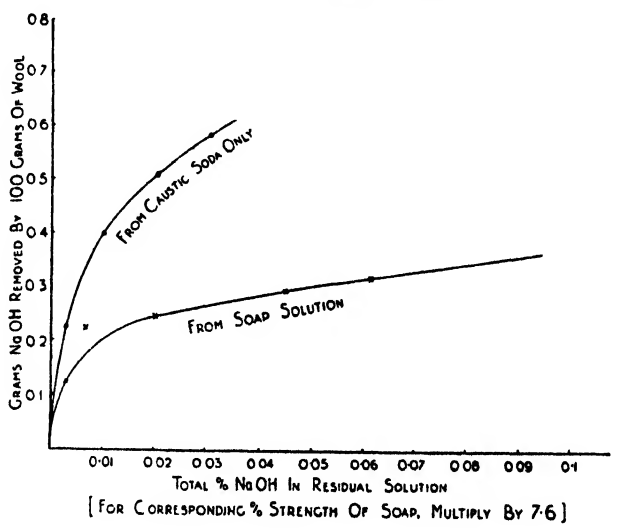


As a result of this work, King[17] has produced a new stoving test for dyestuffs, which is described in the appendix.

Estimation of Soap in Wool[18]

When an unknown sample is submitted for analysis, it is first necessary to extract with petroleum ether to remove oil as such. This oil should be examined for soap and if present should be determined. The wool is then extracted with alcohol to remove the soap, and it is found that extraction with alcohol gives excellent results. Before use the alcohol should be re-distilled and neutralised and all operations should take place in glass vessels.

Since neutral soap is " caustic " to wool and as scouring with neutral soap alone is not practised in the majority of scouring processes, there will be obviously an absorption of alkali by the wool. The following is a graph of the results obtained, showing the absorptive effects of caustic soda and soap solution. A similar curve for sodium carbonate would presumably lie between the two curves on this graph.



Oil Testing

The usual standard methods of oil analysis are employed, but it may be of interest to note that for the determination of iodine values, although Wij's solution is quite satisfactory for routine work, in special cases where oxidation has occurred or in the case of wool grease, it is preferable to use Hübl's solution, for the following reasons. Holde[4] found on using Hübl solution, that Cholesterol gave an iodine value of 73 to 77 (65·7 theoretical) and Phytosterol 41 to 76 according to the time given for the reaction, but with Wij's they gave the value of 135 for both, which is approximately double the theoretical value. McLean and Thomas[5] found that the acid in Wij's solution acts in certain cases as an enolysing agent on carbonyl compounds and that the addition of halogen then takes place. The Hübl agent, being neutral, has little or no enolising action.

The effect of ultra-violet light and the use of the fadeometer have been found by Hirst[6] to be of service for testing both samples of oils and pieces for spots of oil, and also to account for the development of stains in dyeing.

A highly unsaturated oil or one containing unsaturated impurities shows, under ultra-violet light, an intense fluorescence on the surface of the oil, the deep penetration of the light being prevented by the screening effect of the unsaturated material. If the oil be diluted with non-fluorescing purified paraffin or petroleum ether, a value may be obtained by dilution at which the fluorescence extends downwards throughout the whole of the oil.

Mineral Oils

Give a yellow to brown stain when subjected to sunlight or to the fadeometer and show with ultra-violet light a fluorescence from blue to white respectively. Highly purified mineral oil such as medicinal paraffin gives no stain on exposure to sunlight or to the fadeometer, and shows no fluorescence with ultra-violet light. A typical American spindle oil gave a blue fluorescence and on being exposed for 175 hours in a quartz tube to the fadeometer, a brown precipitate formed which was insoluble in petroleum ether, whilst the fluorescence was then seen to have changed to white.

Spots of Mineral Oil on cloth show a blue fluorescence, and on being submitted to sunlight or to the fadeometer or for a much shorter time to steaming in air, oxidation takes place. On subjecting the cloth to a light scour and then dyeing, it is found the spot now appears to be darker in shade than the remainder of the piece, indicating a greater penetration of dyestuff or increased dyeing affinity at the spot.

Vegetable Oils

Give varying shades of fluorescence from blue to yellow but usually a blue. Cotton Seed Oil after twelve days' exposure in a quartz tube to the fadeometer gave a yellow fluorescence and after six weeks, no fluorescence. As would be expected the iodine value of the oil decreases with time of exposure and the viscosity of the oil increases.

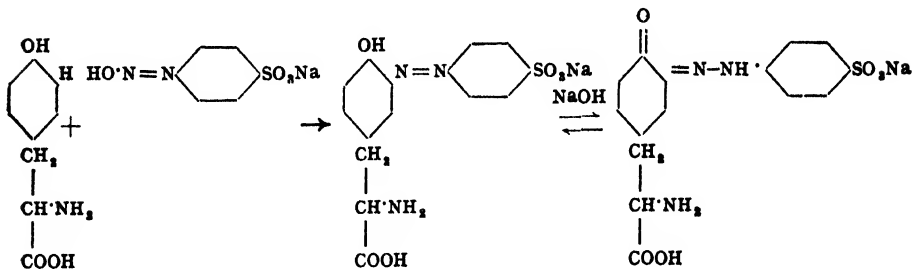
Spots of Vegetable Oil on wool do not exhibit pronounced fluorescence because this is similar to the fluorescence of the wool. On being exposed to sunlight or the fadeometer or for a shorter time to the action of steam in air, oxidation occurs and the spots resist the action of a light scour. On dyeing the cloth, the spots appear to be of a lighter shade than the remainder of the piece.

Olive oil has been found to take the longest time of the vegetable oils tested before it resists to scouring and dyeing. Particulars of the scouring and dyeing processes are contained in the appendix.

Harsh Treatment of Wool in Process Work

Harsh treatment in process work is detected by the Pauly Test which has been developed by Rimington and Burgess[7] for the quantitative estimation of rough treatment or damage. Pauly utilised the fact that portions of the wool fibre, namely the cortex below the epithelium scales, are capable of coupling

with diazotised sulphanilic acid with the formation of a brown colour whilst the scales are unaffected. The test is in fact Erlich's well known diazo reaction for Phenols, Hydroxy Aromatic Acids and Imidazols. The chemical reaction with Tyrosine is given below, Histidine also being involved in the reaction.



Tyrosine | Diazotised Sulphanilic Acid | Enol form | Keto form

PAULY TEST FOR TYROSINE

Sieber[8] employed Benzopurpurine 10B for this purpose and found it unnecessary to diazotise the dye.

Kronacher and Lodemann[9] use Methylene Blue, while Herzog[10] uses a cold saturated solution of indigo-carmine, and to emphasise the colour, he then stains the scales with picric acid.

Sulphur in Wool

There are two chief methods for the determination of sulphur in wool. These are based on the oxidation of sulphur to sulphate and the simultaneous destruction of the organic matter. The methods are as follows (1) The Carius Method. This method is found to be excellent, the chief disadvantages being the labour in sealing the tubes and the cost. (2) The Benedict Denis Method. This process is rapid but there is a danger of losing material during the ignition and not only is it necessary to use high class chemicals, but also duplicate blank determinations should be made on the reagents. Both methods are described in the appendix.

The following are typical figures obtained by Barritt and Rimington:[11]

Sample	Total S by Carius method % dry weight	Total S by Benedict Denis method % dry weight
Crossbred 50's wool	3·46	3·47
Turkey Mohair (coarse)	3·03	3·02
White Alpaca	3·92	3·85
Crossbred 40's wool	3·02	3·03

Estimation of Total Nitrogen

The Kjeldahl method is employed and found to be quite satisfactory for nitrogen estimation.

Barritt[12] obtained the following typical figures in dry wool.

Australian Merino 58's ...	16·63%
Australian Merino 60's ...	16·78%
Australian Merino 64's ...	16·63%
Welsh Mountain	16·54%
Alpaca White	17·00%
Alpaca Brown	16·66%
Alpaca Black	15·85%

Effect of Alkaline Scour on Nitrogen Content.—1 per cent. sodium carbonate scour on New Zealand Wool caused an increase in the nitrogen content of 0·25 per cent. calculated on the wool or an increase of 1·50 per cent. of the total nitrogen.

2 per cent. sodium carbonate scour on Black Alpaca increased the nitrogen content by 0·37 per cent. calculated on the wool or 2·33 per cent. of the total nitrogen.

This indicates the removal of a soluble portion of lower nitrogen content than the original wool by this alkaline treatment.

Effect of Carbonising on Nitrogen Content.—Two samples of burry wool carbonised with 10 per cent. Sulphuric Acid showed a decrease in nitrogen content of 0·20 per cent. and 0·22 per cent. respectively calculated on the wool or a 1·20 per cent. and 1·31 per cent. loss of nitrogen.

Effect of Chlorination on Nitrogen Content.—Barritt also treated worsted cloth with Chlorine Water and estimated the chlorine taken up by the wool and the percentage of nitrogen. The following figures were obtained.

Percentage Chlorine taken up by the cloth	Loss of N calculated on cloth	Loss of Total Nitrogen
	%	%
3·53	0·04	0·24
6·89	0·18	1·09
10·26	0·23	1·39

Inorganic Matter

Wool is difficult to ash on account of the fact that it swells up and froths under the effect of heat.

I have found the use of a saturated solution of ammonium nitrate in 67 per cent. alcohol for wetting the wool, to assist the combustion and to promote the formation of a porous carbonaceous mass. The burning-off is conducted in the fume cupboard and the crucible is finally heated in the muffle.

A successful process for dissolving the wool prior to ashing, is to use hydrochloric acid as in the Benedict Denis method. Twenty c.c. of a 20 per cent. solution of ammonium nitrate solution are added, the solution evaporated to dryness, heating in the fume cupboard, and the fixed carbon finally burnt off.

Estimation of Metals in Ash

The question of inorganic chemical and micro-chemical analysis here arises. I propose to summarise by stating that in addition to ordinary analytical methods employed, the micro methods of Pregl[19] and of Feigl[20] are used when necessary. The hydrogen electrode is used for checking hydrogen ion determinations and for the micro analysis of such ions as the determination of Calcium ions, and of Chlorine ions, and the use of the glass electrode is being investigated.

It may be of interest to conclude by indicating the lines on which chemical testing is being investigated.

Copper Iron and Manganese promote oxidation of organic matter causing discolouration stains and spoil first class bleaching. The use of sulphocyanate for the detection of iron has generally met with the greatest response in laboratories.

The red colour with ferric salt is due to undissociated salt and its double compounds, the ionised salts are colourless, and the reaction is interfered with to a certain degree by fluorides, phosphates, arsenates, oxalates, citrates, tartrates and iodates, and to a less degree by acetates and sulphates.

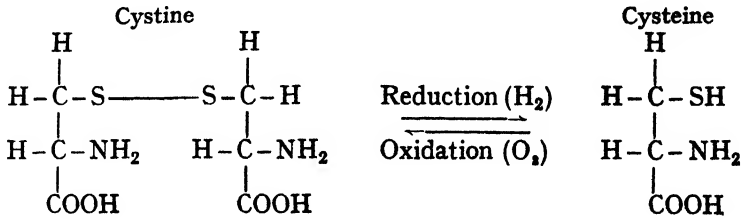
Feigl[20] gives the recognisable limits with Ferric Iron.

Potassium Sulphocyanate $2{\cdot}5 \times 10^{-7}$ grams.

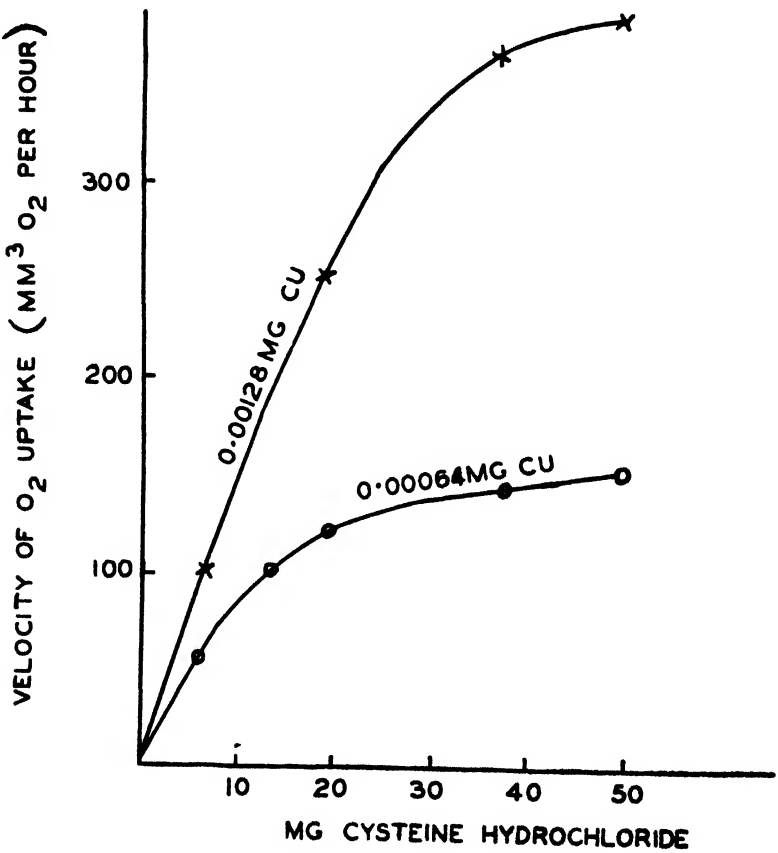
Potassium Ferrocyanide 5×10^{-8} grams.

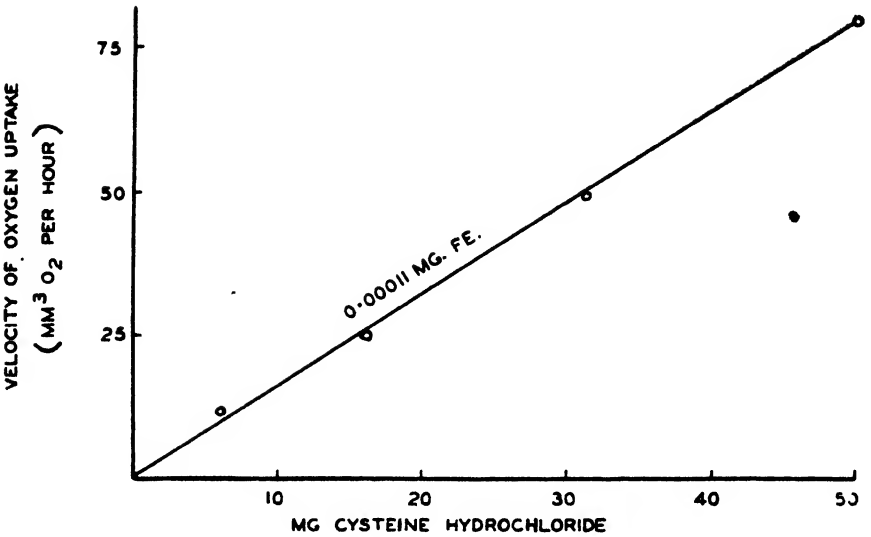
Ferrous Iron.
Dimethyl Glyoxime 4×10^{-8} grams.
size of drops 0·05 c.c.

A most delicate micro method for the determination of minute traces of copper and iron has been employed by Warburg[13] who studied the catalytic effect of iron, copper and manganese on the rate of oxidation of Cysteine to Cystine as shown in the following equation.



By this method he succeeded in determining the amount of iron, copper and manganese in 1/10 cubic centimetre of blood serum, Elliott[14] obtained the following graphs showing the velocity of oxygen uptake in the presence of small amounts of copper and iron respectively.





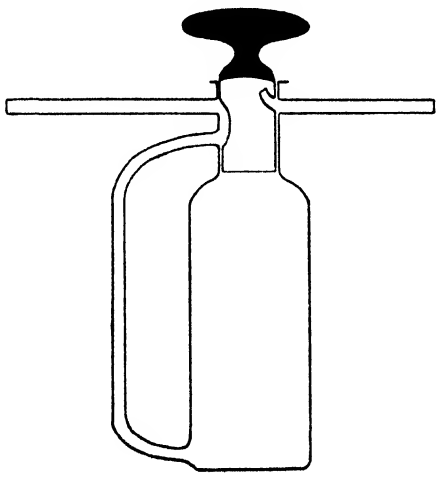
The catalytic effect of iron and manganese can be totally prevented by the addition of pyrophosphate which does not affect the activity of the copper.

As cystine exists in the keratin molecule in wool to the extent of about 13·1 per cent. and as free cystine is completely converted into cysteine by excess of sodium sulphite, the above reaction is being worked upon to see if there is any possibility of the micro analysis of iron, copper and manganese *in situ* on the wool.

APPENDIX

MOISTURE DETERMINATION

Moisture is estimated by the use of a special bottle (see diagram).[21] One position of the tap enables a current of air to be drawn through the wool, the air entering at the bottom of the bottle. On turning the tap through 90° the bottle



is completely closed. The bottle containing the weighed wool sample (about 1 gram) is heated in an electric oven at 104° – 106° C., and a current of dry air,

dried by means of the usual drying agents (sulphuric acid and calcium chloride) drawn through.

After 1½ to 2 hours the tap is closed and the bottle then transferred to a desiccator for half-an-hour and then weighed. The bottle is re-heated for half-an-hour and its weight taken. This is repeated until the weight is constant and in almost all cases two re-heatings are sufficient.

ESTIMATION OF WOOL DIRT, GREASE AND SUINT

The method outlined below is that according to Sutton,[15] but slightly modified.

The wool is spread out in a room of fairly uniform temperature and humidity, and after 24 hours is sampled. Two gram samples are used for the determination of moisture content.

For the grease determination 20 grams are taken and dried at 105° C. to a constant weight. The sample is then transferred to an extraction thimble (43 mm. × 123 mm.) care being taken not to pack the wool too tightly. The extraction apparatus is insulated by means of asbestos tape and the extraction carried out with dry benzene for six hours. The benzene is evaporated off and the grease dried at 106° C. and weighed.

This grease should be then examined for complete freedom from suint by burning a portion and testing for an alkaline ash. If this is present a known quantity of the grease is taken, dissolved in petroleum ether and washed several times with 50 per cent. alcohol in order to separate the suint from the grease. The purified grease obtained by distilling off the petroleum ether is then dried and weighed. If desired, the trace of suint may be recovered by distilling off the alcoholic washings, drying, and weighing.

The wool after extraction of the grease is gently dried in the thimble to get rid of benzene. It is then soxhlet extracted with water for six hours, the extract in the flask being taken to dryness and weighed. This residue is the suint.

The extracted sample of wool is then removed from the thimble, rinsed first in warm water, then in warm soapy water and finally in plenty of warm water, any foreign matter being picked out. After air-drying the clean sample is dried at 105° C. and weighed. The weight of soil, seeds and other matter is obtained by difference.

ESTIMATION OF ALKALI IN WOOL

Hirst & King[1]

Take 10 grams of wool to 200 c.c. of water, warm and add an excess of terephthalic acid, usually 0·4 grams, raise the temperature to 60° C., stir and allow to stand for two hours. Pipette off 50 c.c. into a beaker and add 15 c.c. of N/10 acid to decompose the sodium terephthalate, filter off the terephthalic acid from the cold solution and wash with cold water collecting the filtrate and washings in a conical flask. Titrate the filtrate and washings with N/10 sodium hydrate using Phenol Phthalein or Phenol Red as indicator. Multiply the difference of the alkali used from the acid added by four. The result is equivalent to the amount of alkali in the wool.

The correction for the slight solubility of Terephthalic acid, namely 0·0168 grams per litre, is only necessary when the volume of the washings becomes excessive.

ESTIMATION OF MINERAL ACID IN WOOL

Hirst & King[1]

Take 10 grams of wool to about 100 c.c. of water, warm and add an excess of sodium terephthalate, usually 50 c.c. of N/10, make up to 200 c.c., raise the temperature to 60° C, stir and allow to stand for three hours. Pipette off 50 c.c. into a beaker and add 15 c.c. of N/10 acid to decompose the sodium terephthalate. Filter off the terephthalic acid from the cold solution and wash with cold water collecting the filtrate and washings in a conical flask. Titrate the filtrate and

washings with N/10 sodium hydrate using Phenol Red or Phenolphthalein as indicator. Multiply the difference of the alkali used, from the acid added, by four. This result is then equivalent to the amount of undecomposed *N*/10 sodium terephthalate. The difference between the quantity of N/10 sodium terephthalate originally added and the undecomposed N/10 sodium terephthalate found is equivalent to the acid contained in the wool.

ESTIMATION OF SOAP IN WOOL[18]

The alcohol used should be redistilled and neutral and preferably absolute. The material for analysis should be placed in a soxhlet extractor of 200 c.c. capacity. 10 grams of top or worsted sliver or 26 grams of 9 oz. worsted cloth are used. All operations should take place in glass vessels without corks.

Preparation : The dried sample is extracted in the soxhlet with petroleum ether to remove oil. This oil should be examined for soap, which if present should be determined by extraction with 50 per cent. alcohol as in suint analysis.

Temperature : It is necessary to maintain the temperature of the alcohol and wool in the extractor at or near boiling point. To secure this the extractor is covered with asbestos paper or tape.

Duration of Extraction : Almost complete extraction of the soap is obtained by filling and emptying the extractor twelve times with hot liquor ; the time taken is five to six hours. For ordinary analysis, twelve extractions are sufficient.

Treatment of the Solution : The solvent is filtered hot, before evaporation, through a thin Swedish filter paper No. 1.F. The bulk of the alcohol is distilled off, leaving about 50 c.c. This is poured into a wide mouthed flask of 100 c.c. capacity and the distilling flask is washed into the same. The alcohol is then evaporated to dryness on a water bath, and the residue dried in a steam oven, cooled in a desiccator under diminished pressure and weighed until constant. The extract is boiled with 60 c.c. distilled water, methyl orange or methyl red being added. A known excess of N/10 acid is then run in (25-30 c.c.), boiled and allowed to cool, and shaken out with ether three times. The ether must be neutral and is made so by re-distilling over lime. The ether is washed with water and the water added to the liquor. On evaporation the ether extract gives the total oil and fatty acid in the alcohol extract.

Fatty Acid : Dissolve the oil thus obtained in absolute alcohol or alcohol and ether, add a few drops of a 1 per cent. solution of phenolphthalein in alcohol and titrate with a tenth normal aqueous alkali. The end point is a pink colour which lasts two minutes, though after that it will probably disappear.

In the case of difficulty in seeing the end point owing to the darkness of the solution it may be necessary to adopt the method of Bödtker who shakes the oil with 25 c.c. of alcohol, 50 of water, sufficient N/10 soda to give a strong red colour with phenolphthalein and then titrates back. In each case also a fluorescent dye such as Eosin can be used as an indicator.

Soap : The residual liquor after shaking with ether is titrated back with N/10 NaOH and the difference between added acid and back titration is calculated as sodium oleate.

Calcium : The calcium soaps are included above as sodium oleate, but may be determined as follows :—The liquor after shaking with ether and back titration for soap is evaporated to dryness, washed with a little ether and dissolved in water. Ammonia, ammonium chloride and ammonium oxalate are added and the mixture allowed to stand for several hours. The precipitate is filtered, washed and dissolved in warm 2 per cent. sulphuric acid, then titrated hot with N/10 potassium permanganate. From this the amount of calcium is calculated and expressed as calcium oleate (or sodium oleate). With one set of extractions 0·09 per cent. calcium soap has been obtained.

NEW STANDARD TEST FOR FASTNESS TO STOVING

King[17] makes use of cloth dyed with Bromthymol Blue which he uses as indicator cloth, and he carried out the test as follows :—Whilst the dye under test is being applied to the cloth, a similar pattern of Bromthymol Blue indicator cloth is treated in an acid bath under the same conditions with the exception that the dye is omitted. The two patterns are washed off together to leave the same residual acidity. They are then treated together in the soap solution until the yellow indicator cloth changes to a greenish blue shade, preferably matched against a standard, otherwise there is a little uncertainty as to alkalinity of the patterns.

The pattern under test is now divided into two portions, and these, along with the indicator cloth pattern are hung in the stoving vessel. One portion is removed immediately the indicator cloth pattern has become just yellow (which requires a minute or so), put aside under a bell jar over water to keep it damp, and examined along with the other portion when this is removed at the end of the stoving period. The fastness is expressed thus :—

Ordinary Test	Alteration	Bleeding
New Test.	Alteration	Bleeding

WOOL SCOUR FOR OIL TESTS AND DYEING PARTICULARS

Scour for 20 minutes in 0·2 per cent. Potash Olive Oil Soap and 0·1 per cent. Soda Ash, 50 c.c. per gram of cloth at 45° C. with constant agitation in thermos flask. Wash in running water. Dye with 0·5 per cent. Fast Blue R.H. and 5 per cent. of 50 per cent. Acetic Acid.

TEST FOR HARSH TREATMENT IN PROCESS WORK[7]

Solutions required

Sodium Sulphanilate 10 per cent.	88·7 grams of sulphanilic acid dissolved in one litre of water containing 20·5 grams of sodium hydroxide.
Sodium Nitrite 8 per cent.	80 grams dissolved in one litre.
Sodium Carbonate 9 per cent.	243 grams of the crystalline salt in 1 litre.
Sodium Hydroxide 10 per cent.	100 grams dissolved in water and made up to 1 litre.
"New Acid Brown S" 0·1 per cent.	1 gram of dyestuff dissolved in 1 litre of water and the solution filtered.
Concentrated Hydrochloric Acid.	Density 1·16.

The reagent is prepared by mixing 10 c.c. of a 10 per cent. solution of Sodium sulphanilate with 5 c.c. of an 8 per cent. solution of sodium nitrite, then adding 2 c.c. of concentrated hydrochloric acid down the side of the vessel, mixing with a gentle motion and allowing to stand for one minute before use. A sample of the material is taken weighing about 0·1 or 0·2 grams (greasy wool should be washed first in benzene or ether) and wetted out in 15 c.c. of a 9 per cent. sodium carbonate solution, and to this the reagent is added. After exactly 10 minutes the wool is withdrawn, rinsed thoroughly in water and transferred to a test tube. 4 c.c. of 10 per cent. sodium hydroxide solution are then added and the tube placed in a bath of boiling water for exactly 5 minutes. The tube is cooled under the tap and the resulting reddish solution transferred to one (" Wool ") of two similar graduated measuring cylinders, marked " Standard " and " Wool " respectively. Water is added, rinsing out the test tube to bring the volume up to 25 c.c. In order to compare the strength of this solution with the standard (0·1 per cent. New Acid Brown) it is necessary to use a Dubosc or Rober colorimeter, or else the cylinders are placed side by side on a sheet of white paper near to a window and sufficient standard dye solution is poured into the cylinder marked " Standard " until, when viewed from above, the colour appears identical in the two.

When a match is obtained the volume of solution in the " Standard " cylinder is recorded.

Construction of the Numerical Scale

For convenience it has been decided to assign the value of " 100 units of damage " to a sample of wool (or cloth), such that 0·1 gram treated as above and made up to 25 c.c. final volume gives a solution of colour intensity exactly equal to that of the standard dyestuff (0·1 per cent.) Values are then calculated for individual samples as may be seen from the example worked out below.

Weight of sample taken 0·100 grams.
Total volume of final solution, 25 c.c.
The standard dyestuff solution set at 13·7 matched the wool solution set at 25.
The number of units of damage for the sample is therefore

$$\frac{13{\cdot}7}{25} \times 100 = 54{\cdot}8$$

A convenient formula is obtained as follows.

Let the volume of solution in the standard cylinder be S. and W. = the weight of wool taken.

$$\text{Damage} = 100 \times \frac{S}{25} \times \frac{0{\cdot}1}{W}$$

$$= \frac{S}{W} \times 0{\cdot}4 \text{ units.}$$

DETERMINATION OF NITROGEN

For each determination two samples of wool are taken. One sample about 0·7 grams in weight for the Kjeldahl digestion and about 1 gram for the determination of moisture content.

The Kjeldahl method employed is as follows. (J. Barritt.[12]) The sample is heated gently for about an hour with 20 c.c. of nitrogen free sulphuric acid, and the flask allowed to cool; 10 grams of potassium sulphate are added and the contents of the flask boiled until colourless, the heating being continued for at least 1 hour. The cold liquid is then poured into 100 c.c. of cold water contained in the distilling flask of an ammonia distillation apparatus, and the flask rinsed with successive small quantities of water, which are also transferred to the distilling flask.

The apparatus used for the ammonia distillation is that described by Stock[16] with minor modifications; 25 c.c. approximately 0·5N sulphuric are distributed between the receiver flask and the attached Peligot tube, the acid in the Peligot tube being coloured by the addition of two drops of methyl red. A few pieces of pure zinc foil are dropped in the distilling flask, to the contents of which a few drops of methyl red are added. Strong caustic soda solution is run in from a funnel, care being taken that the liquid seal is not broken so as to ensure that no gas escapes.

The time of distillation is of the order of 1½ hours and the contents of the flask and Peligot tube being finally washed out into a 600 c.c. beaker and titrated with approximately 0·1N sodium hydroxide, the end point being very sharp.

Duplicate determinations agree usually to within 1 in 150 and are often more concordant, and a blank determination carried out using 1 gram of dextrose gave a result affecting the determination to less than 1 part in 400 and was therefore neglected. The results obtained on the wet weight of the wool are reduced to the standard basis of dry weight from the determination of moisture content made on the control sample.

ESTIMATION OF ORGANIC SULPHUR

Preparation of Material

The sample is treated two or three times with sulphur free benzene at about 45° C. to 50° C., air dried and then hand sorted to remove all small particles of foreign matter. It is re-washed in benzene, dried off, washed with 0·1 per cent.

saponin solution in distilled water, then washed with many changes of distilled water, dried and allowed to condition in a suitable room free from sulphur fumes and maintained at a definite relative humidity.

Weighing out of the Wool or Hair

Samples of the order 0·25 to 0·5 grams are weighed out for sulphur determination and a sample of about 1 gram is taken for a moisture determination which is best carried out by the " Bottle " method of Barritt and King (supra), the principle of the method being to dry out the wool by heating to 104° C.—106° C. in a current of dry air.

Determination of Sulphur

(1) *Carius Method* (Barritt and King).[21]

About 3 c.c. of fuming nitric acid (S.G. = 1·53) are transferred by means of a long funnel and pipette to the bottom of a Carius tube, and the wool transferred by means of forceps and pushed down the tube to within about 6 inches of the bottom by means of a glass rod. The tube is then sealed in the usual manner, and estimations are carried out in duplicate for each wool. The tubes are heated together in a Carius furnace and in a period of about 1½ hours the tubes are raised to 250° C. and maintained at this temperature for 8 hours. Each tube is allowed to cool overnight and is opened up by softening the tip with a bunsen flame, a pressure being found in the tube. After withdrawing from the furnace and cutting off the ends, the tubes are gently warmed to expel dissolved gases and the contents washed into beakers, evaporated to dryness (on steam) with the addition of hydrochloric acid, this being repeated to remove all traces of nitric acid, which is detrimental to the sulphate estimation.

About 100 c.c. of hot distilled water are added, and the contents filtered off to remove any trace of glass introduced when opening the tubes. The liquid, about 400 c.c. in volume, was acidified with dilute hydrochloric acid, heated to boiling and precipitated by the slow addition of 50 c.c. of boiling N/20 barium chloride solution. After keeping hot for some hours and allowing to stand overnight, the barium sulphate was collected and estimated on a weighed Gooch crucible in the usual way. It should be especially noted that to ensure complete breaking up of the wool it is essential that the temperature of the tubes be not less than 200° C. and further that only a short length, at most one inch, of tube project beyond the iron furnace tube.

(2) *Benedict Denis Method.* Rimington[11]. 10 c.c. of hydrochloric acid solution (2 parts concentrated acid, 1 part water) are pipetted into a silica crucible (40 c.c. size) which is then heated on the hot plate until the contents begin to simmer. The wool is added (0·2 to 0·5 grams), using a glass rod to aid transference from the weighing bottle, and the mixture warmed with gentle stirring until solution is effected. 1 c.c. of Benedict Denis solution is then added and the mixture evaporated to dryness on the water-bath; a further 4 c.c. of reagent is added, followed by evaporation, after which the crucible is covered with a lid of the " peaked " or " platinum shaped " type. The contents are *carefully* ignited with a small flame directed first obliquely downwards on the lid thus heating the contents by reflux. A vigorous reaction occurs accompanied by some decrepitation and for this reason it is essential that the lid should be well fitting. When crackling has subsided, the full flame of the bunsen is directed on to the bottom for 2 to 3 minutes and the crucible then allowed to cool. The lid is removed and placed in a suitably sized evaporating basin; 5 c.c. of 10 per cent. hydrochloric acid solution are then added together with a little water and the basin is heated until its contents boil. Any particles adhering to the crucible lid are dissolved during the operation, the solution together with washings being transferred to a beaker. The open crucible is next heated to red heat for 10 minutes, allowed to cool, and the contents are dissolved (by heating on the water bath) in 10 c.c. of 10 per cent. hydrochloric acid to which are added about

10 c.c. of water. No undissolved particles should remain: if specks of carbon are present, the operative procedure must have been at fault. Solutions and washings are transferred to the beaker: the combined liquids are filtered, and precipitation is accomplished by running in 25 c.c. of hot 10 per cent. barium chloride solution, the main bulk of the liquid being maintained just short of boiling temperature. After keeping overnight, the precipitate is filtered, washed, and dried in the usual way.

Benedict Denis Solution

25 grams Copper Nitrate, 25 grams Sodium Chloride, 10 grams Ammonium Nitrate per 100 c.c of solution.

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DISCUSSION.

Dr. J. B. Speakman, Chairman, introducing the foregoing paper, said that one important matter to be kept in view was that twenty years ago the whole of textile testing was in the hands of trade consultants working individually, the number of tests available was limited and their reliabliity open to question in many instances. More recently, through the activities and development of Research Associations, new chemical tests had been developed and others perfected. He believed this was the first occasion on which the various tests had been collected together with practical details summarised in an appendix. The paper was, therefore, likely to form the basis of all chemical testing in the wool textile trade, and the responsibility of the meeting was correspondingly great in so far as the discussion must reveal whether the scheme given by Mr. Hill was a suitable one in every respect.

The Chairman, opening the discussion, said it was a pity Dr. Krais was not present so that his views might have been secured. Whereas Dr. Krais appeared to prefer mechanical tests, the Wool Industries Research Association recommended Rimington's modification of the Pauly test. Both methods had their peculiar

disadvantages, and there was still room for the development of a sound method for estimating fibre damage. As regards the Pauly test, Rimington's modification was certainly ingenious, but it was not sufficiently sensitive to reveal the different degrees of fibre damage caused by suint scouring as compared with the best soap scouring practice. Some difference did exist and could be detected in spinning, but no method of testing yet suggested could measure small differences in the extent of fibre damage of this type.

In regard to the testing of oils, wool fat presented peculiarities in determinations of iodine value. From work which he had done, it was found that the value obtained depended on the time of reaction, the excess of reagent used and the method employed. For any one time of reaction and excess of reagent, different values for iodine value were obtained by Hubl's, Wijs' and Dam's methods. Hence wool fat could not be given an iodine value unless the method of testing were defined, and the time of reaction and excess of reagent specified. This was very rarely done in the literature of the subject.

The behaviour of an oil in scouring was extremely difficult to estimate, and the only technique which would give sound results was one using a model piece-scouring machine, driven mechanically, the ratio of scouring liquor to wool being exactly as in trade practice.

Finally, referring to Fig. 1, Dr. Speakman said that the method used by Meunier and Rey to measure swelling could not fail to give incorrect results. The swelling of wool at $p\mathrm{H}\,0$ was certainly not the same as at $p\mathrm{H}\,4$, contrary to what the figure indicated.

Mr. Hill, in reply to the Chairman, said it should be clearly understood that the Wool Industries Research Association did not recommend the Pauly test for the estimation of mechanical damage in preference to mechanical tests. In this paper, which was confined solely to chemical testing, the Pauly test along with Rimington's modification was included because he had found it to be useful in supplying information of definite evidence of surface disturbance of the scales of the wool fibres. He instanced the case of two tops of similar botany wool which had been scoured under similar conditions but the finished top in the one case gave a lively handle and a slight Pauly reaction, while the handle of the other top was relatively dead and gave an intense Pauly reaction. These differences would be easily shown by rigidity tests on the individual fibres, but the time taken would be much longer than that taken by the Pauly test. For these reasons he included the test.

The difference between suint and modern soap scouring was not entirely one of scale damgae.

Iodine values for oils were merely to indicate the degree of unsaturation of the molecule, and considerable work had been carried out in the laboratories of the Research Association on iodine values, and also on bromine and cyanogen values. It was easy to obtain reliable iodine values by taking the precautions referred to in the paper.

The laboratory scouring test mentioned was mechanically shaken and was a test which could be used in any laboratory and which gave reliable results on the oil tests mentioned in the paper.

The classical Meunier and Rey curve was inserted to indicate that wool swells under the action of acids and alaklies. Any similar curve would equally illustrate the point and the question of any small deviation of the curve from absolute accuracy had no bearing whatever on the chemical tests contained in the paper.

Mr. T. Morley asked whether the lecturer referred to skin wool or fleece wool and in reply, Mr. Hill said it was fleece wool. Mr. Morley then asked how one accounted for the difference and Mr. Hill replied that this difference was caused by mechanical damage due to carding or combing or both.

Mr. Sever said he imagined the combing would not change the character of the top to any great extent.

Mr. Hill said that the question of damage in combing depended on the type of comb and the various factors relative to the machine the wool and the labour.

In answer to Mr. Copley, who asked if the wool was dyed, the Lecturer said it was not.

At the conclusion Mr. Hill expressed his thanks to Dr. Speakman for officiating in the Chair.

COMMERCIAL STRENGTH STANDARDS FOR LINEN YARNS AND FABRICS

By W. J. COWDEN, F.T.I.
(Public Textile Testing and Conditioning House, Belfast.)
Chairman: Mr. H. C. BARNES

This short paper deals exclusively with flax products, the subject matter being mainly summaries of the results of many tests made on commercial yarns and fabrics and deductions drawn from the same; it is not intended to set forth or lay down any hard and fast rules regarding tensile strength standards for linen goods, but rather, by means of expressing some of the results of our experience in the Belfast Textile Testing House, to endeavour to focus attention on, and create interest in a subject which is of considerable importance to all engaged in the manufacturing, buying and selling ends of the trade.

Those who are engaged in commercial textile testing are often required to determine or express an opinion as to whether a submitted or inspected yarn or cloth, conforms to, or is equal to the standard which would be expected for its reputed or specified quality and particulars of manufacture.

It is generally difficult, and usually unsafe, to judge the quality of textile materials by mere inspection or handling; skill in manufacture and finishing can give a fabric the appearance of a quality which is superior to its real nature.

In such a " quality " determination, the average breaking load and regularity of a yarn in relation to its lea and spin; or the actual tensile strength of a fabric as compared with its setting, yarns, weight and finish, are usually the most important of those factors, which in the aggregate, go to make up what is termed the *quality*. Any undue deficiency in the strength of a yarn or cloth is an indication of some of the following defects:—use of inferior flax, spinning or weaving faults, wrong cloth structure, overbleaching or overfinishing, or the presence of injurious chemical agents in the material.

In the absence of recognised standards (other than specifications in some cases) for the tensile strength of textile materials of different qualities and makes, and having regard to the great variations in setting and lea numbers which occur in the same type of goods, we endeavour to secure a basis for guidance and comparison by ascertaining the average relation which exists between the weight and the strength of cloths of the same character.

YARN TESTS

The lea number or size of the yarns, the setting and the weight of a cloth can be accurately determined and expressed in terms of recognised standards, each of these three factors, threads, lea and weight, has a definite relationship to the other two, but the strength of the component yarns in a fabric depends on, or is influenced by a number of factors including:—

1. Quality of Flax Fibre.
2. System of preparing and spinning.
3. Draft.
4. Reach.
5. Temperature of water in spinning.
6. Twist.
7. Method of drying.

The most important of these factors is No. 1., as, assuming other conditions to be similar, the relative strengths of yarns of the same lea number will depend

almost entirely on the quality of the fibres from which they have been spun, so that for any given lea number of yarn, the strength or average breaking load of the single threads and the *quality* are practically synonymous and interchangeable terms.

As linen fabrics are manufactured in various grades, from the coarsest to the finest textures, the character of the yarns purchased by a cloth manufacturer is regulated by his particular requirements, to suit the class of material woven; therefore yarns of the same lea number are spun with considerable variations in *quality*.

Broadly speaking, linen yarns may be divided into a few main qualities, according to the classes of work for which they are generally used, and as the strength of yarns of the same quality varies inversely (approximately) as their lea numbers, the relative strengths for the different lea numbers in each quality may be estimated by the formula S = K/L, where K = the strength "constant" for quality, L = the lea number and S = the average breaking load in ounces.

K being the theoretical strength for 1^{s} lea yarn in each quality.

Table I—Linen Yarn Strength Constants

Based on summaries of various tests made on Porter or Mulholland machines, 36″ reach, traverse of pulling grip = 45 inches per minute.

Line Quality	Use	Strength Constants		
1	Linen material of the highest tensile strength and quality	$\frac{2000}{\text{Lea No.}}$	=	Average single thread breaking load in oz.
2	Double Damasks and Superior Linen goods	$\frac{1600}{\text{Lea No.}}$	=	,,
3	High class linens	$\frac{1400}{\text{Lea No.}}$	=	,,
4	Medium linens	$\frac{1200}{\text{Lea No.}}$	=	,,
5	Line weft yarns	$\frac{1000}{\text{Lea No.}}$	=	,,

FINISHED FABRICS

The results of many hundreds of combined sett, weight and tensile strength tests carried out on commercial fabrics, coming from various sources, indicate that for cloths of the same type and quality, though differing in relative setts, yarns and weights; there is a fairly definite relationship between the weight per square yard of the fabric and the tensile strength results.

The relative strength of the warp as compared with the weft will vary according to the number of threads per inch and the lea of the warp and weft yarns, but the combined strength of the warp and weft for any given make and quality of cloth under normal conditions, seems to bear a certain ratio to the weight in ounces per square yard of the fabric.

The actual relation between the weight and the strength of a submitted cloth as compared with the average relation of same in fabrics of a similar make or type of material, should serve as an indication or guide to the quality.

Tables II, III, and IV are summaries of threads, weight and strength tests made on representative commercial samples of Bleached and Finished Damasks, Bleached and Finished Sheetings, etc., and ordinary Bleached and Finished Linens.

The breaking load or strength tests were made on 12″ × 2″ strips, 7″ between grips, on a Goodbrand machine (1000 lb. capacity) at a traverse of 18 inches

per minute. The warp and weft results are an average of six tests of each (dry tests).

The manufacture of Double Damask fabrics requires the use of warp and weft yarns of a high strength, usually $\frac{1600}{\text{Lea No.}}$ = ounces-standard, or over.

Theoretically this strength of yarn (ignoring the influences of weaving) should produce a cloth with a combined warp and weft strength when tested in the standard manner on 2″ wide strips, 7″ between jaws, 18″ per minute traverse, equivalent to 100 lbs. for each oz. in the weight per square yard.

When tested in this manner, the relation or ratio between the weight and the strength would be :—

Weight per sq. yard.	Expected Combined strength of warp and weft in lb.
4 ounces	400 lbs.
5 ounces	500 lbs.
6 ounces	600 lbs.
7 ounces	700 lbs.
8 ounces	800 lbs.
pro rata for intermediate weights.	

Table II—Bleached Linen Double Damask

Ref. No.	Total threads per sq. inch	Weight per sq. yard in ozs.	Breaking load in lb.			Combined Strength of Warp and Weft — Ounces per sq. yard
			Warp	Weft	Combined Warp and Weft	
C.2529	283·5	7·1	330·8	423·2	724	101·9
N.4020	207·5	6·65	276·5	351·5	628	94·4
N.4184	252	6·0	317·5	302·5	620	103·3
C.3919	202·5	6·92	329·3	317·3	647·1	93·5
C.3655	216	6·68	297	355	652	97·6
C.3489	223	5 85	308	257·2	565·2	96·5
C.3490	224	6·40	311·2	339·7	650·9	101·7
C.3522	166	5·85	328·5	219·7	548·2	93·7
N.3012	203	6·38	329	286·5	615·5	96·9
C.2827	227	6·65	307·4	355·2	662·6	99·6
N.2866	258	6·63	336	364	700	105·6
C.2867	225	6·48	313	333	646	99·7
C.2795	228	6·83	305·4	363	668·4	97·8
N.2796	227	6·28	308	341	649	103·3
N.1986	248	6·40	316·6	335	651·6	101·8
C.1705	255	6·74	316·5	356	672·5	99·8
C.1706	257	6·88	310	368·3	678·3	98·6
C.1707	171	6·28	295·5	299·5	595	94·7
C.1543	192	6·42	324·2	290·8	615	95·8
C.1246	252	6·02	334·5	270	604·5	100·4
N.920	210	6·90	292	409	701	101·6
C.922	213	7·03	321	377	698	99·3
N.628	196	6·28	253·5	331	584·5	93·0
C.9801	284	6·26	240	428	668	106·7
N.9821	209	5·38	306·3	204·7	511	94·9
N.9646	204	5·45	344·7	223·2	567·9	104·2
N.9033	194	7·0	324·3	226·3	590·6	84·3
C.7093	210	5·89	276	308	584	99·1
C.7089	208	6·82	314	317	631	92·5
C.7451	196	6·32	362·6	266·6	629·2	99·5
	AVERAGE	6·426				98·39

Average of the actual tests = 98·39 lbs. Theoretical Standard = 100 lbs.

Table III—Bleached Linen Sheetings and Pillow Linens

Ref. No.	Total threads per sq. inch	Weight per sq. yard in ozs.	Breaking load in lb.			Combined Strength of Warp and Weft ÷ Ounces per sq. yard
			Warp	Weft	Combined Warp and Weft	
9304	134	4·53	183·3	147·2	330·5	72·9
8643	121	5·18	168	191·5	359·5	69·4
0270	176	5·50	217	193·7	410·7	74·6
9851	136	3·98	166·3	137·3	303·6	76·3
9696	136	5·65	203·8	231·7	435·5	77·1
9740	172	4·86	217·6	188·5	406·1	83·5
7478	135	6·20	223	237·5	460·5	74·3
7046	139·5	6·30	241	256	497	78·9
7128	135	6·48	214·5	240·2	454·7	70·2
3620	145	5·95	204·7	181	385·7	64·8
3624	129	5·60	207·6	158	365·6	65·2
3645	128	5·34	245·5	158·8	404·3	75·7
3648	125	4·15	171·7	147·4	319·1	76·9
3649	131	4·92	214	181	395	80·3
3650	121	5·58	155·3	195·8	351·1	62·9
4169	138	6·71	311·3	223·5	534·8	79·7
4170	131	6·30	223·5	187·4	492·6	78·2
4171	131	5·72	212	174·4	386·4	67·5
4174	110	6·65	264·3	239·3	503·6	75·7
3912	164	4·71	181·7	174	355·7	75·6
3913	165·5	4·75	190·6	168	358·6	75·5
2819	107·5	4·42	161·6	183·5	345·1	78·0
2820	148·5	4·22	164·6	187·5	352·1	83·4
2821	131	3·85	145·6	121·1	246·7	64·0
2822	127	4·09	179·3	135·7	315	77·0
2610	150	5·51	216·2	227	443·2	80·4
1424	108·5	4·63	189·7	185	474·7	80·9
1494	111	4·51	181·7	178	359·7	79·7
1378	110·5	4·83	200	199	399	82·5
1380	110	5·86	219	305·5	524	89·5
	AVERAGE	5·23				75·7

Pillow linens and Sheetings are made from lower quality yarns than Double Damask fabrics, usually $\frac{1200}{\text{Lea No.}}$ = ozs. to $\frac{1400}{\text{Lea No.}}$ = ozs.

Results show samples 3620, 3624, 3650 and 2821 to be somewhat low in strength for their setting and weights.

Table IV—Bleached and Finished Linens

Ref. No.	Total threads per sq. inch	Weight per sq. yard in ozs.	Breaking load in lb.			Combined Strength of Warp and Weft ÷ Ounces per sq. yard
			Warp	Weft	Combined Warp and Weft	
3828	170	5·13	210	173·2	383·2	74·7
3862	132	6·11	256·2	197	453·2	73·1
3646	135	4·84	229·2	232·6	461·6	95·3
3459	124·5	4·07	214·8	177·8	392·6	96·4
2270	125	5·65	210·5	209·5	420	74·3
1291	142·5	5·0	207·2	197·7	404·7	80·9
1292	145	4·63	187	198·5	385·5	83·2
1346	97·75	8·42	288·5	414·2	702·7	83·4
1348	135	5·85	226·5	227·3	453·8	77·4
1389	227·5	3·54	152·2	131·7	283·9	80·2
0063	130	4·05	155·2	153·2	308·5	76·1
0774	169	5·03	235·3	171·2	406·5	80·8
0520	113·5	5·19	244·7	191·3	436	84
0350	143·75	4·50	184·5	171·8	356·3	79·2
0351	153	4·75	208·5	202·2	410·7	86·5
0353	150·5	4·34	159·6	164·8	324·4	74·7
0383	130	4·46	184·3	162	346·3	77·6
0384	129	4·73	188·2	169·5	357·7	75·6
9850	145·5	4·05	200	140·2	340·2	84
9961	119	5·52	243·3	193·8	437·1	79·2
9719	129	4·24	166·3	164·7	331	78
9776	175·5	5·30	215·8	200·2	416	78·5
9777	173	5·21	232·7	196·3	429	82·3
9049	131	4·41	146·3	121	267·1	60·7
9192	169	5·09	205·3	202·7	408	80·1
8440	109·5	6·68	232·7	342·3	575	86·1
7786	137·5	6·42	215·5	242·2	458·2	71·2
8166	135	5·96	205·2	234·2	439·4	73·7
7893	136	6·46	213·2	257·6	470·8	72·9
2822	131	3·13	145·6	122·1	267·7	70·0
	AVERAGE	5·11				79·0

For the usual qualities of bleached and finished linen fabrics, yarns of $\frac{1200}{\text{Lea No.}}$ = ozs to $\frac{1600}{\text{Lea No.}}$ = ozs. are used according to the purpose for which the cloth is intended.

Sample 9049 is somewhat tendered, due to overbleaching.

The tests set out on tables II, III, and IV have been taken at random and are fairly representative of the series in each class of fabric.

Further tests which are being carried out and summarised, seem to confirm that the factors of relative weight and strength have a close relationship for each type or class of linen goods and also that any undue fall below the average to be expected is an indication that the quality or finish is probably at fault.

DISCUSSION.

The Chairman, Mr. H. C. Barnes, said the contributor had given them considerable insight into the commercial and mill practice of the linen industry in regard to testing.

Answering Mr. Heylin who said he should have thought the dry test was practically dead, Mr. Cowden said he merely used the term dry test as opposed

to the wet test. Similarly when he referred to the lea, he was alluding to the size of the yarn. The actual yarn tests were on single threads. In the linen industry, the term " lea " was not used with the same significance as in the case of the cotton industry.

DETECTION AND ESTIMATION OF CHEMICAL DAMAGE IN WOOL*

By P. Krais, Dresden

To be able to estimate the amount of damage which is done or may be done to the wool fibre during the various alkaline, acid, reducing and oxydizing processes, it has to undergo during the manufacture of fabrics of any kind, has been a matter of importance since a long time. Very numerous proposals have been made in this direction. Colour reactions, the action of chlorine water, the coupling with diazo compounds, the estimation of soluble nitrogen, the biuret, sulphide of soda, bichromate and other reactions.

We do not think much of colour reactions in these cases, because they seem to give sometimes an exaggerated idea of the damage and we do not think one should alarm the industry without urgent need and without giving unmistakable proof.

Therefore, we maintain that any colour or chemical reaction which is to be accepted, must be corroborated in full detail by mechanical tests. It is not the chemical behaviour but the mechanical strength and elasticity, which count in the practical use.

Still, there is another point. We have observed that there are chemical damages, especially by alkali, which do show in the amount of soluble nitrogen, but have no effect upon the mechanical properties, unless an acid treatment, such as dyeing at the boil with sulphuric acid or bisulphate, has followed. These latent faults are, of course, very tricky. They do not show if you test the fibre mechanically in the dry state, but they show strongly in the wet state, the strength of the yarns as well as of the single fibres being considerably affected.

Under determination of soluble nitrogen we understand the method first proposed by *O. Sauer*, in 1916, and simplified by *Krais* and *Schleber*, in 1929. The total nitrogen contents are first determined by the Kjeldahl method, and then small quantities of the original and the treated samples are kept in a solution of alkali and hydrogen peroxide for three days, then filtered, washed, the filtrate acidulated and kjeldahled. (Exactly : ·1 g. of Sample with 8 c.c. water, 10 c.c. 1 per cent. hydrogen peroxide and 2 c.c. n/2 Potassium hydrate solution). The nitrogen going into solution (in form of ammonia, aminocarbonic acids, etc.) is calculated in per cent. of the total nitrogen. Thus we find in a fine wool about 4 to 5 per cent. soluble nitrogen in the original, in the damaged wool a rise up to 32 per cent. and more.

We give now two examples, which show the relations between chemical and mechanical tests. A fine wool of 24·9μ hair diameter (average of 1,000 measured fibres) and a 10 m. weight of 6·515 mg., corresponding to the metric Number 1535, and a coarser wool of 32·8μ diameter, a 10 m. weight of 9·85 mg. and the metric Number 1015 were treated as follows :—

I. **Alkali** : 3 hours at 80° C. in 3 per cent. Sodium Carbonate solution.

II. **Bleach** : treated cold with a ·1 per cent. Potassium Permanganate solution with excess of sulphuric acid, then with bisulphite and sulphuric acid.

III. **Weak acid** : boiled for 3 hours in a ·2 per cent. Sulphuric Acid solution (reflux cooler).

IV. **Strong acid** : boiled for 10 hours in a ·5 per cent. Sulphuric Acid solution.

After treatment the samples have been rinsed and dried at ordinary temperature.

* In the absence of the Author this paper was presented by Title only.

	Fine Wool Treatments					Coarser Wool Treatments				
	Original	I	II	III	IV	Original	I	II	III	IV
1. Soluble Nitrogen %	3·42	3·91	3·77	3·91	9·58	3·38	3·82	3·70	4·95	9·64
2. Breaking strength in g dry	11·2	11·7	10·3	11·1	6·7	19·9	16·3	21·6	19·1	10·4
3. ,, ,, ,, ,, wet	8·3	5·6	6·7	7·5	3·7	15·3	10·2	14·6	12·4	4·6
4. % wet of dry strength	74	48	65	67	55	77	62	63	65	44
5. Extension at breaking point in % dry	38·5	33·8	35·3	33·3	3·2	43·7	38·5	33·1	41·0	24·2
6. ,, ,, ,, ,, ,, % wet	63·6	51·2	55·8	50·5	34·1	66·6	61·1	64·5	53·2	39·0
7. Increase wet in %	65	51	58	51	970	52	59	95	30	60
8. Extension curves *dry:* good	82	52	70	55	—	94	81	94	94	33
9. ,, ,, ,, middling	18	22	20	33	3	6	15	3	3	33
10. ,, ,, ,, bad	—	26	10	12	97	—	4	3	3	33
11. ,, ,, *wet:* good	96	97	100	100	42	100	100	100	94	88
12. ,, ,, ,, middling	—	3	—	—	42	—	—	—	—	12
13. ,, ,, ,, bad	4	—	—	—	16	—	—	—	6	—
14. Breaking length in km, dry	17·4	17·9	15·8	17·0	10·3	20·2	16·5	21·9	19·4	10·6
15. ,, ,, ,, ,, wet	12·7	8·5	10·3	11·5	5·6	15·5	10·3	14·8	12·6	4·7

To the figures under 2, 3, 5 and 6 is to be said that they are averages of 25 to 30 dates each. Of every sample about 130 fibres have been gummed unto paper frames of 1 cm. free width, then the diameter has been measured and only those fibres have been tested, the diameter of which was within $\pm$ ·2 μ within the average diameter.

For the wet tests under 3 and 6 the fibres were wholly immersed into a 1 per cent. solution of Nekal BX for one minute and then tested in the immersed condition.

The classification of the extension curves, as given under 8 to 13, was made so, that the fibres showing all three periods (slow, quick, slow), which are found in the sound wool hair, were called " good," those showing only two were called " middling," and those breaking already within or shortly after the first period were called " bad."

The breaking length (14 and 15) in km. is found by multiplication of the metric Number by the breaking weight.

The apparatus we used is described in the *Journal of the Textile Institute*, 1928, p. T32.

It seems that, looking over the figures of the table, one might give up even the Nitrogen method as too little differentiating, and to rely exclusively on mechanical testing. And here we think, that the classification of the extension curves and the comparison of the breaking strength in g. or the breaking length in km. of the single fibres in the dry and wet condition gives us a very good measure indeed of the amount of damage done to the fibres.

In general we may say, that coarser wool is less affected by chemical treatments than finer wool.

NOTES AND NOTICES

Council of the Institute

The June meeting of the Council, held at Headquarters on the 15th of the month, was associated with so lengthy and important an agenda that it was decided to commence the meeting at 2 p.m. instead of at the usual time of 3 p.m. There was a good attendance and at the outset the President (Mr. George Garnett) moved the re-election of Mr. Henry Binns as Chairman. The re-election was carried unanimously and a similar vote was recorded in regard to the re-election of Mr. Frank Wright as Vice-Chairman. First consideration was given to certain proposals of a Special Committee in regard to the establishment of an Information Bureau and the publication of a Textile Dictionary. A good deal of discussion took place and, on the score of division of opinion, the matter was referred back to the Special Committee for further report and consideration of statements made at the Council meeting. Mr. Frank Nasmith was re-appointed Honorary Secretary of the Institute and Mr. W. W. L. Lishman Hon. Treasurer. A vacancy in the list of Vice-Presidents had arisen owing to the death of Mr. W. Anderson, of Portadown, and Mr. W. H. Webb, of Randalstown, was elected. Reference was made to the distinction of O.B.E. recently conferred upon Mr. W. Wilkinson, Head of the Technical College at Blackburn and Fellow of the Institute, and it was decided to offer the Council's warm congratulation to the recipient.

Institute's Annual Conference

Six of the papers read at the Institute's Annual Conference, held during Whit-week at Leamington Spa, are printed in this issue. Altogether, there were fourteen contributions under the general heading of the testing of textiles. The experiment of provision of a series of papers covering various aspects of a wide subject may be said to have proved both interesting and desirable. If the attendance was not quite so large as usual it is certain that the interest of

members who did attend was well maintained throughout the proceedings. Participation in discussion, also, as opportunity offered, was undoubtedly more general than usual. The holding of the Conference at a health resort in preference to an industrial centre did not result in any disappointment in regard to facilities for visits to industrial works. The afternoon visits to works at Coventry proved exceptionally interesting. Further instalments of the papers read at Leamington will appear in later issues of this Journal. In all cases of contribution to discussion, the contributors have been afforded opportunity of verification of the record.

Examination in General Textile Technology

There were twenty-two candidates in connection with the Institute's Examination, open to selected applicants for the Associateship, which took place on Wednesday, the 22nd June, at Manchester, London, and Dunfermline. For the future, in accordance with the revised Regulations governing awards, the Institute Examination will be extended in scope. The Examination will be in two parts :—Part I (Auxiliary Subjects), and Part II (General Textile Technology). Applicants for the Associateship may be required to pass one or both of the Parts, according to the decision of the Selection Committee. An important consideration in regard to the Institute Examination is the recent decision whereby the event is to take place annually instead of at intervals of six months. Members of the Institute contemplating application for the Associateship and anticipating the probability of reference to examination, should consider carefully the matter of submission of their application in time to admit of participation. For 1933, the examination is fixed to take place during the month of June. Any application for Associateship calculated to involve reference to the June examination should reach the Institute not later than the beginning of April if the applicant desires, after reference, to take the examination in the same year. Usually, it is advisable for Members to make application for the Associateship early enough to allow ample margin of time with respect to reference to examination.

Institute Membership

At the June Meeting of Council, the following were elected to *Membership* of the Institute :—J. H. Ackroyd, 75 Arodene Road, Brixton Hill, London, S.W.2 (Textile Examiner, Principal Viewer, Royal Army Clothing Dept.) ; Wm. Billing, 82 Cobden Street, Derby (Foreman Knitter Mechanic, Moore Eady & Co., Derby) ; Ralph L. Chisholm, 95 South Street, Boston, Mass., U.S.A. (Technical Engineer, Universal Winding Company) ; H. Eickemeyer, 20 Walker Avenue, Great Lever, Bolton, and Holbeinstrasse 12/III, Augsburg, Germany (Textile Engineer) ; H. Windfeld-Hansen, Veile, Denmark (Managing Director, Windfeld-Hansens Cotton Mill) ; A. M. Latham, 173 Colne Road, Burnley (Demonstrator in Textiles, Manchester College of Technology) ; J. Lomax, Testing Bureau, University College, Shakespeare Street, Nottingham (Manager of Testing Bureau, and Lecturer in Textile Testing) ; F. Marsden, Densmar Mill, Foleshill Road, Coventry (Director and Manager) ; J. Prescott, Angus P.O., Hooghly District, Bengal, India (Production Superintendent, Angus Engineering Works) ; S. Shloimovitz, Crescent House, Cheltenham Crescent, Broughton Park, Salford (Worsted Manufacturer) ; J. Smith, 34 Cottam Terrace, Legrams Lane, Bradford (Overlooker, Worsted-Drawing, Spinning and Twisting) ; H. B. Taylor, " Fernbank," Heads Nook, near Carlisle (Manager and Designer, James Waddell & Son, Heads Nook) ; F. P. Thompson, 179 Slade Lane, Levenshulme, Manchester (Technical Department, Lever Bros., Ltd., Port Sunlight). The following were elected to *Junior Membership* of the Institute :—S. H. Carter , 308a Archway Road, Highgate, London, N.6 (Salesman, Furnishing Fabric Department) ; H. K. Chang, Devonshire Hall Headingley, Leeds (Student) ; T. Colclough, 38 Burlington Avenue, Oldham (Assistant Carder in Cotton Mill) ; Frank S. H. Doo, Mukden Cotton Mill, Mukden, Manchuria, China (Textile Engineer) ; Ralph E.

Hale, The Bell Co., Millbrook Street, Worcester, Mass., U.S.A. (Textile Chemist with Fancy Worsted Manufacturer); David Hewlett, 8 Cardigan Street, Royton, Oldham (Operative Cotton Spinner); A. S. Mamooji, College of Technology, Sackville Street, Manchester (Student).

Scottish Section

The annual meeting of the above-named Section of the Textile Institute took place at the North British Hotel, Edinburgh, on Saturday, 16th April when over twenty members attended from many districts. A meeting of the Section Committee was held in the morning after which the members of the Section took luncheon together.

Mr. T. M. Lees (Galashiels) presided at the annual meeting and after warmly welcoming the members, said that last session of meetings provided a satisfactory record and he hoped the Committee would be able to present at least, equally interesting arrangements for the ensuing year. He congratulated Dr. Stevenson (Galashiels) on his election to Fellowship and Messrs. J. Callander (Paisley), E. Y. Johnston (Alva) and C. J. Wright (Paisley) on their election to the Associateship of the Institute.

Mr. A. W. Blair (Glasgow), as Hon. Secretary, submitted apologies for absence from Messrs. W. Black, Hy. Cook, W. B. Robertson, and Jas. Ross.

In his annual report, Mr. Blair stated that the membership of the Section at end March, 1931 was 83. Twelve new members had been elected, 2 transferred from other Sections, and 1 re-admitted. At 29th February, 1932 the membership reached 89—an increase of 6. The distribution was as follows:—East and Midland, 30; West and South-West, 29; Borders (including Carlisle), 27; North, 3. The total expenses of the Section for the year amounted to £8 14s. 6d. of which £5 12s. 0d. was in respect of hire of rooms for meetings.

Moved by Mr. J. Macpherson Brown, seconded by Mr. J. P. Beveridge, the report and statement of expenditure were adopted.

The following members were elected to form the Selection Committee:—Messrs. J. Macpherson Brown, T. M. Lees, W. Blair, A. Smith, A. R. Geary, and Dr. Stevenson.

The Chairman pointed out that Mr. J. P. Beveridge remained on the committee as an ex-officio member.

The Chairman welcomed the General Secretary who was in attendance, and in response to a request Mr. J. D. Athey gratefully acknowledged the welcome. He congratulated the Section on their endeavours which had been particularly satisfactory having regard to the long distances involved in attendance at meetings. Referring to the forthcoming Annual Conference at Leamington Spa, he was glad to observe that the Section would be represented.

A short paper, which gave rise to a useful discussion, was contributed by Mr. David A. Watson, A.T.I., on the subject of "The Fastness of Colours," and the meeting terminated with a hearty vote of thanks to the Chairman.

REVIEW

The Flax, Hemp and Jute Year Book, 1932., Published by H. R. Carter & Son. Belfast. (XX, 341 pp., and Index. Price, 5s.).

We are frankly unable to appreciate why this volume and others of an analogous type are called "Year Books." This is not to say that these volumes have no value—far otherwise, but they do not record the annual events associated with the "pukka" year book. Some additions are made, of course and some deletions, and excellent summaries of machinery or process developments are, often, as in the volume under notice, provided. The index now added is a very necessary feature and will be capable of development. One thing mars both the appearance and the use of this reference book and that is the employment of blue and red paper. Modern knowledge of optics should have indicated how undesirable these colours are for reading matter. T.

THE JOURNAL OF THE
TEXTILE INSTITUTE

Vol. XXIII JULY 1932 No. 7

PROCEEDINGS

Examination in General Textile Technology

An examination in General Textile Technology in connection with applications for the Associateship of the Textile Institute took place simultaneously at headquarters, Manchester; London; and Dunfermline; on Wednesday, 22nd June, 1932. For the information of members and others interested, the examination paper, in two parts, is recorded as follows—

PART 1 (SECTIONS I AND V OF SYLLABUS)

10 *a.m. to* 1 *p.m.—22nd June,* 1932.

Candidates to answer THREE out of FOUR Questions in each Section of Part I

Section I—Fibres and their Production

(1) In the greasy condition, wool is contaminated with various impurities. Discuss their nature and describe the commercial process of suint scouring. What are the relative merits and de-merits of soap scouring and suint scouring?

(2) State the characteristic features of flax, hemp, and jute fibre, respectively; and provide sketch of cross-section of each.

(3) (a) What is the reason for the characteristic lustre of rayons? (b) In what respects are they affected by wetting? (c) How and why does acetate-silk differ from the other principal types of artificial silk?

(4) In what respects does fine Egyptian cotton differ from Indian cotton? Which of these would you select as most suitable for mercerisation, and why?

Section V—Analysis and Testing of Raw Materials, Yarns, and Fabrics

(1) How would you proceed to test piece goods in respect of liability to shrinkage? In the case of wool treated to prevent shrinkage, what modification of appearances on the fibre would you expect to be revealed by the microscope? How would you investigate a complaint of shrinkage on a made-up garment?

(2) Why is a rubbing or wearing test difficult to standardize? Describe any fabric wear testing machine with which you are familiar.

(3) What are the arguments for and against the substitution of the Lea or Skein test by the Ballistic test for purposes of routine mill control ?

(4) How would you determine the amount of size in a sample of cotton cloth ?

PART 2 (SECTIONS II, III, AND IV OF SYLLABUS)

2.30 *p.m. to* 5.30 *p.m.—22nd June,* 1932

Candidates to answer TWO out of THREE Questions in each Section of Part 2

Section II—Conversion of Fibres into Finished Yarns

(1) Enumerate the various principles involved in achieving regularity of the material in preparation for spinning.

(2) Describe the processes involved in converting one of the following raw materials into finished yarn :—(a) wool, (b) cotton, (c) flax. State specifically the quality of the raw material employed and the type of resultant yarn.

(3) What do you understand by " counts," and what are the principal systems employed ? In what counts system would each of the following yarns normally be expressed ? :—(a) dry spun linen yarn ; (b) thrown silk ; (c) worsted (for suitings) ; (d) ramie ; (e) jute carpet yarn.

Section III—Conversion of Yarns into Fabrics, and Fabrics produced by Special Methods

(1) Describe a system of warping, taken from your own knowledge of the wool, cotton, linen, or silk industries, stating the particular type of woven fabric for which it is most suitable.

(2) Give a general account of the construction and mode of operation of any modern circular machine for making knitted fabric.

(3) What do you understand by the terms " shedding," " picking " and " beating-up " when applied to weaving.

Section IV—Conversion of Fabrics into Finished Materials

(1) What are the considerations which determine the stage of manipulation at which (a) wool, or (b) cotton is dyed ?

(2) Describe briefly the physical and chemical properties of (a) cotton, (b) wool, and (c) acetate silk, which determine the appropriate methods of bleaching, dyeing, and finishing of fabrics composed wholly of cotton, wool, and acetate silk, respectively.

(3) Write a short essay on the so-called aniline or coal-tar dyestuffs, with special reference to their advantages and disadvantages when compared with dyestuffs of vegetable and mineral origin.

Annual Conference of the Institute

LEAMINGTON SPA, 18th, 19th, and 20th MAY, 1932

THE MEASUREMENT OF FIBRE LENGTH

By W. SEVER, M.Sc.
(Textile Chemistry Laboratory, The University, Leeds.)

The value of a fibre for textile purposes is determined by a wide range of physical properties, not all of which are well adapted to measurement. The most fundamental of all, however, that of length, is fortunately the easiest to measure, and in view of this it is a little surprising to find textile manufacturers content for the most part with very rough estimates of staple length. An average staple length is, indeed, of comparatively little value unless accompanied by some expression of the proportions of longer and shorter fibres present, and the visual estimate of this length distribution is undoubtedly one of the primary objects of the usual " draw " on the velvet board.

The insufficiency of a simple average will be apparent if one postulates two samples of wool having the same average length, one containing exclusively fibres of about this mean value while the other comprises a wide range of different lengths. Different treatment would obviously be required to make the best use of these and even then the resulting yarns would certainly show very appreciable differences. Such extreme divergences are unlikely to occur in practice, but analogous cases occur every day, and it is safe to state that precise analysis for length distribution cannot fail to be of value at all stages of production and manufacture. It will be the object of this paper to indicate one or two such practical applications and to describe a simple instrument which has been devised for the measurement of fibre length.

Available methods for measuring fibre length may be divided into two categories—those which obtain only the mean length of the sample, and those which further provide a distribution analysis.

The first of these two groups naturally presents the simpler problem, and it may at once be stated that all precise methods of any practical importance are based on determining the weight of a known number of fibres and deriving their mean length by calculation. In the simplest instance it is further necessary to know the mean diameter of the fibres and their density under the conditions of measurement. As the corrections involved in these physical data are apt to be somewhat perplexing to non-scientific workers, several modifications have been devised to simplify the subsequent treatment of the results. A convenient account of the majority of useful methods will be found in two volumes compiled by the Director of the W.I.R.A. and published by the Empire Marketing Board.[1,2]

The most expeditious of these methods is that of J. A. F. Roberts[3] which depends on the average *weight per unit length* of the fibres present in the sample. This quantity is first determined by weighing known lengths of selected typical fibres on the microbalance ; some 200-300 fibres are then counted out at random and weighed on an ordinary chemical balance, when their average length can be at once deduced.

All gravimetric methods are, however, subject to certain practical disadvantages. It is always necessary to know the true moisture content of the fibres, for which a room at controlled humidity is almost essential unless—which is equally rare outside scientific institutions—apparatus is available for absolute dry weight determination. It is also necessary to scour the samples, which

involves further delay in their accurate conditioning. And the measurement of diameter is always present in effect; even in Roberts' method one must select as standard fibres which are reasonably uniform in diameter and truly representative. The fact that fibres are usually elliptical in section as well as exceedingly variable is a further possible source of uncertainty, though it has been shown that this is not ordinarily of serious consequence.[4]

It would therefore appear that direct measurement of length is to be preferred wherever possible, since it avoids diameter measurement altogether, is almost independent of humidity,* and may be used equally well on scoured and unscoured specimens. Indeed, the only error to which it is liable is stretch.

Wool fibres are normally crimped, and to determine their true length one must pull them out straight. It has been objected by one authority that the risk of producing significant stretch in this straightening is sufficient ground for abandoning the direct methods in favour of the gravimetric, but one may note in reply that the method of Roberts, which the same authority prefers, is subject to this identical danger in its fundamental measurement of the weight of known lengths of fibres. Reasons are given below for the statement that this risk of stretch is much less serious than might be supposed, and in fact, the direct method has been largely used by several authorities, notably Burns and Kronacher, both of whom have devised ingenious methods of limiting the tension applied.

The error may be entirely eliminated by a method due to the W.I.R.A.; the enlarged image of the fibre is projected on to a screen and its sinuous course directly followed with an ordinary map-measuring wheel. The Association does not appear, however, to recommend this method as suitable for general use, though its unequivocal freedom from errors other than those of the optical system and measuring device renders it a valuable contribution to the technique of fibre measurement.

Apart from the instrument described below there is no special appliance for the direct measurement of individual fibres. This brief review of existing methods would, however, be incomplete without some reference to those devices which, while dealing with fibres in bulk, are nevertheless designed to yield length analysis. Several such methods have been perfected but the best known by far is the Schlumberger machine for top analysis. This apparatus mechanically sorts a combed specimen into a series of tufts of progressively decreasing length, the range of length in each tuft being usually 1 cm. The tufts may be weighed or counted and an analysis thus obtained which is much used as a standard of reference. The machine is, unfortunately, very expensive, and according to the Director of the W.I.R.A., ". . . the subsequent evaluation of these fibre lengths and the numerical proportion of each class is a matter of considerable tedium and labour."

Hand drawing on the velvet board, the parent of the above method, is of venerable antiquity and undoubtedly affords a rapid means of visually estimating length distribution. In the hands of an experienced manipulator it can yield much valuable information, but it has two most serious faults which cannot be avoided: it is subject to a very large personal factor, and it cannot be effectively recorded. One may, indeed, trace the outline of the "draw" but unless the latter is perfectly uniform in density throughout its length—which is virtually unattainable—such a record merely perpetuates an error. The operator who prepared the original draw would most likely perceive its fluctuations in density and would almost subconsciously make allowance for them. But the trace gives no indication of their existence, and is, therefore, misleading.

Of course, the "draw" yields far more information than fibre length when examined by an expert judge of wool. Fineness, crimp, lustre, colour, and the

* The change in length of a fibre from wet to absolute dry is only about 1 per cent., the majority of this, even, being confined to the end of the range. For ordinary room fluctuations it may be ignored.

presence or absence of kemps and other faults are all noted and because of this comprehensive utility the " draw " will never be superseded by other methods, no matter how precise. But as a means of studying length distribution it should always be supplemented by some more exact technique, independent of personal bias and capable of numerical expression.

Reasons have been given above for preferring the direct measurement of individual fibres, even where average length only is required. An instrument for this purpose has recently been devised at Leeds University which considerably facilitates the direct method and this will now be described.

It is required, in effect, to pull a fibre straight under just sufficient tension to straighten it without extending it, and to place it against a scale for direct measurement. This is achieved by means of three clips mounted on common slide bars. The central clip has a powerful grip (Fig 1, A). The two other clips, B and C, are mounted on carriages which slide along the bars ; their grip is different from that of A, being light and adjustable by means of the knurled screws shown. Slow motion of either carriage is provided for by traversing screws which are disengaged for rapid motion by depressing a square stud on top of either carriage, the latter then sliding freely in either direction. A scale is attached to B and read by an index on C, continuously indicating the distance between the two clips.

To operate the instrument, the carriages are slid to the centre and a fibre is placed in the jaws of all three clips. B and C are moved away from the centre until each in turn is almost at the corresponding tip of the fibre. It will be found that the fibre slips smoothly through the jaws of B and C as these are moved, and any necessary adjustment of the tension is made at this stage. With a little experience it is possible to judge at a glance whether a fibre is still slightly crimped or whether it is being appreciably stretched and the grip of B and C is adjusted accordingly.

It is probable that the relatively broad jaws of A have trapped a certain amount of crimp, and now that the fibre is under slight tension, the grip of A is momentarily eased to allow this to correct itself. This assured, the motion of B and C is resumed, using the screw traverse. As each clip in turn reaches the corresponding tip of the fibre the latter springs back to its crimped form, giving a beautifully definite end-point.

The distance between the moving clips, B and C, is now evidently equal to the length of the fibre under the tension applied, and is directly read off from the scale as already mentioned.

The speed of work with this instrument is considerably higher than might be imagined from the above description. A normal working rate of 120 fibres per hour is easily maintained and can be considerably exceeded under favourable conditions, much depending on the openness and uniformity of the sample. Even with a somewhat tangled specimen of uncombed, scoured wool it was found possible to measure 100 per hour, though of course a bad tangle would necessarily limit this further. It will be shown that a batch of about 500 fibres is usually quite sufficient to give a reliable analysis for length distribution, so that this can be accomplished in a morning's continuous work. For mere average length a much smaller number is sufficient. The technique of sampling is, however, vitally important, but before discussing this it will be convenient to discuss the possible errors due to tension.

Under ordinary conditions of relative humidity (*c.* 60 per cent.) wool requires a force of approximately 7×10^6 grams per sq. cm. cross section to extend it by the 2 per cent. over which it obeys Hooke's Law. For a fine Merino fibre, such as commonly occurs in qualities about 70s, the sectional area is about 3×10^{-6} sq. cm. The load to extend it by 2 per cent. is therefore in the region of 2 grams, and lesser loads produce a proportionately lower extension.

Direct trial shows that a fibre of this fineness is pulled straight by a load of not more than 0·3 gram, so that the maximum error due to extension should not exceed 0·3 per cent., and will in practice be less than this owing to a combination of opposing errors which deserves some notice. Rossouw[5] has pointed out that there is a remarkably definite point in the gradual extension of a crimped fibre at which the crimp proper may be seen to have vanished while a slight waviness remains, this residual wave not being removed without a considerable increase in load and an appreciable extension of the fibre. This change in appearance is very well seen with the writer's instrument and is used to indicate correct adjustment of the tension. Now at this point the load is, as mentioned above, such as to produce an extension of not more than 0·3 per cent. which is roughly equal in amount to the reduction in apparent length arising from the residual waviness. These errors are thus largely compensatory and the absolute accuracy of the measurement is probably at least as high as the accuracy of repetition, which is normally 0·2 per cent.

For most purposes the absolute accuracy is of less importance than the relative accuracy, and the precise tension error may therefore be ignored. If it is desired to obtain true values the writer suggests that the only possible standard of reference is the projection method of the W.I.R.A. mentioned above. Great care will be necessary to ensure that there is no optical distortion in this method and it is strongly recommended that the map-measurer be regarded as inaccurate until it has been proved otherwise by careful test on lines of known length and irregular path.

With reference to the other possible error of the instrument, that in determining its zero, it may be noted that the exact position in either clip at which the fibre escapes cannot be easily identified. The scale is therefore set to read correctly with a fine human hair of known length, and occasional calibration by this means is advised. The straightness and relatively great strength of the hair virtually eliminate tension error and such measurements should always agree to the accuracy of reading the scale, i.e., 0·1 mm.

Given the instrument it was still necessary to establish a reliable technique for obtaining a truly representative sample not exceeding 500 fibres. The writer set out originally to select fibres at random, either from the levelled end of a drawn tuft or from the bulk of a larger specimen. Both methods gave most unsatisfactory results and it was not for some time that the reason for this was traced. The following series of 1,000 gave the explanation. From each of five separate compound tufts, 200 fibres were measured, the 200 being divided into four consecutive groups of 50 each. The five first 50s were then averaged and compared with the second, third and fourth sets of five 50s, with the following results for average length :—

Table I—Four consecutive average lengths from one sample of 64s top, 250 fibres in each average.

First set	Second set	Third set	Fourth set
89·20 mm.	87·58 mm.	85·21mm.	84·16 mm.

Evidently the longest fibres are unintentionally selected, a fact which has not yet received satisfactory explanation. It has been suggested that the fibres of greatest diameter are at once the most conspicuous and the most likely to be above average length, and a rough trial of the diameter of a number of fibres in order of their selection agrees with this hypothesis, but it is difficult to reconcile with other observations and for the present one can only record the fact that it has been found unexpectedly difficult to pick fibres at random, if indeed it is possible.

Without recounting further failures we may now describe the method of sampling which has so far been found reliable and convenient. It depends on

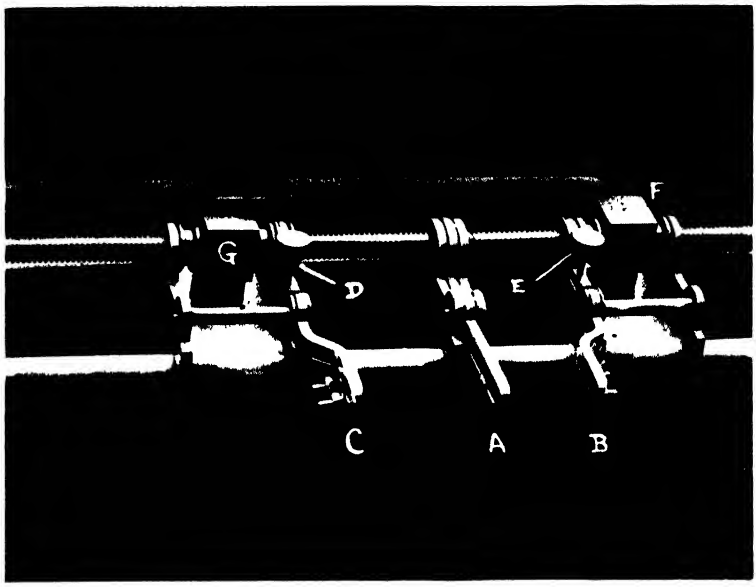
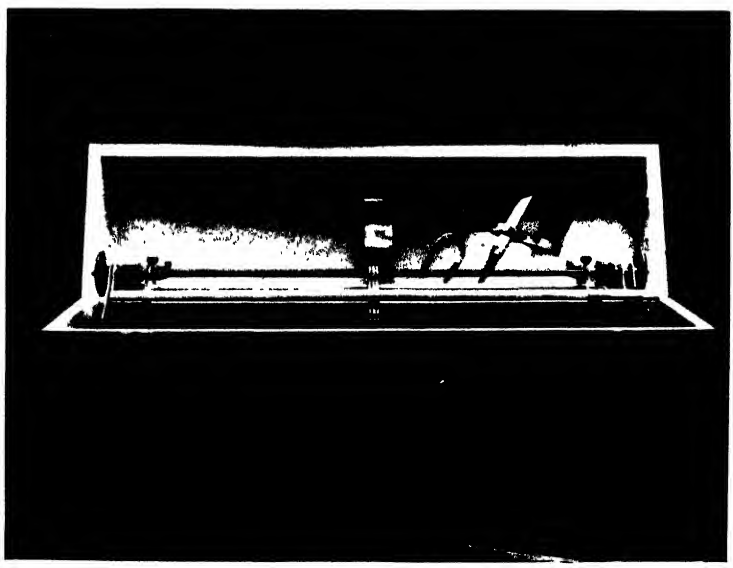


FIG. 1.

A · Fixed clip
B, C Moving clips.
D, E Tension adjusting screws
F, G Traverse screw disengaging studs

The fibre has just escaped from C, when its other end has escaped from B, BC length of fibre and is directly visible on the scale.



GENERAL VIEW OF INSTRUMENT IN CASE

measuring every fibre which passes through a small area in the cross-section of a combed specimen and was originally devised by Wilkinson for his method of gravimetric analysis.[6]

A group of fibres of convenient bulk—100-200 in most cases—is securely bound round at one point with a needle and thread, *while still in situ* in the sample. Once tied it is carefully withdrawn and all fibres not passing through the plane of the tie are removed with a small comb or brush. The result is a symmetrical tuft, tied round the middle and resembling two " drawn " tufts placed with their level ends in contact. This Wilkinson tuft is spread out on the velvet baseboard of the instrument, the tie removed, and each fibre measured in turn.

It will be seen that the chances of any fibre passing through the plane of the tie—and therefore of appearing in the results—are proportional to its length. The weight of a fibre is also proportional to its length if diameter is assumed uniform and a little consideration will show that the number of fibres of any one length found in such a tuft is proportional to the percentage by weight to which fibres of that length occur in the original sample. To obtain a length distribution analysis expressed as *percentages by weight* of the total weight of wool it is thus only necessary to sort out the measured lengths into consecutive ranges of length and to express the number in each range as a percentage of the total number measured. For most purposes this *weight analysis* is the most useful form but it is always worth while to calculate the equivalent *number analysis*, i.e. one showing the percentage of the total number of fibres present in each range of length. It will in general be found that the proportion of short fibres is astonishingly high, as will be seen in the instance cited below. The process of converting the analysis is very simple; the percentage by weight occurring in each range is divided by the average length of that range and the resulting proportionate numbers are again converted to percentages.

Practical work with this instrument since adopting this standard method of sampling has been almost wholly confined to tops of good quality. For these it has been found that three Wilkinson tufts of about 150 fibres each are sufficient to provide a reliable analysis. It will no doubt be considered by many that this number is far too small but the writer's experience is in accordance with that of other workers. For example, Burns[7] has found that 50 fibres gave a reliable average length. The writer has usually divided his 500 measurements into 10 or 12 ranges of length, so that there have been on the average 40 to 50 fibres in each range. Arguing inversely from Burns' experience, this should be a representative sample, especially as the entire group is confined to a range of only 1 cm. while Burns' 50, being from the fleece, would be more widely distributed. As a practical illustration of the possible accuracy four analyses of the same 70s top are here shown.

Table II—Four standard analyses of the same 70s top.

Groups	Top No. 1	Top No. 2	Top No 3	Top No. 4
	Percentage by Weight			
Less than 30 mm. ...	3·7	4·7	4·3	5·0
30-40 mm.	5·0	6·2	6·7	5·8
40-50 mm.	7·9	8·7	8·0	7·8
50-60 mm.	10·2	9·3	8·9	9·8
60-70 mm.	9·1	9·4	10·1	10·0
70-80 mm.	10·7	10·9	11·2	10·7
80-90 mm.	13·0	12·8	13·6	11·7
90-100 mm.	15·2	13·7	14·3	14·2
100-110 mm.	10·2	10·4	10·5	10·3
110-120 mm.	8·2	8·1	7·1	7·8
120-130 mm.	4·3	3·7	3·4	4·0
More than 130 mm. ...	2·7	2·2	2·4	2·7

It will be seen that the extreme difference between any two measurements in the same range is less than 2 per cent. and usually not more than 1 per cent., and one may be permitted to suggest that no very marked improvement in accuracy is likely to result from the use of the much larger samples commonly regarded as essential. Exception must of course be made where the material is seriously lacking in uniformity of distribution though even this could probably be met by taking an increased number of tufts whilst decreasing their size so as to retain the same total of about 500 fibres.

Yarns may be untwisted and examined in a precisely similar manner, though a certain knack is necessary to avoid trouble from the twist. By keeping the fibres well pressed into the pile of the velvet board during manipulation their tendency to tangle can be overcome and a number of yarn analyses have been successfully accomplished in a research mentioned in the next section.

PRACTICAL APPLICATIONS.

There is no stage of the wool industry at which a knowledge of fibre distribution is without value though it naturally receives more attention in the earlier processes. The sheep breeder, in both experimental and standard strains, must perpetually watch the length distribution within the lock and throughout the fleece if he is to maintain or improve quality. An interesting analogous case where careful observation of this type led to results of unexpected interest is the work of Dry[8] on the occurrence of " growth waves " travelling over the pelt of mice and numerous other workers have found it necessary to make daily observations of the type proposed.

In processing it would be of great value to know exactly to what extent fibres of different length are broken at each stage from scouring to spinning. The writer is indebted to Mr. Day of this department for permission to cite some unpublished data as an illustration of the results which may be looked for in this field. The results are somewhat tentative as the amount of work yet completed is small and not strictly representative of actual practice but it appears that the extent of fibre breakage in skin wools depends to a marked extent on the method of stripping. Cut wool, as might be expected, is the best, though painted wool is very little inferior, but sweated wool shows a much higher proportion of breakages. Another interesting point is the position at which these breakages occur. The original wool has only one probable length but after processing there are two, one being that found for the raw wool while the other is half this amount. Apparently fibres have a preferential tendency to break at the middle. This is capable of a simple mechanical explanation. Frictional tension applied to a fibre in processing may tend to rupture it at any position but the chances of slip occurring instead of breakage will clearly be least when this tendency occurs at the middle of the fibre and will increase as the ends are approached. That is, if there is a shorter end pulling against the longer end, slip will be more likely to occur than if both halves of the fibre are equally gripped. Further work on the nature of breakage in carding is in progress in this laboratory and it is hoped to publish a fuller account of results in a future issue of this *Journal*.

It is, however, in the production and inspection of tops that length analysis reaches its highest importance. Every top manufacturer recognises this importance and keeps standard " draws " by which to set his production. But how much more satisfactorily the length factor could be maintained by the use of a standard accurate length analysis. We have already expressed the opinion that the " draw " is too inaccurate to be satisfactory but the ordinary textile manufacturer and his operatives are usually very sceptical about the advantages of increased precision. The writer has in his own experience the case of a warp top of high quality produced by a firm whose tops bear a very

good name. The normal analysis of this top showed the type of distribution about a single most probable length which one finds in most probability studies. But for certain reasons the composition of this top was altered to a widely different form with two most probable lengths; the change was in fact a milder instance of the case postulated in an earlier paragraph. But, and this is the point, that blended top was being sold in quantity and was doubtless " drawn " and examined by many actual or potential customers, none of whom detected anything unusual. It is not suggested that the modified top was of lower quality, but the difference in its composition which escaped detection on the velvet board could not possibly be missed in a proper analysis.

The four analyses of Table 2 are taken from the writer's data for this top; the average of all four is given below for comparison with the corresponding *number* analysis. It was mentioned earlier that the *number* analysis often revealed matter which was not obvious in the *weight* analysis, and this is a case in point. The lower probable length is only faintly suggested in the latter while from the former it will be seen that there are two very definite probable lengths and that there are actually more fibres in the short group than in the long.

DIAGRAM TO ILLUSTRATE TABLE 3

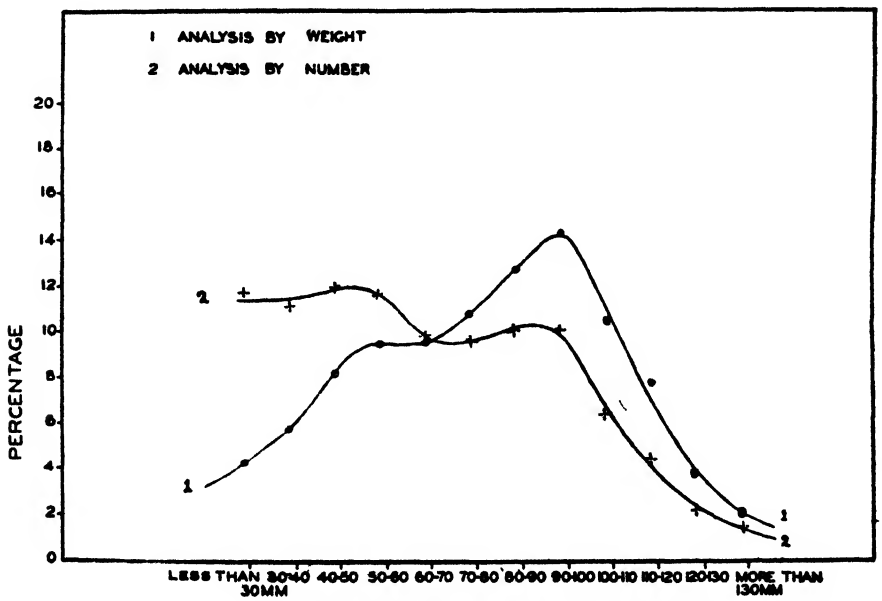


Table III—Analyses by weight and by number of a blended top.

Less than 30 mm.	30-40 mm.	40-50 mm.	50-60 mm.	60-70 mm.	70-80 mm.	
4·5	5·9	8·1	9·6	9·7	10·9	% by weight.
11·8	11·0	*12·6*	*11·6*	9·8	9·6	% by number.

80-90 mm.	90-100 mm.	100-110 mm.	110-120 mm.	120-130 mm.	More than 130 mm.	
12·8	*14·3*	10·4	7·8	3·8	2·0	% by weight.
10·0	*10·0*	6·4	4·5	2·0	1·4	% by number.

The foregoing examples will, it is hoped, arouse some interest among manufacturers in the possibilities of the more precise study of length distribution. It may be emphasised that the method recommended in this paper is suitable for use by persons without scientific knowledge and that its technique can be mastered by any intelligent operative in the course of a few hours' practice. Arrangements have been made for the instrument to be manufactured under patent and it can now be supplied to anyone interested. The writer will be pleased to offer any assistance in his power to enquirers.

In conclusion, the writer desires to acknowledge his indebtedness to Dr. J. B. Speakman, of Leeds University, for his continued interest in this work and for many valuable suggestions.

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POSTSCRIPT TO ORIGINAL PAPER.

The points raised in discussion of my paper are almost solely concerned with the number of fibres necessary for a reliable sample and this point is of such vital importance to research workers both in the trade and in scientific institutions that I should like to add some further data to those cited above. To anyone familiar with the ordinary " reduction of observations " it will naturally appear odd to obtain concordance such as that shown from a comparatively small number of measurements ; mathematically speaking, it is impossible with a *purely random distribution of independent variables.* I can only conclude from my own experience that tops, rovings and yarns of ordinarily good quality are, on the whole, much less random in their composition than my questioners appear willing to concede and that the occasional grosser variations referred to by the Chairman do not constitute a serious danger.

An intelligent student in any branch of measurement must always learn when to reject a freak observation and when to take another batch for safety and the same enlightened common sense must be the guide in these analyses ; each particular case requires its own standard of accuracy and exhibits its own range of variation, and the number of fibres required must be adjusted to suit. I should like again to draw attention to the statement in the paper that the choice of 500 fibres, i.e., an average of 50 in each range of length, is well supported by the work of other students of fibre length and I repeat that for ordinary reasonable accuracy such as that shown in Table II five tufts prepared as described will be found sufficient.

It will perhaps be of general interest to manufacturers as well as to those sceptical of the 500 fibre limit to examine the following case of a complaint submitted to me for report since the Conference.

Dark weft bars in a fine worsted suiting were found to contain yarn of practically normal shade, count and twist, the darker appearance being due to an increased amount of weft " nap." The weaver returned the fabric to the spinner with a complaint of faulty weft yarn. The spinner accused him of mixing in similar yarn of different origin. Fabric and a sample of yarn as delivered were submitted to me for investigation.

When unpicked the dark weft was found as stated to match the normal in count, both being 2/28s worsted ; there was a small difference in shade and twist but not enough to explain the fault. It was noticed that the dark portion

was more woolly and that its manner of breaking suggested a shorter fibre and analysis was resorted to.

In each of the three cases, normal, dark, and comparison the specimen was prepared by untwisting a few inches of the twofold yarn and preparing a Wilkinson tuft of one single yarn. Three such singles were examined in each case and the results were collected into three ranges of length so as to preserve the usual figure of about 50 fibres per range. The results are shown below and leave no room for doubt as to which yarn is which.

Length in mm.	0 to 40	40 to 80	80 to longest	Total No. measured.
Dark weft bar	55·3%	33·8%	11·0%	136
Normal weft	17·5%	51·4%	30·8%	143
Yarn delivered	16·9%	53·8%	29·1%	165

(Percentages by weight, uncorrected for diameter.)

The normal fabric is obviously composed of weft as delivered by the spinner while the dark bars are due to yarn of a totally different class, though similar in count, twist and shade. The correct yarn is a fine worsted, while the other is, judging from fibre arrangement as well as other factors, most probably a dry mule spun yarn. The spinner has no mules and spins only worsteds while judicious enquiry showed that the weaver had in his mill yarn of the type suggested. This has by some mischance been mixed into the piece and its shorter and less orderly fibre has resulted in a more conspicuous " nap " as stated.

It will be seen that a practical works problem has here been settled by the examination of about 150 fibres in each of three different yarns and that the accuracy in comparison of the two found to be alike is precisely that already shown in Table II. This is only natural as the same number of fibres has been collected in each range of length in the two cases, i.e., a number of the order of 50.

Three tufts of only 50 fibres apiece are here seen to give a result accurate enough for reasonable industrial purposes. It is surely not too much to suggest that three times that number will ordinarily be *sufficient for similar* purposes.

DISCUSSION.

Professor E. Midgley occupied the chair, and said the subject was important. The processes to which wool was subjected, the degree of treatment in each process varied according to the length of fibre. Even more than that the plant of preparing, combing, drawing and spinning machinery for very short wool was not suitable for long wool. He purposely mentioned these facts to emphasise the importance of the subject of investigating fibre length, which undoubtedly contributed to the increase of industrial efficiency. It would also be a factor in reducing costs of production, as maintaining uniform fibre length resulted in increased production along with more perfect yarns and fabrics.

The Chairman asked what methods had been employed to obtain 500 fibres from the top to get accurate results. His reason for asking was that there were very few tops that were pure in respect to the origin of the wool. They were usually blends. Of a blend, 50 per cent. might be of a fibre which averaged 4 inches in length, whilst the remainder might be a type with an average length of 6 inches. How was it possible to obtain an equal number of those fibres which varied in length ?

The Chairman said that on dealing with certain types of defects in fabrics it was found that the fibres were always in clusters and it was due to these fibres not being thoroughly mixed that the defect had developed. It struck him that 509 fibres was a small number under the conditions which prevailed in the worsted trade.

In reply the Lecturer said he thought Professor Midgley would find a sufficiently complete answer as to the validity of a 500 fibre sample in the results cited in Table II of the paper and he would like to draw attention to the fact that these referred to just such a blended top as Professor Midgley suggested.

The data given in the more recent addition to the paper might appear even more remarkable but he could give an assurance that these were in every way typical of work in which he was engaged at present.

The suggested presence of a " nep " would render the tuft in which it appeared an obviously unfair sample and it might safely be left to any intelligent worker to decide whether to reject the tuft or to analyse sufficient tufts to smother out the effect of grosser individual abnormalities. Time available and the degree of precision required must obviously weigh in the decision and would usually agree in the more direct course of rejecting the abnormal sample. It should be unnecessary to point out that the minimum number of tufts must be governed by their degree of concordance and he could only add that so far he had not found it necessary to exceed 5 tufts of about 100 fibres apiece.

Mr. H. Binns asked if the Lecturer could tell the degree of reliability of the measures of his sample by the probable error.

Mr. Sever, in reply to Mr. Binns, said he had been primarily anxious to obtain such accuracy as would suffice to identify materials with certainty by their analysis and had not attempted to define the mathematical accuracy which this represented. One could readily deduce the probable error as suggested, though for a series of proportionate numbers, such as those in question, it might be rather difficult to define. The simplest method would be to find the probable error for each range and average the lot but as the extreme ranges contained but few fibres, and therefore were of little importance, their error would be proportionately high and a simple average would give an overall probable error somewhat too great.

Dr. A. W. Stevenson doubted if it was desirable to express the results of wool fibre length measurement in a single statistical figure. In yarn-making the long and short fibres were wanted for different purposes, the long for strength and lustre, the short for fullness, surface finish and milling properties. The quantities of long and short, and not any sort of mean length was what the yarn-maker must keep in view. In regard to the Wilkinson tuft method it was well known that short fibres were usually smaller in diameter than long fibres. This would weaken the contention that the method gave a true weight percentage and the deduced percentage-by-number would be still farther out. In reference to Mr. Sever's verbal additions regarding carding experiments, the fibre breakage was surprisingly high. The new measuring technique would be a very valuable instrument in carding and spinning research. He did not agree that the tests of oil-treated and emulsion-treated fibres were reliable. Each method should have been given its own preferential treatment in regard to the time elapsing between oiling and spinning. To adopt for both the time suitable for the emulsion treated fibres was bound to lead to erroneous results.

The Lecturer said Dr. Stevenson's views on the futility of a simple mean staple length were entirely in accordance with his own views and he wished to thank him for raising the point of fibre diameter which had been omitted from the paper. The " weight " analysis was subject to error whenever the average sectional area differed from one range to another, though he fancied from some very casual observations, that the extent of such variation was, in many cases, insufficient to cause any large error. For precise work, or where the specimen was composed of widely differing fibre types, correction must certainly be applied for the " weight " analysis. He submitted that in the " number " analysis, this was no longer the case. The original measurement consisted solely of number and length and was not affected by diameter in any way. The final analysis, again, contained only number and length and any erroneous weight used in the calculation must, therefore, have appeared twice with opposite significance and cancelled out ; careful following of the successive stages would show that this did occur. For industrial purposes comparative results were most usually needed and the Lecturer suggested that here there was no appreciable advantage to be

gained by correcting for diameter, while the loss of time involved when the diameter would not otherwise be measured was serious. He had personally nothing to do with the oil *versus* cream test except that the rovings from it were suggested to him as an interesting opportunity for his instrument to supply data which could be obtained by no other means. Since the point had been raised, however, he might suggest that the time lost in waiting for oil to spread over the fibres was one of the main reasons for preferring the cream and the test showed, that where time was valuable, the cream had an unquestionable advantage.

Mr. W. E. King asked if Mr. Sever had made several tests on his machine from different portions of the same top and if so had these tests agreed. He pointed out that if several tests were made on the Schlumberger top tester from different portions of a blended top different results could be obtained. In a Schlumberger test at least twenty times the amount of top used by Mr. Sever would be tested each time. If such a relatively large quantity gave different results it seemed to him that in testing only 500 fibres there would be too great a variation recorded by this new method for satisfactory results to be obtained. Was 500 fibres a sufficient number to test and could this number be said to be truly representative of the whole of the top ?

In reply to Mr. King, the Lecturer said that this again was purely an inquiry into the sufficiency of his 500 fibre sample. He had no first-hand experience of the Schlumberger technique for sampling but submitted that any sampling for any purpose must include as many different specimens as would suffice to average out their mutual discordances to the accuracy required. The larger tufts used in the Schlumberger did not, in his judgment, matter nearly so much as the number of separate tufts taken from different regions of the material. As with the question of average staple length, he considered that *where the material itself varied widely from one region to another* no single analysis by any method could convey a useful meaning unless accompanied by a statement of the variations which occurred. But in a good top or yarn the very great proportion of the material was of constant composition, remarkably constant in fact, and if an unusual tuft was found it must either be compensated for by taking an extra number of tufts or else, if the circumstances warranted, it might be rejected as patently unrepresentative.

The Bradford Conditioning House had promised to investigate fully the comparative reliability of his instrument and the Schlumberger machine, each with its own method of sampling, and this question would, therefore, receive an authoritative answer at some later date. Until then, he would ask Mr. King to suspend judgment, only drawing his attention to the reliability shown by the examples in the paper and the additions thereto.

THE STRENGTH OF TEXTILE FABRICS AND THEIR SATISFACTION-GIVING QUALITIES IN CONDITIONS OF NORMAL USE

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The purpose of this paper is to submit for consideration a principle that should govern the interpretation of test results on textile fabrics, and to give certain data which should prove helpful in the interpretation of strength test results on fabrics.

In engineering design the " factor of safety " is of recognised importance. The ordinary stress in conditions of use is estimated, and if the factor of safety is to be five, then the item is designed so that it should not break down until the stress is over five times this ordinary stress.

When in use, fabrics are exposed to stresses and in ordinary circumstances the useful life of the fabric endures until (owing to the effects of wear or deterioration, etc.) it is unable to resist these stresses. We may use the term " Normal Stress " to designate the maximum tension or pressure to which a fabric may be subjected in conditions of ordinary use. If the strength of the fabric is less than this value, then the fabric will fail in conditions of use ; if the strength is above the value of the Normal Stress then the probable life of the fabric is expressed by :—

$$\text{Life} = \frac{\text{Original breakdown strength} - \text{Normal Stress.}}{\text{Rate of deterioration or wear.}}$$

There may be two reasons for the testing of textiles. One is to secure data about the fabric in order to establish a standard for the control of quality, or to give data for the comparison of samples. The other is to secure information as to whether the fabric is likely to be satisfactory in conditions of use, and also to what extent it should prove satisfactory.

The need for the study of the satisfaction-giving qualities of textiles is becoming increasingly important, and it is in connection with this that the concept of Normal Stress has special value. The problems of strength were perhaps not so important in the past when fabrics were usually heavy and strong. But now that lighter and necessarily weaker fabrics are in demand, and synthetic textile fibres of inferior strength to the natural fibres are extensively used, the strength problem is certainly of great importance.

The Normal Stress on a fabric could be determined by direct measurements under controlled conditions, and experimental investigation on these lines is desirable. But another, and maybe more valuable method for the estimation of this factor, is by tests on fabrics which have torn in use, or which have been discarded because they are worn out. A critical value is not to be expected because the variation of treatment in use will be wide. But from the examination of an adequate number of samples this method will give an indication sufficiently exact for practical guidance.

In passing it may be noted that, while in this paper the considerations are restricted to those of strength, the principle is of equal importance in relation to the testing of other factors affecting the satisfaction-giving qualities of textiles, such as colour-fastness, shrinkage, and the slippage of threads in the woven structure as the result of tensions in use. For instance, it would be very useful if one knew the minimum grade of colour-fastness which could be expected to give satisfaction in defined conditions of use, as say the light-fastness required on a frock for business wear and that required on a frock for outdoor summer wear.

Appendix No. 1 contains the results of tensile strength tests on a number of fabrics that had torn in conditions of use, or that had been discarded because they were considered to be worn out. In order to " bracket " the Normal Stress value, the samples have been divided into three groups based on inspection before testing, and these are (1) slightly worn, (2) worn, and (3) seriously worn. The basis for classification is given in the appendix. The strengths were determined in the air-dry condition, and using the grab test on a calibrated Salter's Spring Dynamometer. The grab test was used because it is more rapid than the strip test, but it may be noted that the test is also somewhat closer to the conditions obtaining in use. The jaws of the machine were 4 inches in width and also 4 inches apart. The fabric tested had a width of at least 5 inches and usually of 6 inches. Test on cotton sheeting showed that strip tests gave tensile strength values approximately 10 per cent. less than those given by the grab test. The author has not had the time to spare for a more complete comparison of the results given by the two methods.

Inspection of the results in Appendix No. 1 discloses a fact that is somewhat unexpected. Over a wide range of fabrics for a wide range of uses the Normal Stress may be taken for practical guidance as a tension of 40 lbs. on a four-inch

grab test. This is based on a consideration of all the results, but in particular of the upper limit of the minimum strengths of fabrics in the worn group. In certain cases the value will of course be above or below this figure; when fabrics are used only for special purposes the Normal Stress should be determined for these particular conditions. But when a fabric is used for many and varied purposes then the general Normal Stress value is the best basis for reference. The probable explanation for the common value of the Normal Stress for many types of fabrics is the fact that most of the stresses on a fabric are produced by human agency in wear or in washing.

Turning now to consider the bursting strength, it is to be noted that this test may be deceptive as a practical guide to the qualities of a fabric. For if a fabric has a strong warp that is very resistant to stretching, and a weak weft that stretches easily (as say with crepe de chine) then the weft stretches and the stress is taken by the warp, and so the warp strength determines the results that are obtained. But the test has the advantage over the ordinary tensile strength tests that local loss of strength can be investigated, and it is also valuable in the testing of knit fabrics. A number of fabrics tested for Appendix No. 1 were also tested using a Mullen bursting test machine, and the values obtained were found to be in approximately simple proportion to the minimum tensile strengths of the fabrics. The results indicated that for practical guidance the Normal Stress may be taken as a pressure of 37 lbs. per square inch.

In Appendix No. 2 are given some bursting strength tests on worn fabrics, or those which tore in ordinary use. They confirm the general Normal Stress of 37 lbs. per square inch. It may be noted, however, that for net curtains (which are subjected only to small stresses in use, and which receive careful and special cleaning treatments), the Normal Stress may be taken as 16 lbs. per square inch.

At this point we may also note that the Normal Stress is of importance in other tests on textiles. In frictional wear tests the end-point should be when the worn fabric breaks down under the Normal Stress. This value should also be used to fix the tension used in the measurement of the zone of slippage of fabrics (such as occurs at the seams in the case of tightly-fitting frocks).

With the Normal Stress determined it is possible to state, from the results of tests, when a fabric should be considered as worn out. This is a matter of importance when dealing with complaints about the wear of fabrics, especially from the launderer's point of view. When fabrics are offered to the retail buyer at a low price because they are weak or damaged, the Normal Stress gives a basis for reporting when such fabrics shall be considered as not fit for sale to the public at *any* price. Moreover, in the design of fabrics of light weight the Normal Stress gives a limit to the strength sacrifices which may properly be made, and the values in the "Slightly worn" group of Appendix No. 1 give an indication of the minimum factor of safety that is desirable.

In the testing of fabrics a simple air-dry strength test may not give sufficient information.

This applies especially to rayon fabrics, for their retention of strength when wet may commonly vary from 40 per cent. to 50 per cent., and it may exceed the limits of 30 per cent. and 60 per cent. The wet strength is of importance because it determines the degree of risk of damage in washing operations. Fortunately rayon fabrics are usually of sufficient strength when wet to resist the stresses of a careful washing treatment. Therefore it has not been possible to base a Normal Stress value on the results of an adequate number of cases of actual damage in washing. But as a provisional standard the author has adopted a tensile strength of 20 lbs. on a 4 inch grab test as the minimum acceptable strength when wet. While this figure was adopted without consideration of the strength of worn fabrics, it may be noted that the minimum tensile strengths of the fabrics in the "Seriously worn" group of Appendix No. 1 indicate that a strength of about 20 lbs. is the point at which fabrics tear even with careful handling.

Where fabrics are below normal strength the possible effects of washing treatments require consideration. Cellulose fabrics after deterioration by serious over-bleaching or by the effects of sunlight, lose much of their strength after an ordinary boiling wash in soap and soda. Their strength when wet is also less than that of similar fabrics which have not been deteriorated by these agencies.

In Appendix No. 3 are data for five sets of fabrics where on considerations developed in this paper some were reported as not fit for sale, or as not satisfactory. Two rayon crepe-de-chines have weft strengths so low that they would tear in ordinary use. One of a pair of otherwise similar ginghams has a weft strength with 60 lbs. excess over the Normal Stress, while the other has only an excess of 30 lbs. It is not unreasonable to conclude that under similar conditions of wear the first will give about double the life of the second. The results on the two velveteens show that one has probably been tendered in manufacture, but the important point is that it has been tendered to such an extent that it must be considered to be unfit for sale.

Appendix No. 1.

The grouping is based on inspection prior to testing and is :—

Slightly worn :—Fabric still usable ; looks fairly solid and has little damage such as holes or tears.

Worn :—Discarded as not worth repair or as likely to tear in laundering.

Seriously worn :—Fabric generally thin ; many holes or tears.

Where fabrics had no selvedge or other indication of the warp threads, then the stronger direction of the fabric has been assumed to be the warp.

Item	Strength in lb. on 4" grab test. Slightly worn Warp	Slightly worn Weft	Worn Warp	Worn Weft	Seriously worn Warp	Seriously worn Weft	Remarks
Gingham frock ...	...	...	65	43	...	...	
Silk frock	...	...	109	39	...	...	Crepe de chine
Delaine frock ...	84	49	...	...	...	...	This material gave several complaints of tears in use.
Print rayon union fabric	...	...	...	...	160	25	Tore very easily in wear.
Cotton warp satin...	...	...	...	...	150	25	Petticoat tore easily in use.
Cotton overalls ...	64	62	110	45	80	34½	
,, ,, ...	102	81	108	* 75	...	...	*Torn at pockets and seams but not in body of fabric.
,, ,, ...	70	70	60	38	...	...	
Wincey pyjamas ...	...	...	...	...	55	32	Split in use after damage by bleach in laundering
Silk and cotton union pyjamas ...	174	70	...	...	...	...	Torn only; but in ordinary wear.
Flannelette nightdress ...	136	60	...	...	...	...	Torn only; but in ordinary wear.
Silk neckerchief ...	...	...	...	...	250	32	Weak fabric; tore in use.
,, ,, ...	...	...	...	...	14	25	Worn-out fabric.
Linen crash towel ...	...	...	107	45	44	29	
,, ,, ,, ...	...	...	...	...	64	26½	
Linen face towel ...	122	66	112	40	...	...	
,, ,, ,, ...	107	66	105	38	...	...	
,, ,, ,, ...	100	64	...	...	...	...	
Cotton face towel ...	...	...	127	50	33	105	Honeycomb weave.
Terry towels ...	47	76	48	82	23	31	
,, ,, ...	...	...	...	...	22	55	

Appendix No. 1 (continued)

Item.	Strength in lb. on 4″ grab test. Slightly worn Warp	Weft	Worn Warp	Weft	Seriously worn Warp	Weft	Remarks
Bedsheets	63 *	213	...	...	41	160	*Intact edge of seriously worn sheet.
,, ...	56 *	47	...	...	...	...	*Ditto of another sheet.
Pillow cases, cotton	...	...	51	34	50	25	
,, ,, ,, ...	...	...	55	42	21	18	
,, ,, linen...	...	...	30	27	...	...	
Tablecloth, cotton...	104	67	42	57	23	51	
,, ,, ...	102	63	50	51	...	...	
,, ,, ...	...	...	60	39	...	...	
,, ,, ...	...	...	42	51	...	...	
Table napkins, ,, ...	70	57	...	...	...	...	
,, ,, ,, ...	72	49	80	57	29	42	
,, ,, ,, ...	97	70	...	...	...	...	
Handkerchiefs, ,, ...	...	...	48	35	63	21	
,, ,, ...	...	...	39	36	47	24	
,, ,, ...	...	...	52	40	...	...	
,, ,, ...	...	...	47	34	...	...	
,, linen	...	...	52	40	36	34	
Kitchen cloths, linen	49	56	30	33	24 *	37	*Very seriously worn
,, ,, ,,	...	...	...	...	25 *	17	* ,, ,, ,,
,, ,, ,,	...	...	...	...	14 *	19	*Average of three of similar strengths and very seriously worn.
Window drapery—							
Cotton rep ...	...	...	40	31	...	...	Evenly tendered fabric.
,, ,, ...	...	...	40	45	...	...	,, ,, ,,
,, limbric ...	50	69	42	50	35	27	
Wool bunting ...	106	87	68	31	97	38	Discarded flags.
,, ,, ...	98	49	75	39	20	75	,, ,,
,, ,, ...	114	106	103	61	30	74	,, ,,
,, ,, ...	101	99	36	31	77	57	,, ,,
,, ,, ...	...	...	65	104	...	...	,, ,,
,, ,, ...	...	...	121	36	...	...	,, ,,

Appendix No. 2

(A) Bursting strength tests on two worn cotton poplin shirts. Taken on intact fabric, and in the case of tears, as near as possible to the tear.

	Bursting strength lb. per square inch.	
Outer side of elbow, right arm (torn)	26½, 34	22½, 39
Top of shoulder, brace strap wear (torn)	34½, 33, 21½	45, 41, 41
Back of right shoulder (torn)	21½	38
,, ,, left ,, ,, ...	34½, 33	39, 39
Bottom centre of front tail	34½	44
,, ,, ,, back ,, ...	—	35

The distribution of wear was also investigated.

Bursting strengths across the front tail starting from the right side and measuring four inches from the bottom. Width of tail, 23½ inches.

Distance	2″	5″	7½″	10½″	13″	15″	18″	21″	22½″
Bursting strength.									
Shirt No. 1	84	65½	49	34½	46	53½	64½	72	85
,, No. 2	80	77	60	44	49	54	61	69	78

Bursting strengths of Shirt No. 2 up centre of back, distance measured from neckband; total length of shirt 33½ inches.

Distance	5″	7″	10″	13½″	17½″	21″	34½″	29″	32″
Bursting strength ...	38	48	53½	60	66½	47	41	38	57

Also tested for wear across back tail, three inches from bottom, width of tail 22 inches.

Distance	2½″	6″	9″	15″	18″	20½″
Bursting strength	58½	52	38	37	46	48

(B) Consignment of silk stockinette knickers gave occasion for several complaints of tearing in wear. Branded goods and "Wear guaranteed." Tested and found to be tendered.

Bursting strength ... ... 32 lbs. per sq. inch.

(C) Seriously worn cotton stockinette drawers (weft knit structure).

	Bursting strength
Inner part of leg near top, seriously torn	19, 24, 23
Outer part of leg, worn thin and torn	32
Seat centre part, worn thin but not torn	35½, 38, 35
Right side top, apparently not worn	58

(D) Cotton fabric (woven) d'oyley. Worn and torn.

Bursting strength 35, 36, 37, 37½

(E) Two linen bed sheets. Worn thin by shoulder wear and with weft tears about two inches in length. No evidence of damage due to bleach or micro-organisms.

Bursting strength around the tear in lbs. per square inch.

(1) 27½, 29½, 35, 34, 31½, 28, 36 ... ... Average 32
(2) 39½, 30½, 41½, 31, 29½, 40½, 46, 44 ... ... Average 38
Average of first six 35

Bursting strength at unworn bottom corner of sheet (1) ... ... 133 lbs.

(F) Cotton cellular fabric drawers. Not seriously damaged by wear.

Right inner fork of leg ... ... 23, 16, 20 lbs.
Centre portion of seat, thin but not torn ... ... 27½ lbs.
Outer part of left leg, apparently not worn ... ... 31 lbs.
Right side near top „ „ „ ... ... 41½ lbs.

(G) Cotton net curtains scrapped as too weak after use.
Bursting strengths :—

Cotton net	(1) 23, 22½, 22½, 20, 18, 20½	21 lbs.
	(2) 16, 18, 17, 17½, 17½	17 lbs.
	(3) 12, 14½, 16, 13½, 14	14 lbs.
	(4) 11, 10, 10½, 12½, 12	11 lbs.
	(5) 17, 17½, 16, 15, 15, 15, 17	16 lbs.
Fine net	16½, 19, 17, 17½, 16...	17 lbs.
Cable net	(1) 15, 14½, 14½, 12, 14	14 lbs.
	(12, 14, 11, 14, 14½	13 lbs.

(H) Drawn thread linen curtains. Squares of fabric 3½ inches outlined by drawn thread work. Scrapped as drawn thread portion had torn. Bursting strength in lbs. per square inch :—

Drawn thread work portion ... ... 22, 23, 21, 18, 21, 18, 21½. Average 21 lbs.
Fabric of squares ... ... 45½, 45, 46. Average 45 lbs.

(I) Fancy cotton net curtain tendered but still not torn. Considered usable.

29, 29, 28, 26, 28 ... ... Average 28 lbs.

(J) Weighted silk georgette used for curtains and seriously torn in first dry-cleaning. Very tendered.

11, 11, 12, 11, 12½ ... ... Average 11½ lbs.

Appendix No. 3

Fabric.	Weight per square yard Ozs.	Threads per inch Warp	Weft	Tensile strength in lb. per 4″ grab test Warp	Weft
Rayon crêpe de chine... ...	3·3	135	74	136	77
	3·2	137	69	158	71
	2·55	138	80	87	36
	2·8	—	73	90	32
Cotton poplin shirting... ...	3·4	112	57	235	126
	3·7	112	59	—	62
Cotton gingham	2·9	72	63	138	100
	3·25	74	60	137	70
Silk crêpe de chine	1·71	156	99	149	70
	1·78	158	89	96	42
Cotton velveteens	5·9	80	61	150	87
	5·7	80	61	109	38

SUMMARY

The useful strength of a fabric is its excess over the maximum tension or pressure occurring in ordinary conditions of use. The term Normal Stress is used to designate this tension or pressure. Tests on fabrics which tore in use or which had been discarded as worn out show that for a wide range of uses the Normal Stress may be taken as equal to a tension of 40 lbs. on a 4 inch grab test, or as a pressure of 37 lbs. per square inch. The importance of the Normal Stress value in other tests on textiles and in the design of textile fabrics is indicated.

DISCUSSION.

The Chairman, Mr. Henry Binns, congratulated the author on opening up the subject of textiles from a new angle. It was necessary that the " Preference Values " in selling to the public should be co-ordinated with the " Intrinsic Values " of production. Hitherto the retailer and manufacturer overstressed one aspect at the expense of the other from different viewpoints. Both were of the greatest importance and could now be regarded as falling within the scope of the distributors' investigations.

In reply to Mr. Henry Binns the author said that he fully concurred with the remarks about preference values and intrinsic values. The investigation of preference values should be an important part in the testing of textiles for retail distribution. He had done a little work on this subject and the results might be of interest. Sixteen lines of cotton sheets which would retail at ten shillings per pair (single bed size) were arranged in order of test merit so far as the wearing qualities were concerned. These sheets were then arranged in order of preference by ten members of the public and by four well-experienced salesmen of household linens. On the average preference of the members of the public, the first four sheets in the test order of merit were graded 1, 6, 11 and 3 and the last four were graded 13, 15, 14, 16. The grading by the salesmen were 10½, 1, 9, 2½ and 15, 16, 12, 10½. It will be noticed that there appears to be a considerable difference between the preference of the members of the public and that of the salesmen. The public all carefully felt the fabric and were mainly influenced by its texture and general appearance. Three out of the four salesmen were very considerably influenced by the weight of the sheets. Similar tests have been applied on a smaller scale to silk crêpes de chine and cotton winceyettes; here the salesmen appeared to reflect more accurately the public taste. The noticeable

feature of the work done was that there was a very good agreement in disliking certain samples. This type of investigation offered a fruitful field for work and meant a fabric could be produced which would sell best and serve best. The question of the variation of taste in differing localities could easily be investigated; the author doubted whether the variation was as wide as some people supposed.

Mr. Garnett welcomed the paper from the point of view of its bearing on the ethics of salesmanship. If Science and Industry could co-operate to give service to the public in the direction of supplying goods suitable for specified purposes, this was a very important feature. Such co-operation had been wanting in the past. It was desirable for example to secure information as to the precise responsibility for any defect which laundering revealed. It was not satisfactory for the manufacturer to assume all the responsibility because that did not necessarily lead to the removal of the causes of the defects. The outcome of investigation would be to the all-round benefit of all concerned.

The author stated that he thoroughly agreed with the remarks made by Mr. Garnett and that the textile industry should be regarded as one unit from the seller of the raw fibrous material to that last stage when goods went into the rag bag. Co-operation between producers, wholesale and retail distributors, launderers and dry-cleaners, and makers-up of garments, etc., would be beneficial to all concerned. The directions for improvement were indicated by complaints received from the public. Maybe the Textile Institute could be the central body in such co-operation.

Dr. L. L. Lloyd said the subject was one of considerable interest though it was beset with difficulties. Such factors as wear, for example, entered into the problem. He instanced a case of a number of girls' sports costumes wherein the effects of wear, as revealed by laundering, were most marked in the portion of the garment over the knee where friction had aided fracture of the fibres. Again the problem varied with different fibres, grades of the same fibre, and with the machinery used in processing at all stages from the raw material to the finished garments. He also pointed out that tests would vary if made on the same fabrics before and after laundering. The heat treatment during pressing or ironing after laundering was perhaps one of the main sources of variation of strength of material, which might be multiplied by repeated laundering.

In reply to Dr. Lloyd the author agreed that the problems of the service-giving qualities of fabrics were many and involved. The paper only put forward one aspect of the problem. As very much work was necessary he hoped that this rather " practical " research would receive its share of attention from those who had the time for research work.

Mr. H. B. Heylin asked if information secured by the author in his department was passed on to the salesmen of the same firm. The younger generation of salesmen was being encouraged by the London Employers' Association to attend textile classes for instruction in the material properties of the fabrics and garments they had to sell. In London, particularly, schools and classes were established for this purpose and the London Section of the Institute was playing its part in the work. Mr. Heylin proceeded to refer to his experiences of shopping during the past 20 years and to criticise some statements of shop assistants in relation to textile materials. It was hardly to be expected, he said, that a shop assistant would always be able to assert the truths about textile materials without having definite knowledge of their manufacture and construction. There were many youths in London shops to-day who were keen to learn as much as possible about textile constructions.

Replying to Mr. Heylin the author said that the technical education of salesfolk was an important part of his work. This was done by lectures and by private publications circulated to the buyers of the groups of stores with which he was associated, and the author had already written a book on the subject. He would, however, like to point out that education about methods of

manufacture and construction of fabrics would not enable a salesman to know much about the factors of real importance such as the colour fastness, strength, shrinkage, etc., of particular samples of cloth. In a large departmental store the wool piece goods department might contain from 400 to 1,000 different lines of dress goods and flannels, and in each of these would be a range of colours. If the salesfolk were to have detailed knowledge of the particular properties of each one of all these ranges of fabrics, then remarkable memories were going to be required, especially as in the retail trade the stock was continually changing. When the range carried in a store was considered it would be seen that the testing of every item of merchandise was not a practicable economic proposition. It was for this reason that the co-operation mentioned by Mr. Garnett was so necessary if the best service was to be given to the public. As a practical solution to the problem the author sought to grade merchandise into three groups which could be described as " guaranteed," " satisfactory," and " unsatisfactory " ; the third group was not sold and salesmen were instructed not to give the assurance appropriate to " guaranteed " goods without proper warrant for such course. The author considered that the present systems of education for salesfolk paid too much attention to the processes of manufacture and not enough to the properties of the finished merchandise in use.

Mr. J. Crompton said that he appreciated the paper very much and felt that it was evidence that the Textile Institute constituted a focus for all textile interests. He did not agree with the previous speaker entirely though all would wish to see buyers and salesmen educated in respect of the goods with which they dealt as far as practicable. He would welcome any movement that resulted in an improvement in the quality of the goods supplied at a given price rather than a progressive move towards reducing prices by degrading quality. He instanced in illustration the depreciation in quality which of recent years had taken place by the replacing of doubled yarns by singles in certain types of shirtings. The buying public ought to know what constituted essential quality in such goods. He also instanced the present demand for uncrushable 100 per cent. rayon fabrics made from highly twisted yarns as a move in the right direction. He thought ladies had learnt the unwisdom of buying very low priced single yarn rayon dresses which frayed at the seams and looked shabby after wearing only a few times. Assuming the labour cost of making a garment to be much the same whatever the quality of the material, it was true economy to choose a good wearing fabric.

Mr. Williams said he was in complete agreement with Mr. Crompton. Instead of competing by lowering price the right direction was to maintain the price and improve the quality. This was desired by all intelligent buyers for the retail trade.

Dr. R. E. V. Hampson, called upon by the Chairman, said that what he had to say would be largely on the lines of the paper he was to contribute to the Conference the next day. He pointed out that the launderer had got a good deal of undeserved criticism to overcome and a reputation even if unmerited was not easy to re-establish. In his opinion the way to salvation lay through co-operation from the yarn to the laundered article. Given reliable information as to the character of the goods to be washed, processes could frequently be devised to meet their special characters or to overcome possible causes of complaint.

The Lecturer agreed to these remarks.

Dr. Guy Barr (in a written contribution) stated that Mr. Williams suggested, as a result of tensile tests on worn materials, that a strength of about 10-lb. per inch represented approximately the limit below which the article might be said to be worn out. He would like to suggest that another and perhaps equally important criterion might be found in a strain limit. The strength of 10-lb. per inch corresponded presumably with that at which a material tore when tested by hand, or possibly with some fairly constant pull exerted during washing,

but would not failures of garments during wear normally be related to the occurrence of a critical strain ? When, for example, the elbow of a coat was worn out, the final failure would take place when the extension produced by flexing the elbow (an extension which would be moderately constant for a fit of a certain order) was in excess of the extension which the weakened material could sustain. The actual stress which was produced by such extension would naturally be much larger for a calico than for a loosely knitted woollen fabric. It would be of interest to obtain data for the extensions to which material was liable in those regions where failures of clothing occurred, postulating either a tight or a loose fit. The immediate suggestion, however, was that in such further tests as Mr. Williams or others might make in this connection, it might be valuable if breaking extensions as well as breaking loads were recorded.

With reference to the contribution by Dr. Barr, Mr. Williams agreed that a measure of the extension of a fabric at breaking point would be of interest and was desirable. But in the great majority of cases the stress on fabrics would be a continuing one not greatly relieved by the strain. The particular cases where the strain effect might release the stress, were in tight fitting garments ; in these cases there were also other factors such as thread slippage at the seams, and, especially with rayon, the permanent elongation of the threads leading to permanent cockling or to outstanding loops of threads. In the case of fabrics of a weak type the extensibility with stresses undoubtedly determined the capacity to withstand stresses of brief duration. It did not seem probable that the extension of break would prove equally important with the stress at breakdown in use or that common values of practical significance would be obtained as the variations in tightness of fittings would be too great.

THE SIGNIFICANCE OF RESULTS IN TEXTILE TESTING

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INTRODUCTION

The scope of this paper is distinctly limited, as it is impossible to cover the whole field of the subject. The spinning and doubling of cotton yarns, and the problems bearing on these processes, cover most of the range of the author's experience in textiles, but much of the subject matter of this paper is applicable to other branches of the textile industry if appropriate modifications are made. The scope of the paper is also further limited to the results of quantitative tests, though actually they cover the larger portion of the testing of textile materials. This limitation is deliberate, because quantitative results may be handled by statistical methods and their accuracy may, therefore, be numerically defined.

If one were asked which was the most striking feature of the values of measurements of any single property of a textile material, one would unhesitatingly say " their wide variation." We are all familiar with the remark " the danger of generalising on a single observation," but what we wish to know is whether, in dealing with a very variable material, it is even possible to obtain a significant result if we take a large number of observations of a well-defined property of the material. The wide variation in magnitude of the observations may be due to one possibility or a combination of possibilities.

(1) The testing arrangement may be either defective or unsuitable.
(2) Faulty manipulation of the testing apparatus by the observer.
(3) The effect of outside conditions, such as atmospheric state, vibration, etc.
(4) Real variations in the materials under test.
(5) Bad sampling of the materials.

In a good testing laboratory, possibilities (1), (2) and (3) may be ruled out as insignificant when compared with the possibilities (4) and (5). We cannot make this arbitrary distinction in the case of many mill-testing rooms, but as the majority of mills have access to a reliable testing laboratory, it is safe to proceed, accepting this simplification as justifiable. It is well here to stress the view that while mill staffs fully realise the importance of eliminating possibilities (1) and (2), they do not fully realise the necessity for eliminating possibility (3). At this point, a few remarks on the atmospheric state of testing rooms will not be out of place. It is desirable to keep the relative humidity and the temperature as constant as possible, and control of the former is the more important. The temperature may be allowed to vary, within wider limits, provided the variations are slow, without serious consequences. It is desirable to control the relative humidity of the testing room within $\pm$ 2 per cent., but a variation of $\pm$ 4 °F in temperature is permissible.

REAL VARIATIONS IN THE MATERIAL

That there are real variations in the properties of textile materials is obvious to the eye, and they are still more obvious when viewed in the form shown in Table 1, where 200 determinations of the strength of individual cotton fibres taken from an Egyptian Sakel sample are recorded.

Table I. The Fibre-Strength of a Commercial Sakel Cotton.

Strength Range (grams)	Number of Fibres of Strength within the Range
0·6– 1·5	Nil
1·6– 2·5	21
2·6– 3·5	30
3·6– 4·5	35
4·6– 5·5	46
5·6– 6·5	33
6·6– 7·5	19
7·6– 8·5	9
8·6– 9·5	4
9·6–10·5	3
10·6–11·5	Nil
Total Number of Fibres Tested	200

Assuming these 200 fibres represent a true sample of the cotton, how are we to answer the question " What is the fibre-strength of this cotton ? " We are asked to provide a significant or reliable answer to this question.

The only complete answer would be the table of figures, but unfortunately it cannot be easily visualised, and is so incomprehensible that we are unable to make much use of it. If we give the arithmetic mean or average of the 200 determinations, which is so often done, we do not convey any idea of the large variation of the individual tests. Even if the maximum and minimum values also are stated, we only exaggerate the importance of two out of 200 results, and we give no indication of the way in which the results are distributed over the whole range. It is possible, using statistical mathematics, to describe the distribution of such a variable group of values by single items which are all related. These items are called the probable error, the standard deviation, the coefficient of variation, etc., and they have calculable numerical values. The choice of method of expressing the variability depends on the nature of the result required and the form of the distribution of the values, but it is beyond the scope of this paper to show how the numerical values of these items are evaluated. A list of books, etc., is appended which deal with the mathematics of the science of statistics. The significance of a result depends as much on the statistical way it is expressed as on the apparatus, the observer, or the

other factors associated with its production, and the result of any test on the property of textile materials is open to suspicion unless one of the above items is correctly calculated or the whole series of values is given.

The necessity for the use of statistical methods may be shown in another way. The reliability of a mean or average result depends on the accuracy of the result, and it is a waste of time to talk of the significance of a result unless its accuracy is defined. The science of statistics enables us to define the accuracy, and it is absolutely indispensable to the testing of textile materials.

The probable error, standard deviation (or error) and the coefficient of variation are really various forms of expressing the probability or chance of a result being correct. We will suppose that the calculated probable error of a single determination of the strength of the 200 cotton fibres is plus or minus 1 gram (usually written $\pm$ 1 gram), and that the actual mean strength is 5 grams. Such a result would mean that half of the observations (100) would lie between 4 and 6 grams. The probable error defines the limits between which there is a 1 : 1 or evens chance that any observation will fall.

The standard deviation, or standard error, is a little larger than the probable error, and for most purposes may be defined as one and a half times the probable error. If we express the standard deviation as a fraction of the mean or as a percentage of the mean, we obtain the coefficient of variation, which is, for many purposes, a useful form of expressing the variability or accuracy of a result.

Several examples of the application of these methods of expressing accuracy to textile investigations will show their usefulness. For instance, how many tests of a property of a textile fibre are necessary to obtain a mean result of known accuracy, say within 5 per cent. or 1 per cent. ? We may answer such a question by using, as an example, the 200 determinations of single fibre-strength given in Table 1, from which we find that

the Probable Error of a single observation is $\pm$ 1·21 grams,
the mean strength is 4·87 $\pm$ 0·086 grams.

The methods of evaluating the Probable Error are given in all books on statistics.

In Table 2 are given the numbers of tests it is necessary to make to obtain defined accuracies and the corresponding odds that the accuracies are correct.

Table II

Accuracy desired for mean result	Odds the result is correct to the desired accuracy	Number of Tests required
5%	1 : 1	25
,,	55 : 1	305
,,	1350 : 1	625
1%	1 : 1	625
,,	55 : 1	7,660
,,	1350 : 1	15,630

If we accept 1350 : 1 as certain odds, we see from this table that an alarming number of tests must be taken to obtain the mean fibre-strength of a Sakel sample to an accuracy of 1 per cent. Even with the most rapid fibre tester, 15,600 tests would mean days of work for a skilled operator, and the number is impracticable in almost any laboratory. In the Fine Cotton Spinners' laboratory we make 200 observations for ordinary purposes, and more only when the test is of special importance, but we do not lose sight of the consequences of issuing a result obtained from a statistically insignificant number of observations. The probable error (single observation) used in these calculations, which is about 25 per cent. of the mean strength (for 200 observations), is typical for Egyptian Sakel cottons. The range for 50 recently tested cotton samples varied from 20 per cent. to 28 per cent.

Even if sufficient observations had been taken, these calculations are not strictly accurate, because the method used is only true when the distribution

of the observations is " normal." The departure from normality is not very great for Egyptian Sakel cottons, but for Indian cottons, as Turner and Koshal[1] have shown, the departure is serious and special statistical methods have to be applied. The treatment of results by these special methods is a task which can only be attempted by those well-equipped with the mathematics of statistics, and even then it is tedious. Quicker methods are wanted very badly even though they sacrifice a little accuracy, and it is pleasing to note that Tippett[2] has already developed a rapid method for determining the standard error which is applicable not only to distributions of the normal type, but also to those which do not greatly depart from the normal.

The single fibre-strength of cotton is one of the most variable properties we have to measure, but the twist of a singles cotton yarn approaches it in variability if the measurements are made on one-third inch lengths, which experience has shown to be necessary for medium and fine count yarns.

A textile laboratory is frequently asked to say whether one material is better than another. We will suppose that we are asked to decide whether one singles yarn is stronger than another, and that the single thread test is used for the comparison. We must also stipulate that a true and adequate sample of each yarn is available. A concrete example is perhaps the best way to illustrate the method by which such a problem is tackled. After making 200 single thread strength tests on each of two yarns, " A " and " B," the following results were obtained :—

" A "—Mean Strength 83·9 ± 0·51 grams (the Probable Error of mean).
" B "— ,, ,, 85·2 ± 0·55 ,, ,, ,,

It may be shown that the probable error of the difference between the two means is equal to the square root of the sum of the squares of the probable errors of the means, which in this example is 0·75 grams. It should be noticed that the probable error of the difference between the means must always be greater than either of the probable errors of the means. As the difference between the two strengths is only 1·3 grams, and the probable error of the difference is 0·75 grams, it is obvious that we may make no very definite statement about the superiority of " B " over " A " in single thread strength. If we are to make a valid decision, the number of tests on each sample will have to be increased until the probable error of the difference is reduced to a value which makes the actual difference significant. The odds that a difference between two mean quantities is significant may be obtained from Table 3 below, where " E " is used to denote the probable error of the difference between the means.

Table III

The difference between the two quantities	Odds that the difference is significant
1 E	3 : 1
2 E	10 : 1
3·5 E	110 : 1
5 E	2700 : 1

This information enables us to determine the number of tests we should make to be sure that the difference between the strengths of the yarns " A " and " B " is significant. We must first decide the odds we are to accept for certainty, and most people would be content with 110 : 1. To fulfil these odds, 3·5 E must not be greater than 1·3 grams (the difference between the mean strengths), or E must not be greater than 0·37 grams instead of 0·75 grams. By calculation we find that four times the number of tests on each sample will satisfy these conditions, or that 800 tests per sample are necessary.

We may look at the example another way. If only 200 tests are taken, what difference in mean strength between the samples may be considered as significant ? As the number of tests is not large, it is safer to use 5 times E as the criterion of significance, from which we calculate that the difference in strength must not be less than 3·8 grams.

In the investigator's opinion, a very good example of the necessity for a large number of observations will be found in F. Charnley's paper[3] entitled " The effect of roller delivery motion on the irregularity of mule yarns." In this investigation, yarns were spun on the mule with and without the roller delivery motion, and 5,200 single thread strength tests were made on each type of yarn with the following result :—

Mean Single Thread Strength without roller motion 104·1 ± 0·147 grams.
" " " " with " " 102·0 ± 0·157 "

The probable error of the difference between the mean strengths is 0·215, and since the actual difference (2·1 grams) is nearly ten times this value, the author concludes that mule yarn spun without roller motion is definitely stronger than mule yarn spun with roller motion. In the same paper is given another statistical method for determining the variability of a property of a material and expressing it in a form which may be easily visualised and interpreted. The method, called the " irregularity," is in some respects superior to the above methods, because it depends on the distribution of observations, which are less than the mean values. The choice of method of expressing variation must be decided by consideration of the application of the result. A spinner will not be congratulated on the number of extra strong parts in his yarns, but he will certainly be blamed for an excessive number of weak places. This is not an injustice to the spinner. The manufacturer will not notice the strong parts, for they will pass through his loom normally, but the weak places break down and their presence is forced upon his attention in a manner not conducive to good feeling for the spinner. The best method of deciding whether a yarn is up to standard would be to weave it on looms working under standard conditions and to make a break-time test, but this is impracticable except for those special researches where it is desirable and profitable so to do. We must adopt some method of emphasising the extent of the variation on the weak side of the mean yarn-strength. In our Association we often express the yarn strength by a mean value and a percentage of observations falling below a fraction of the mean strength value. The method does not absolve us from making sufficient tests to enable us to define the accuracy of the mean value on the lines previously considered. It is not a short cut ; it is an extra and strong weapon for obtaining a significant result for special conditions.

The result may be made even more significant by carrying out a winding under constant tension test. The constant tension is arranged to be a fraction of the mean strength, and the test records the number of breaks in a measured length of yarn. The test automatically selects the weak places, and it has a further advantage in that a very long length of yarn may be tested very rapidly, and without an observer's assistance except to tie up the broken ends and note down the reading on the length recorder.

The problem of obtaining significant results when the number of observations is small is more difficult, but recent work, particularly in agricultural experiments, has led to the development of more exact methods under such conditions, and these are being incorporated, where appropriate, in textile investigations. There is open to the statistician an extensive field of enquiry into the method of analysing and presenting the results of textile tests, and the work of Turner and Tippett in this direction has already been noted.

SAMPLING FOR TESTS

When there are several factors concerned in obtaining a result, it is bad practice to measure these factors with different degrees of accuracy. This

statement is as true for textile testing as for any kind of scientific investigation. A result obtained from thousands of tests on a textile material is worthless if the sampling of the material is inaccurate, even though the tests be made under the best conditions. In making a true sample, two conditions at least have to be satisfied; we must be sure that sufficient has been taken to include at least one representative of all the possible types in the bulk supply, and there must be no selection or bias in the process. From experience we know how unsatisfactory is the simple task of buying apples on the basis of the appearance of the display in the shop window. The shop-keeper, wisely or unwisely, makes a favourable selection for display purposes, but in this case the selection is often suspiciously deliberate. Even though the selection is made without prejudice on the part of the selector, an unconscious selection in favour of one or more particular kinds often creeps in. Turner and Koshal[4] give a good example of unconscious selection of cotton fibres for strength testing purposes. When the observer chose the fibres individually, he unconsciously selected the longer fibres. The difficulty was overcome by choosing bundles of fibres and testing all in each bundle. This is not peculiar to this particular observer, as other investigators have found the same effect. It is even possible to find observer's prejudice in making simple length determinations where the units on the measuring scale have to be divided into tenths by eye. The same prejudice may be found in splitting up the one pound scale intervals of a lea tester into fractions, but errors of this type are few and insignificant when the observations are performed by a skilled experimenter. The first step in obtaining a satisfactory sample is largely one of technical manipulation, and the sample should be taken by one who has sound knowledge of the processes through which the material has previously passed. It is true that statistical methods may be used to ascertain the chance that the sample is representative, but the closest co-operation between the technician, the statistician, and the experimenter is necessary if waste of time and effort are to be avoided.

A representative sample having been obtained, the number of tests to be made is determined by the variability of the results and the accuracy desired. The simpler statistical method for determining the number of fibre-strength tests, described earlier, will suffice to show how the problem is tackled, unless the distribution of the variations is considerably abnormal. To be safe, more than the estimated number should be taken, but where abnormal distributions are found it may be shorter to spend some time in searching for the appropriate statistical treatment.

OBSERVATIONS ON TESTING APPARATUS

We have seen that for the majority of problems it is necessary to make a large number of tests to obtain a significant result. From this condition it follows that every endeavour should be made to make each observation as rapidly and as accurately as possible. Wherever possible, the testing apparatus should be made automatic, not only in performing the test but also in recording the results. When attempting to devise self-recording mechanism, it is very necessary to make sure that the power used in recording is only a very small percentage of the power or force being measured. The ideal recording device is frictionless. If the apparatus cannot be made self-recording, every effort should be made to make the observer's task as easy and as free from personal error as possible. All this seems very obvious, but it is surprising how many testing appliances contain opportunities for error which could have been easily eliminated in the design.

CORROBORATIVE METHODS

The significance of a result in textile testing may often be made almost certain if several independent methods provide the same answer. There is something very convincing about corroborative evidence, even if the individual

clues are doubtfully significant. If the accuracy of each method is defined on the lines previously considered and has a reasonable significance, only a stubborn individual would refuse to accept a decision so obtained. It is difficult for one observer to estimate the correct distance of an object even with the aid of a one-man range-finder, but two observers with much simpler appliances are able to obtain a much more accurate result, if the distance between them is a fairly large percentage of the distance to the object. Three observers suitably spaced are able to obtain a very accurate result, and the third observer is able to verify the estimate of the two original observers. If the third does not verify the estimate, all three must repeat their observations. The application of this analogy to textile testing methods should not be overstrained, and is only intended to illustrate the increased confidence which a third observation brings to the result. It will be noticed we stipulated that the observers must be widely separated, which means viewing the object from widely different angles. It so happens, particularly in testing textiles which have passed through several processes, that a combined attack from the physical, chemical, and statistical viewpoints will produce a result which is far more convincing than one obtained by a single method. These combined methods are extremely useful in dealing with finished goods and, as we shall show later, the senders of such goods for testing may help very considerably in attaining significant results. Multi-directional attacks are sometimes possible on problems connected with grey yarns, where damage by mildew, bacteria, ill-treatment, etc., are possible sources of trouble. Such methods not only assist in reaching a decisive result, they also help to locate the origin of the defects. Qualitative results, when the method of observation has been suitably planned, may also be used as confirmatory evidence. Thus there is open an interesting field for enquiry into the application of new testing methods to textile problems. We have inherited many methods which, though satisfactory for the needs of our ancestors, are now peculiarly unconvincing in the light of modern knowledge and in their application to our rapidly changing requirements in technical usage and for clothing.

DIFFICULTIES IN OBTAINING DECISIVE RESULTS

Every textile laboratory which serves a large section of the industry is confronted with many real difficulties in supplying significant answers to enquiries for decisions on the uniformity of twist and strength of yarns, or of other properties of textiles. It is comparatively easy to measure the variation in a commercial sample, but when we try to pronounce judgment on its variability in relation to trade standards, the task is not easy. In the first place we have no real standards. Falling prices, speeding up, weather, and all the changes of recent years preclude the possibility of setting up stable standards. Statistical mathematics is quite capable of overcoming the difficulty if the necessary information is available, as the distribution of variations may be treated in much the same way as single observations are treated. The best that may be done is to fix a standard with a reasonable tolerance.

The distribution of variabilities is seldom "normal" in the statistical sense, and our experience has shown that the distribution is skewed, but not seriously. The distribution or frequency diagram is always steeper on the lower side of the modal value, which is always the value at which the greatest number of observations occur. To make this clearer, let us suppose we are comparing the single thread strength variability of similar groups of yarns spun by 100 different mills, and the coefficients of variation for similar types have been evaluated for each mill. If we find that the range of the variabilities is greater on one side of the mean variability than the other, the distribution is said to be skewed. Our experience, which is insufficient to be statistically certain, indicates that the variability range is always more extensive on the side of the mean variability which contains values greater than the mean. We believe this will be generally true in manufactured articles, unless some revolutionary

invention for improving uniformity appears within the period of observation, and if this did happen the only reasonable plan would be to scrap the old mean standard and evaluate a new standard for articles made by the improved method. Our reason for this belief, at least in the case of yarns, is that it is easier to make a yarn more variable than the mean standard of uniformity than to produce a yarn which is less variable. For instance, let the mean variability of yarn twist, as represented by the coefficient of variation or any suitable measure, be 7 per cent. Without much difficulty it would be possible to make a yarn with a variability of 12 per cent., an increase of 5 per cent., but we should like to see a yarn with a variability of 2 per cent., a decrease of 5 per cent. Having established a standard, there seems to be no point in fixing a tolerance on the side of better quality, as no mill is likely to err greatly in this direction. It may seem dangerous to fix a tolerance on the side of inferior quality, lest the spinner be encouraged to spin yarns which just come within the limit imposed by the tolerance. Actually, there is very little danger, because the range of variability found in yarns which makes the tolerance necessary is also a protection against exploitation. Any attempt to work close to the limit of the tolerance is bound to end in overstepping the limit.

Table 4
The variability of certain properties of commercial yarns and some suggested standards.

Description of Yarns and Yarn-Properties	Mean Coefficient of Variation	Standard Deviation of Variability	Suggested Mean Standard Variability	Variability Tolerance
SINGLES TWIST VARIABILITY				
Counts 1/30's to 70's	21·1%	2·75	22%	5·5%
,, 1/71's to 130's	24·8%	3·40	25%	7·0%
Twist Factors up to 2·9 ...	25·2%	3·32	26%	7·0%
,, ,, 3·0 to 3·9 ...	21·2%	2·96	22%	6·0%
TWOFOLD TWIST VARIABILITY				
Counts 2/40's to 2/80's ...	11·1%	1·87	12%	4·0%
,, 2/81's to 2/120's ...	11·9%	1·88	13%	4·0%
Twist Factors up to 2·9 ...	12·1%	1·74	13%	4·0%
,, ,, 3·0 to 6·0 ...	10·5%	1·93	12%	4·0%
SINGLE THREAD STRENGTH VARIABILITY				
Singles Yarn:				
Counts 1/30's to 1/70's ...	11·6%	1·45	13%	3·0%
,, 1/71's to 1/100's ...	12·4%	1·43	14%	3·0%
,, 1/101's to 1/160's ...	13·5%	1·50	15%	4·0%
Twist Factors up to 2.9 ...	11·7%	1·60	13%	4·0%
,, ,, 3.0 to 3.9 ...	11·4%	1·45	13%	3·0%
Twofold Yarns:				
Counts 2/30's to 2/60's ...	7·4%	1·24	9%	3·0%
,, 2/61's to 2/100's ...	8·7%	1·46	10%	3·0%
Twist Factors up to 2.9 ...	8·5%	1.53	10%	4·0%
,, ,, 3.0 to 6.0 ...	8·1%	1·41	10%	3·0%
Threefold Yarns:				
Counts 3/30's to 3/60's ...	6·6%	1·46	7%	3·0%

NOTES:—Singles Yarn Twist—on $\frac{1}{8}$ inch lengths.
Folded ,, ,, on 2 inch lengths.
Where the twist factor range only is given the count range covers both groups.
Single Thread Strength—on 18 inch lengths, bottom jaw speed 12 ins. per minute.
All tests carried out on specially designed instruments made in the Experimental Department, The Fine Cotton Spinners' & Doublers' Association, Rock Bank, Bollington, near Macclesfield.

In Table 4 we have collected some mean or standard variabilities and tolerances for such simple yarn properties as single and two-fold twist and single and two-fold strength (single thread). It is not suggested that these should be accepted as trade standards for medium and fine yarns, but they do represent the qualities of such yarns as produced by a number of mills forming a large portion of the fine spinning section of the cotton industry. Unfortunately, owing to the difficulty of obtaining sufficient records of tests on yarns of approximately the same count, they have had to be grouped over a range of counts. Each group contains the results obtained from tests on 70 to 140 yarns. The variability of the yarn properties is defined by the coefficient of variation, which is the standard deviation expressed as a percentage of the mean value.

SAMPLES FOR TESTING

When planning an investigation, it is the first duty of the experimenter to arrange for sufficient material for test purposes to ensure that real variations in its quality are allowed full play. Unfortunately, senders of commercial samples for testing seldom make allowance for these real variations. There still seems to be a feeling that the scientific tester is a magician who is able to produce a satisfactory answer to a request for accurate description of a sample which, from its size and appearance, appears to be all the enquirer could get away with without being seen. Happily this illusion is being dispelled as science and industry get to know each other better, but we appeal to the trade to help the investigator to overcome the effect of variations in quality by giving thought to the method he employs to ensure accuracy. It is desirable that industry should fully appreciate the investigator's desire to produce a significant result, and all that it stands for, so that disappointment may be avoided—the disappointment of having to issue a result with more emphasis on its doubtful significance than on its accuracy. The investigator has to make himself familiar with all the possibilities of variation in a textile sample submitted for testing, so surely he is not asking too much if he insists that the supplier of the sample shall not only possess this knowledge but also apply it in making up the sample. We have thought it desirable to give effect to these remarks by stating a few of the requirements for making up samples for testing.

Yarns

Grey.—At least 16 cops or ring tubes of singles yarn.

At least 16 bobbins of folded yarn if the spindles are band driven, though 8 bobbins will often be enough if tape driven.

If the yarn is in other forms, such as hanks, cheeses, pirns, etc., the quantity should be such that it contains yarn from the number of bobbins or cops stated above.

Finished.—The same requirements as above are necessary, except when the yarn is to be tested for faults. In examining faults it is desirable to have adequate samples taken after each process through which the yarn passes. If this is not possible, then a sample of the grey yarn should accompany the faulty processed yarn. In our opinion, the spinner is justified in insisting on having a sample of the control grey yarn included in the testing.

Fabrics

Considerable work has been done in standardising the method of testing fabrics for strength, etc. The size of the sample of cloth should be large enough to allow such methods to be used, and we do not propose to consider this side of testing. Examination of faults in fabrics is now so extensive that some discussion on this subject will not be out of place. The investigator of such faults needs

considerable information before he can decide the testing procedure. The following information is required :—

(1) The nature of the fault should be clearly stated. It may be that there are several kinds of fault in the fabric, but only those should be stated which make the cloth unsaleable or have led to its rejection from the class for which it was intended. This may be briefly summed as " Define the problem set for the investigator's attention."

(2) The extent of the fault or faults, i.e., the amount of cloth which is affected by the faults. The demands on investigators' time are now so heavy that more money may be wasted on investigating the problem than the whole of the faulty fabric is worth.

(3) The stage in production where the fault was first observed.

(4) As much as possible of the history of the production of the cloth, i.e.,

(*a*) The class of yarn used—plain, gassed, combed, mercerised, etc.

(*b*) The method of warp preparation—beam, ball, cheese roller, etc. ; the number of warps used together with the number of ends per warp, its length and the order of creeling.

(*c*) If the faults are in the weft, it is desirable to know whether the supply was from cop or pirn, and the treatment applied to the weft, i.e., whether steamed, conditioned, bleached, etc.

(5) In all cases a full-width piece of the fabric is desirable. The length required depends on the character of the faults and on the particulars defined above, and often may only be decided by discussion between the investigator and the sender of the cloth. It is well to remember that the success of the investigation really depends on the amount of the sample as much as on anything else, and that it is in the sender's own interest to supply as much material as possible. A few square inches of cloth may sometimes be adequate, and at other times a few pieces may be inadequate.

In recent years the textile industry has devoted much more time and energy to the production of new fabrics. Before these fabrics reach their final form they have often passed through many processes, each of which contributes its quota, for good or evil, to the final appearance. If the multi-processed fabric is a failure, each section of the inudstry tries to absolve itself from blame, and the fault-investigator is asked to find the cause of the failure and incidentally to provide the stick with which to beat the offender. The fault-investigator is thus put into an unenviable position, and naturally he tries to make his findings as bullet-proof as possible. In some such cases our experience has been disappointing, and a little foresight might have led to a significant answer to the problem, and possibly to a means of overcoming the defect. Failure has been caused by neglect of such a simple precaution as laying aside a good sample of the material at all stages of manufacture. Often, only a small piece of the finished material is available, and the investigator is asked to pronounce judgment on the cause of the trouble. When a new type of fabric is produced, surely it is worth while setting aside a sample at every stage, as these samples are invaluable to the subsequent analysis of the cause of defect.

Thus we reach the final conclusion, that significant results in textile testing may only be made possible by close and intelligent co-operation between the representatives of the sciences bearing on textile problems on the one hand, and representatives of each section of the industry on the other.

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The following papers and books will be found useful for detailed methods used in Statistics :—

Turner, A. J. " The Significance of the Results of Quantitative Textile Investigations." *J. Text. Inst.*, 1921, **12**, 137.
This paper is used as a model for the earlier part of the present paper, and shows how the statistical treatment is handled.
Turner, A. J., and Koshal, R. S. " Studies in the Sampling of Cotton for Fibre Properties." *Indian Central Cotton Committee Technological Bulletin*, Series B, No. 10.
Tippett, L. H. C. " Statistical Methods in Textile Research : The Analysis of Complex Variations." *J. Text. Inst.*, 1930, **21**, T105.
Idem. " The Methods of Statistics " (Williams and Norgate).
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DISCUSSION.

The Chairman, Dr. A. J. Turner, said that the title of the paper had a definite appeal to all interested either directly or indirectly in textile research. All would be concerned with the significance of any results that were obtained. The businessman wanted to know what were the significance of results in terms of £ s. d. Scientists were interested in the significance of results as a means of interpretation of their work. The scientific worker needed imagination to conceive hypotheses ; he made observations to test or distinguish between them, and then ventured on prediction on which yet more observations had to be made. Thus one set of observations was followed by another set of observations, and they were continually confronted with the problem of ascertaining the meaning of those observations, that is, the significance of the results obtained in textile testing.

The Chairman said Mr. Slater had covered a very wide field. He was particularly impressed by Mr. Slater's emphasis on the necessity for a sufficient quantity of material for testing, as there would be no doubt that a large sample was often necessary before the cause of any fault could be assigned.

Professor W. E. Morton asked if the Lecturer found any appreciable difference in the spindle variant for ring yarn when the spindles were band driven and when they were tape driven. He also asked whether the Lecturer did not think that the variation due to differences in the spindle was greater than that due to differences in roller coverings or in other roller variables. If they wanted to obtain a representative sample, how many spindles must they take to sample out these three variables ?

Mr. Slater said he had not sufficient information to say what difference there would be in the variability of ring yarns spun with tape driven and band driven spindles, but by analogy with doubling he ventured to say that the tape driven spindle yarn would be more regular than the band driven spindle yarn.

Spindle variations generally gave rise to larger variations than roller variations, except where the rollers were badly worn or wrongly set. If all possible variations were to be included in a sample, it would be necessary to take cops from all parts of the spinning room. Machine conditions, atmospheric conditions and even human conditions varied over the spinning room.

Mr. F. Wright said that in the testing of samples of cotton when submitted for buying 18 tests gave a true indication of the value of the cotton. In a long period of years he had tested thousands of cops and had used this number as the test and was quite satisfied to act on the result obtained. He did not know who originally decided this number but was interested to find it practically agreed with that recommended by Mr. Slater. It might be interesting to say this, his firm for 50 years had never bought any cotton except after spinning samples of the cotton submitted.

Mr. G. H. Thompson said that in the list of singles twist variability the Lecturer referred to twist factors of 2·9 to 3·9. To-day trade was demanding

high twist factors or co-efficients even up to 12 and he would like to know what sort of variations the Lecturer considered allowable having regard to the higher twist factors.

Mr. Slater said he had not sufficient information to define the allowable variations in yarns of twist factor greater than 3·9, which were generally double spun yarns. All he could say was that these hard twisted yarns were considerably more regular in twist than the yarns included in Table 4 of the paper.

Dr. A. W. Stevenson asked what consideration had been given to alternatives to the " standard deviation." The latter had distinct mathematical advantages in elaborate statistical work but in textiles the deviation seldom required further manipulation. Some workers had advocated a plain mean deviation rather than a root-mean-square. There was much to be said for this on the ground of simplicity of comprehension but the speaker did not think that equal weight should be given to all the divergencies from the mean. At the other extreme there was the total range method which only took account of the highest and lowest figures. From the textile point of view these were often the important ones. As a compromise the speaker suggested consideration of the cube root of the mean cube of the fourth root of the mean fourth power. These eliminated the objection to the " range " that it only took account of two observations but they attached importance to the large variations which were likely to cause defects. One place 10 per cent. wrong was much worse than ten places 1 per cent. wrong.

Mr. Slater said that before replying to the question he wished to be quite clear that he did not wish to tie down the determination of variability to the root-mean-square method. He hoped he had made this clear in his paper, and each investigator was quite free to use statistical methods specially suited to his investigations. On the other hand, Fisher had shown that the root-mean-square method was generally better than the use of higher powers. It would be difficult to standardise textile statistical methods, but indiscriminate use of special methods could only lead to confusion.

Dr. F. T. Peirce said that he wished to support the views of Mr. Slater as a great deal of time and valuable resources were wasted on insufficient samples. No rigid formula could settle the question, as a sufficient sample might be anything from a few hairs to several pieces, according to the problem. The way out was for those who dealt with scientists to exert themselves to understand a little of their methods. All must endeavour to bridge the gap between the ordinary industrial outlook and the scientific outlook. The industrialist had a lot to say for his attitude, which was schooled by reality, and there was a great deal of real utility in the academic attitude. They both needed the statistical sense, which was a sense of proportion or the scientific sense of humour. Numbers meant nothing in themselves. Dr. Barker had described science as the simple truth : he considered that it had nothing to do with truth. It was based on the concept of congruence : in truth no two things were identical and things could only be described as numbers of units by ignoring differences that did not matter. Science provided a common, consistent description as ground for common action and for agreement as to common experience. Measurements which provided accuracy beyond the threshold of perception were really of little value, especially to the practical man. The scientist could and often did lose his sense of proportion, in pursuit of the ideals of absolute accuracy and meticulous definition which modern research had shown to be unreal. Though, as scientists, they had to preach a doctrine of accuracy, of controlled conditions, these must be related to the threshold of perception, beyond which they entered a realm of little real value. Their object was to obviate the personal and temporary variations of sensual perception on which unaided judgment was based. The bodily senses were peculiarly liable to the first three of the variations enumerated by Mr. Slater and the scientist constructed an extension of his body, called an

instrument, to be free from them. The same expert judgment could use the more precise observations and remained equally necessary. Testing instruments were also limited in their degree of accuracy; statistical analysis was a systematic method of maintaining a real relation between the source of data and the purpose of experiment. He had striven hard for years to see problems from the point of view of the mill man and thought it justifiable to ask in return that the scientists' point of view should be considered. The scientist could devise methods for securing a consistent and reproducible scheme of description, by analysing the factors of experience. This would not replace expert judgment, whereby the complex resultant of many factors was evaluated synthetically but provided common ground for the work of the two groups and of individuals.

Mr. J. H. Lester said Mr. Peirce had given a description of the point of view of the scientist which was very useful indeed. They might regard testing as the strongest link between the scientist and the industry and those employed in the industry. They might find a real basis for co-operation if they spoke of testing instead of research and by so doing they would get nearer to the hearts of the operatives and the managers in industry.

THE TESTING OF LAUNDERED FABRICS

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It is of course obvious that this subject could be treated in many different ways and from many different points of view. I may, however, say at the outset that it is the collaboration of the work of all parties—whether manufacturer, retailer or launderer—interested in the resistance of fabrics of all kinds to laundering treatment, which has been prominently in mind in preparing these remarks. There are, I am glad to say, many signs of a broadening vision in this direction, the very fact of the invitation given to me to contribute to the discussions of this Conference is sufficient evidence of this, were it needed.

Time was, and perhaps not very long ago either, when the laundry was at best simply a place where soiled linen was washed and ironed with little regard for the fabric involved, and less for the relationship of the industry to the public for which it worked. But in recent years research and experiment have made such progress that standard technique and processes are receiving general attention. Scientific control is gradually replacing the empirical methods which have been in use for so long and I believe the time has now come when we can guarantee laundering results where the fabric has been designed with a proper knowledge of the laundering treatment which it must subsequently undergo; that is to say we can give guaranteed laundering of guaranteed fabrics.

Now laundry tests can be of two kinds: (1) The examination of fabrics of known characteristics with a view to determining the effects of various factors as to a process, and (2) the investigation of failures and complaints. The former, important from a constructive point of view, are indeed invaluable for control purposes, but it is from the latter class that I believe we can derive the more useful assistance in discussing the peculiar problem we have set ourselves.

At first sight it might appear that such investigation was casual and unscientific; but on further thought if each occurrence is investigated by a regular analytical routine, I feel we are making just as scientific a survey of the field before us, as does the geologist who examines each outcrop of rock as he travels over a new area. Many a business man, too, will tell us that the foundation of his success was built on the investigation of the complaints he received.

The examination of fabrics exhibiting failure after laundering naturally presents a much more complex proposition than the examination of new goods, either in the process of manufacture or immediately afterwards. For in dealing

with new articles, however many points the examination must cover, there is never a doubt that the cause of any defect must lie somewhere in the process of manufacture. But in the testing of laundered fabrics there are at least three possible sources of failure or complaint which must be considered. Such may have its origin in manufacture, it may be the result of something which has taken place in use or storage, or again it may be the result of the laundering treatment. Hence it is that all these possibilities must be considered when dealing with the testing of laundered fabrics. In many cases definite conclusions cannot be reached owing to lack of evidence. In some interesting cases, however, it has been possible to supplement the more inductive reasoning employed in ascribing causes to failures by results deduced from direct experiment on new material.

As any failure very frequently only becomes apparent when the article is in the launderer's hands (or perhaps when it is returned by his customer), it is his misfortune that he often finds himself responsible either for the settlement of the claim arising, or for disproving his liability. Hence on him lies the onus of carrying out the investigation which shall, if possible, indicate where and how the damage has taken place. It is to some of the results of such investigations that I would now draw attention. I do not propose to enter into details concerning all the possible tests which may be applied, nor in fact to indicate exactly what such tests may show. Details of standard methods have been published from time to time in *The Journal of the Textile Institute* and elsewhere, and the particular technique adopted by any individual investigator has usually been a development of these along some special lines, and with some special end in view.

For purposes of discussion it is convenient to analyse the causes of failure and these fall roughly into one or more of the following main groups, each of which may of course be sub-divided almost indefinitely.

1. Cases involving a loss of strength. This group may contain all cases from complete rupture of the fibres on the one hand to cases where only a slight tendering is shown.

2. Cases in which an alteration in size has resulted. This group would include cases of true shrinkage, of felting of woollens, of elongation in one direction, and all cases of distortion in shape.

3. Cases in which colour is concerned, familiar examples of which are fugitive nature of the dye employed, the effect of light on dyes, the effect of dyes on the strength of fabric and others of a similar character.

A full discussion of the cases examined in each of these classes is a very extensive matter indeed and altogether beyond the purview of this paper. A few examples, however, may serve to illustrate the kind of case to which I am referring.

An interesting example coming under the first grouping was recently examined. It concerned a number of shirts of the same manufacture which developed breaks in several places during the first washing process. Fortunately it was possible also to secure a sample of the new unwashed material for comparative tests. The bursting strength of the shirt as received after one wash was 53 lbs/sq. inch when dry, and only 25 lbs/sq. inch when wet. Clearly the cause of failure was the weakness of the material in the wet state. A similar examination of the new material showed a fall in strength between the dry and wet states from 101 lbs./sq. inch to 65 lbs./sq. inch, and after one gentle washing process the figures were 63 lbs./sq. inch dry strength and 29 lbs./sq. inch wet strength. Not only do these figures indicate a large fall in strength between the dry and wet states, but also an enormous fall in strength as a result of a single gentle wash. An examination of the fabric in cuprammonium solution showed that 77 per cent. of fabric strength had been lost owing to chemical action. A similar examination of the sewing cotton used in making up showed only 1 per cent., indicating

that the over-bleaching had taken place during the manufacture of the fabric and before the garment was made up. But whilst dry and previous to washing, the effect of manufacturer's bleach was unnoticeable, the weakness due to the treatment received became apparent after wetting, and still more so after washing.

Although this is an extreme case, the effect of overbleaching during manufacture is by no means of negligible occurrence. Not infrequently a standard article of usually high quality shows occasional lapses in this respect. In cases of this description the comparative chemical damage suffered by the sewing cotton and the fabric itself affords very useful if not always conclusive evidence. The existence of a considerable difference is definite evidence of the effect of bleach before making up although the contrary is not universally true (bleaching, for example, of handkerchiefs, is sometimes carried out after they have been hemmed up).

Then again there is the very vexed question of the lines of wear which occur in certain classes of goods. This is too large a question to discuss here, but the very fact that their development in weaves of certain design is much more likely than in others, and that such lines of wear invariably take up a direction parallel to the selvedge, is in itself an indication that they are associated with manufacture in some way.

Another question of weave concerns "slippage." The cause is of course simple, and to be expected in certain classes of fabric, but the failure of a shirt recently examined shows definite evidence that this had taken place after only one or two laundering treatments.

Considering cases which fall into the second group, we have of course many examples of true shrinkage. It is well known that this is not confined to goods containing wool. Very many textiles are capable of being stretched when wet and if dried in this state the stretch becomes set, but on subsequent wetting the set disappears. Apart from general shrinkage of a garment which often gives rise to complaints, collars and neckbands of shirts which may have suffered only a slight shrinkage are a very prevalent source of trouble.

In some cases shrinkage only takes place in one direction and actual extension may take place in the other. Complaints regarding washing frocks arising from this cause are by no means infrequent.

Then there is the very different phenomenon of the felting of wool, often erroneously described as shrinkage. Microscopic examination of the wool fibres in cases of complaint concerning the behaviour of unshrinkable wool often reveals incomplete chlorination.

Another interesting case examined recently concerned an example of preferential shrinkage of the coloured stripes in a suit of pyjamas. Here also it was possible to obtain a sample of the new material. Microscopic examination of the fibres did not indicate any particular difference in the degree of chlorination of the different colours, but whereas the average twists of the cream yarn was twelve per inch, the average of the coloured yarn was twenty per inch. This easily accounted for the different behaviour of the stripes and the waviness which became apparent as soon as the new material was wetted.

In the third group of complaints it is perhaps hardly necessary to give instances. Cases in which colours have "run" in the wash; cases in which "marking off" on other goods washed in the same load; cases in which a hot iron has brought about a colour change, are familiar to everyone. There are others, perhaps not quite so frequent, but none the less giving cause for complaint. It is not by any means unusual to hear of a colour which changes completely on coming in contact with a soap solution. In some cases the original colour is restored on treatment with acid. Such colours must necessarily be affected by a washing process using soap and alkali.

Then again the influence of the dye on the fibre is important. Though instances of the destruction of the fibre by the action of the dyestuff are now rare, others in which the dyestuff accelerates the action of light are very frequent. Curtains with a dyed pattern or border exhibit this to a marked degree.

In this connection the comparative behaviour of strips of material composed of a cotton warp and a viscose weft, dyed with a range of dyes and exposed to sunlight for a period of five months is interesting as shown by the following table* :—

Colour.	Cotton Warp, Dry.	Viscose Weft, Dry.	Viscose Weft, Wet.	
	6 × 1 in. Lb.	6 × 2 in. Lb.	6 × 2 in. Lb.	
White	48	66	32	Unexposed.
	47	65	19	Exposed.
Indanthrene Yellow FFRK ...	46	67	—	Unexposed.
	< 7	< 7	—	Exposed.
Indanthrene Yellow G.	50	63	29	Unexposed.
	43	62	23	Exposed.
Grelanone Red 2B	49	61	23	Unexposed.
	34	43	14	Exposed.
Indanthrene G Yellow RK ...	45	65	28	Unexposed.
	37	54	17	Exposed.
Ciba Blue 2B	42	63	25	Unexposed.
	30	58	16	Exposed.
Cibanone Red 4B	53	52	26	Unexposed.
	38	57	16	Exposed.
Indanthrene Yellow 5GK	50	64	27	Unexposed.
	26	30	11	Exposed.
Azoic Black	56	43	13	Unexposed.
	38	34	< 7	Exposed.
Azoic Red	53	70	27	Unexposed.
	39	41	13	Exposed.
Azoic Blue	49	69	25	Unexposed.
	36	36	< 7	Exposed.

All results are the mean of three breaks.

It will, of course, have been observed that all the examples given refer to failures which I do not attribute to normal laundering treatment. I could with equal facility have quoted others in which there was definitely faulty laundering, and from this point of view I do not claim that the examples given are representative.

Although a very large proportion of the cases dealt with have arisen in the first place as complaints to the launderer, and have been submitted for examination to ascertain the cause of failure, we have always held that the impartiality of our findings must remain absolutely unchallenged. It has been our business to hold the scales as evenly as possible between all parties concerned, and we can never comply with any suggestion that we should make the best possible case for the party who seeks our assistance. All investigation of this

* *Journal of the Society of Chemical Industry*, 1932. Vol. 51, No. 9, page 180.

nature is purely scientific, and I am confident that it is only by adhering rigidly to this principle that we can hope to compass the ultimate good of both the launderer himself and the textile retailer and manufacturer. By no other course can we hope to bring about a sense of " laundry consciousness " among others interested in textiles, and in no other way can we educate the public into senses of both " textile consciousness " and " laundry consciousness."

It may be claimed quite reasonably that many of the examples chosen do not refer to defects in manufacture, but to goods made by a well known method known to produce certain results—for example, a " crab " finish, or the intentional introduction of a structure where slippage is inevitable. Such cases were mentioned deliberately, as the point I wish to stress is that of the " launderability " of a fabric, not the faults of either manufacturer or launderer. From this point of view the " launderability " of a fabric must be considered, with due regard to the purpose to which it is ultimately to be put. It would be impossible for instance, to examine engineers' overalls and employ the same standards as would be proper in the case of net curtains. It must also be remembered that a washing process is intended to remove dirt, and in cases of heavier soiling a more severe treatment may be necessary. A margin of safety should therefore always be allowed above the average, so that cases showing soiling beyond the normal may still be dealt with without damage.

Research has done much—I believe it will do still more—to bring about good laundering, but there are limits beyond which we cannot go unless we are given " launderable " fabrics.

In what way then can we work together to bring about that co-operation which I believe will be to the ultimate benefit, not only of the launderer, but of the textile distributor and manufacturer ? Much help would be given by a clear and accurate marking of all goods, " Pure Silk," " Rayon," " Fast Dye," etc., are very useful to a launderer. Only good, too, can arise from a much more extended knowledge of laundry methods ; it is pathetic to find the instruction still given that wool should only be washed with soap and warm water.

But I am convinced that the best cannot be achieved until a full examination of the " launderability " of fabrics is carried out while still in the piece. I should like to see all such fabrics marked in such a way as to indicate that they are " guaranteed launderable." It is possible to employ washing processes of a different character for different classes of work and any certificate of fitness for washing could include a grading indicating the process to be employed. Disputes as to liability as between launderer and manufacturer would then become easy of settlement, and causes of failure eliminated before the goods were ever offered to the public. I do not say necessarily that the public should be given the goods it ought to have in preference to those it desires, although the public choice is often the result of suggestion, and a scheme built up on these principles might have far-reaching effects ; there is, however, nothing in any such scheme to prevent any particular line being marketable exactly as at present. All I ask is that everyone—manufacturer, distributor, launderer, and the public, should know exactly where they stand and what to expect. It may not be that we can always have the highest quality, but I do ask that we may have a defined quality. Anything else I am confident must result in loss—loss in customer confidence, loss in reputation, loss in pounds, shillings and pence.

DISCUSSION.

The Chairman, Dr. W. H. Gibson, thought he might be pardoned for pointing out that the Director of Linen Research was acting as Chairman for the Director of Laundry Research and that such a situation might be regarded as satisfactory particularly if it could be interpreted as indicating their common function of service to the public. Science was their common weapon in performing this duty of public service and hearty and friendly co-operation in this work was absolutely necessary.

The Chairman said he thought some attention should be given to the conditions under which laundry practice and machinery had been evolved and which, in his view, had since been radically altered. In those early days of laundry machinery and processes, fabrics were stronger initially and built to last. Naturally they withstood laundry processes which the modern fabrics could not. To-day as a result of hygienic dictates and fashion decrees, flimsy fabrics had replaced the heavier types. Laundering processing perhaps needed modification to meet these changes: new mass laundry methods must be devised for handling modern fabrics.

In reply to the Chairman's remarks Dr. Hampson said that there was no doubt that laundry machinery and processes must progress in such a way as to enable them to deal with whatever fabrics were placed on the market. Indeed, it was the business of the launderer never to rest satisfied with any process, but to strive continually to evolve methods which imposed less severe conditions on the fabrics which he handled.

In supporting the remarks of a previous speaker on whether too much attention was not being given to research and too little to the practical side, Mr. J. Kerfoot instanced where greater knowledge was required in the ordinary rudiments of the textile trade, so that the customer would be protected. He gave the example of a four-piece silk gown sold by one of the best shops in London, and purchased by the buyer as being one quality of material. The gown was subsequently sent to be dry-cleaned. On its return it was found to be of four distinct shades. The launderer ascribed the change of colour to the fact that the material was not real silk, and said he had had an expert's advice to that effect. The retailers from whom the gown was obtained asserted that the material was real silk and backed their statement by an expert's certificate. The launderer then obtained the services of a Fellow of the Textile Institute who explained to the former that it was silk and that change in colour of the respective pieces was due to the gown having been made of different qualities woven silk. This was probably not known to the retailer and certainly not to the owner. This was an illustration of the immense amount of work still to be done to co-ordinate and put into practice knowledge of textiles sold to the public, and knowledge of processes which such goods could withstand.

The instance given by Mr. Kerfoot, said the author, in which the several pieces of a garment developed different shades after being submitted to a cleaning process was not an isolated one. It was well known that a particular colour could be obtained by more than one combination of dyes. And as different dyes might behave differently in a cleaning process, it was easy to see how different shades could arise if a garment was made up from pieces dyed differently even if the original shade was apparently identical in the separate pieces. Although not frequent, when cases of this kind did arise, they gave considerable trouble to the cleaner.

Mr. J. Lomax thought that in cases of laundry trouble it would be possible for an experienced chemist in almost every case to prove whether the laundry or the manufacturer was at fault. It would seem an easy matter in the case of the garment just mentioned. In his experience of examining damaged and faded garments he had found that perhaps not more than two cases in a hundred were due to any careless treatment in the laundry. He asked whether Dr. Hampson had met in his laundry work such proprietary mixtures as were sold to dyers and bleachers. These mixtures were often sold with extravagant claims and might cause considerable damage, as in the case of one liquid sold to laundries which was merely a dilute solution of bleaching liquor, offered without any explicit instructions for use.

In reply to the point raised by Mr. Lomax as to the possibility of ascertaining whether the launderer or manufacturer was at fault in any given case, Dr. Hampson said it was unfortunately not always possible to give definite opinions

on the evidence which was available. It was quite correct that the experienced chemist could ascertain the causes of trouble if all the evidence was available, but it happened not infrequently that this was not the case. For instance, where damage had occurred prior to washing, it was very probable that much of the evidence of the cause of damage would be removed in the washing process.

With regard to proprietary mixtures, it was unfortunately true that there were a very large number of these offered to the laundry industry, some of which could not be recommended. In some cases the materials might be in themselves objectionable, in other cases the price for a mixture sold under a fancy name was out of all proportion to the value of the ingredients. Realizing the dangers of such a practice, the B.L.R.A. had for a long time analysed such products as soon as they appeared on the market, but had now arranged to distribute to its members copies of such analyses, in order that they could be guided in buying when such products were offered to them.

Mr. Garnett asked whether progress could not be made in the direction of informing customers as to the precise cleansing method to be employed on specific types of garments. It appeared to him very gratifying that all seemed to be uniting towards a common goal and on that account he felt the proceedings had been very successful.

Mr. H. Binns welcomed the discussion as being yet another indication of the valuable work being done at the Conference and for which the Institute was catering and would continue to cater. He referred to personal experience in connection with the sale of numerous types of washable worsted woollen and union woven fabrics. He had had to ascertain ultimately what washing process would give the desired result in all cases ; how to avoid shrinking and stiffening. He had applied his experience in connection with the administration of the laundry of a large public school for boys and with entirely satisfactory results. He thought much might be done on these lines : that was, in the direction of seeking more general solutions rather than those which involved too accurate and minute technical investigation.

Dr. Hampson welcomed the remarks of Mr. Binns as indicating the improvement which could be effected in public opinion by the use of a satisfactory laundry treatment, but such treatment could only be given where a launderer was aware of the character of the goods with which he had to deal. This had a bearing, too, on the remarks of Mr. Garnett. The main point of the paper under discussion was that fabrics should be so classified that the launderer was aware of a suitable process which could be employed in their cleansing. The B.L.R.A. was quite prepared to give suitable washing processes to its members for every type of fabric which was capable of being laundered.

Dr. L. L. Lloyd asked whether investigation had been directed by the Launderers' Research Association staff towards the use of any of the numerous filming or wetting agents now available. Solvents other than soap or alkali might be desirable and he would like to know what had been done in this aspect of the work. Garments containing acetate rayon and white worsted yarns presented difficulties, especially when pleated, the pleating operation often producing yellow to brownish yellow defects—so called scorch marks. These discolourations were almost impossible of correction and in his opinion were mainly formed when the material contained alkali or soap. The foaming agents that were not hydrolytically dissociated did not readily remove dirt in neutral or acid solution but were good when used in conjunction with alkali and after cleansing the goods could be finished in an acid state to overcome the above defects.

The Lecturer, said Dr. Lloyd, had asked what was being done towards the use of the numerous filming and wetting agents which were now available. An enormous number of products were now commercially available which were unobtainable a few years ago, and the investigation of these was being made continually by the B.L.R.A. Indeed at the present time this was one of the most

important subjects of investigation and important developments on the lines mentioned by Dr. Lloyd were likely in the near future.

Mr. J. G. Williams pleaded for an extension of the practical co-operation between manufacturers, retailers, launderers and in fact, all concerned with textiles. He applauded the expressions already made of the sense of service actuating those engaged in the various branches of the textile industries. He felt that some central consultative and co-ordinating body to which problems from all sides could be referred was desirable: could not this be one outcome of the present Conference? Uncertainty as to the variability of fabrics, as for instance in strength or shrinkage, as to what constituted their reasonable usage, and as to their launderability existed fairly generally and much work remained to be done to overcome this lack of reliable knowledge.

Dr. Hampson, said Mr. Williams, had asked for extended co-operation between manufacturers, retailers, and launderers, and it was certain that nothing but good to all parties could arise from such co-operation. In what way exactly this could be done it was not possible to say, but if some means could be instituted whereby fabrics could be examined as to their launderability before being presented to the public, it would at least be the first step in the right direction. This, too, would deal with the difficulty mentioned by Mr. Slater with regard to imitation yarns.

Mr. F. P. Slater pointed out that the man who put money-making first would continue to make imitation yarns—i.e., cotton to look like wool, and it was not to be wondered at that such goods, when laundered as if wool, were not receiving their appropriate treatment. Such problems were not easily overcome, but this did not mean that progress on the lines indicated—i.e., fuller knowledge of all processes and materials and co-operation at all stages, was not desirable and possible.

Mr. W. E. King, referring to the case cited by Mr. Kerfoot, asked if the cause of the difference in shade after dry-cleaning of the different garments in a four-piece costume might not have been due to differences created during wear. If all four pieces had been worn under similar conditions this would not have had to be considered. If two of the garments had been worn out of doors or exposed to sea air and strong sunlight and the other garments only worn indoors, then the variation in conditions of wear might have contributed to the defects under complaint. Had the different shades occurred in different portions of the same garment a difference in the cloth might have been suspected. With a model costume which would almost certainly not be mass produced it was most difficult to account for the variation in shade of the different garments. With mass produced goods this could be possible. The assertion that the difference in the make of the cloth composing the various garments needs careful consideration and further information is obviously needed in this case.

Mr. J. H. Lester also referred to Mr. Kerfoot's remarks, and said that it would be necessary to have more information before any decision could be reached: it was a case for thorough investigation. The "four-piece" garment would begin to be interesting when the several dyes had been identified. He had heard pleas made for co-operation between commercial and industrial men and the men who had to do the testing but he felt that such co-operation often worked out badly in practice. Mr. Kerfoot's problem would be readily solved by the man who could deal with the commercial issues involved and who also knew the possibilities and limitations of testing.

While agreeing with Mr. Lester that co-operation did sometimes work out badly in practice, Dr. Hampson said there did appear in the present instance to be much reason for attempting to get all parties concerned closer together, and the remarks which had been made by various speakers welcoming this in some form or another, were an indication that definite difficulty did exist at the present time and that nothing but good could come from every effort which was made to overcome it.

COMMUNICATION

"AN OBSERVATION ON THE COMPARATIVE RESISTANCE OF DRY AND OILED WOOLS TO ATTACK BY DERMESTIDAE"

To the Editor

Sir,

I wish to offer the following criticisms of the above paper which has appeared in this JOURNAL.* In exposing samples of dry and oiled wool to the attacks of " woolly bears " (*Anthrenus fasciatus Hbst.*) the author provided the grubs with alternate sources of food. This is liable to give misleading results. Had no other source of food been available to the grubs it is conceivable that the oiled samples might have been attacked. The author's conclusions " that machine-spun yarn stored in the grease is perfectly safe " cannot be logically deduced from nor is it justified by the evidence offered.

A second statement with which I cannot agree is " it is also thought that this added oil acts as a protection against moth, but circumstances prevented the confirmation of this belief by definite experiment. Subsequent experience however, of the storage of large quantities of wool yarn in oil confirmed this conclusion." Burgess & Poole (*J. Text. Inst.*, 1931, **22**, T.150) have shown that spinning oils in yarn do not give protection against moth, *confirming a fact already well known to industry where the damage done by moth to oiled tops and yarns is at times severe.*

The author completely ignores foreign work on this subject (U.S.P. 1,694,216 and the discussion Jackson and Wassell *v.* Minaeff and Wright, *Ind. Eng. Chem.* 1929, **21**, 1187-1195 and 1930, **22**, 399) which, in my view, further detracts from the value of his " observation."

The composition of the oil used and the amount present are the deciding factors as to whether oiled wool will be attacked by moths or " woolly bears " and should therefore have been given by the author. May I urge that as the control of textile pests is a serious problem not only in Egypt but the East in general, these matters to which I draw attention be given serious consideration in any future work done in this direction ?

(*Signed*) C. O. CLARK.

FEDERATION OF TEXTILE SOCIETIES AND KINDRED ORGANISATIONS

ANNUAL MEETING

The fifth Annual Meeting and Conference of delegates of the textile societies in membership of the Federation took place at Bradford on Saturday, 7th May, by invitation of the Bradford Textile Society. There was a representative gathering of about sixty delegates from societies in Lancashire, Yorkshire and the Midlands. In the morning, three separate parties were formed and each group conveyed to the works of one of the following :—Messrs. The Airedale Combing Co. Ltd., Lower Holme Mills, Shipley ; Hodgsons (Bramley) Ltd., Bramley ; and Kellett, Woodman & Co. Ltd. (Joseph Wilson Ltd. Branch), Grange shed, Great Horton. In each instance, the works inspection proved exceptionally interesting.

The delegates were entertained to luncheon at the Midland Hotel, Bradford by Mr. Edford Priestley, F.T.I., the immediate Past-President of the Bradford Textile Society. The Lord Mayor of the City (Alderman George Walker) attended and offered civic welco e to the visitors. Mr. J. W. Wolstenholme (Rochdale) as President of the Federation proposed a vote of thanks to Mr. Priestley and the Lord Mayor and also to the Bradford Textile Society. The motion was seconded by Mr. J. Burgess (Ashton) and carried by acclamation.

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* By H. C. Hartley (*J. Text. Inst.*, 1931, **22**, p. 125-129.)

At the annual meeting which followed, Mr. W. Munn Rankin, M.Sc., Principal of Burnley Municipal College, was elected President for the ensuing year in succession to Mr. Wolstenholme.

Mr. Wolstenholme, the retiring President, moved the election and said he had regarded it as a great privilege to have been in council with the representatives of the affiliated societies. His impression of the Federation was that it was of the utmost importance to the industry and meant a vast pooling of knowledge and experience.

Mr. Norman Collinson, Past-President, seconded.

In his reply and presidential address, Mr. Munn Rankin said that as the Principal of a technical college he appreciated election if only on account of the implied recognition of the fact of the organic linkage between textile teaching and textile practice. The only justification for the existence and support out of public funds of the technical college system was that it provided a never failing and fully efficient stream of young personnel for posts of responsibility of many grades within industry. The system encouraged the open, inquiring, and critical mind on all matters touching the operations of the industry. The common complaint that school learning evaporated on school leaving could not be laid against any reasonably efficient technical college, and least of all, against a textile department organised on modern lines so that the central trade subject was flanked by ancillary science, mathematics, art, and economics. Members of textile societies had for the most part attended technical colleges and should continue their interest in and give their assistance to the college so as to secure the closest and most complete adjustment to new and varied developments in textile practice. A move of significance had been made by the Textile Institute in approaching the Board of Education with a view to the consideration of a scheme of National Certificates and Diplomas in Textiles and the experience of the Federation of Textile Societies might prove useful in this connection.

Although the textile industry was primarily a craft, and must always remain such, the steady influx of modern ideas and of the products and methods of scientific research into the atmosphere and operations of the factory must in time effect many changes in the form and function, and, if not also more radically, in the foundations and structure of the industry. These ideas, facts, methods and materials, to be fully of use in their practical application must depend upon the co-operation of a well-trained, educated and contented personnel. It was the prime function of the technical college to prepare this personnel, and equally of the textile society in each centre, and of the Textile Institute as the professional national institution to maintain it as a continually trained body of specialists.

The field of the college was the adolescent stage of 16 to 21 ; its method was by a varied general instruction in the principles underlying the practice of the industry, and, when wisely organised, also by a measure of practical training in some separate craft within the industry. Theory must be joined with practice and knowledge. The field of the textile society was beyond that of the college—to continue its training and instruction by more intensive studies on narrowly limited subjects, upon which all other knowledge and experience could be focussed. Its methods were different from those of a college lecture ; of vastly greater importance than a lecture was the subsequent discussion when views and experiences from men of different occupations and responsibilities were interchanged and pooled for the benefit of all. Knowledge to be won and held was to be more than read or heard ; it should be turned over frequently in the mind, debated with others, and above all tried out in actual practice and under working conditions.

The textile societies distributed in large numbers with a considerable aggregate of membership throughout the country were among the most active organisations of practical men in the industry. They were performing at this critical juncture

in the history of the industry an invaluable service in affording channels for the ready passage of new discovery and thought, from a great variety of sources, external and internal, into the industry, and their diffusion throughout all grades of workers. Increasingly upon the open-mindedness of their members, their quickness of response and readiness to experiment, as also upon their judgment and experience would depend the maintenance and development of the industry. The taking in of new ideas and of building the new into the old and tried, which was what education really meant, should never stop. When a man had stopped learning, he had stopped living, in failing to adjust himself to the continually changing conditions of environment; though walking about, airing his opinions, he was yet dead, and not knowing it might be a nuisance, if not a positive danger.

Technical education for the practical man whether formal and official for the apprentices in the college, or voluntary in the trade society for the man established in his place in industry, should be continuous and unflagging. The college must be content to sow, the society to water, so that the industry might reap.

Election of the Committee of Management and other officers followed. The Committee was re-elected with the exception of Mr. Entwisle (Accrington) whose place was filled by Mr. W. P. Richmond (Nelson). Mr. J. D. Athey was re-elected Hon. Secretary and Treasurer, and Mr. W. Kershaw, Hon. Auditor.

Mr. G. H. Thompson, on behalf of the Oldham Technical Association and Old Students' Union, invited the Federation to hold the 1933 Annual Meetings at Oldham. The Association, he said, would like to celebrate its coming-of-age by the attendance of the Federation delegates.

The invitation was heartily accepted.

A paper on " Worsted Spinning " was contributed by Mr. Edford Priestley, F.T.I., and the proceedings concluded with tea on the invitation of Mr. Foster Pickles, A.T.I., Chairman of the Executive Committee of the Bradford Textile Society.

NOTES AND NOTICES

Section Meetings and Papers.

The Committees of the various Sections of the Institute have already given some attention to the preparation of programmes for the ensuing session. The Lancashire Section Committee is in the fortunate position of having provided for the delivery of papers or lectures in respect of ten meetings. Particulars will be announced as soon as negotiations in regard to date and place of the meetings have been completed. It is fully expected that the programme will be found to be of considerable interest, particularly from the point of view of selection of subject. About half-a-dozen of the meetings are to be held at Headquarters (Manchester), and it is hoped to provide for meetings at Preston, Burnley, and Bolton or Oldham.

Institute Competitions : Fabrics and Yarns.

Considerable revision was effected in the programme of the Competitions of the Institute for the current year. The entries are now closed. Apparently, the amendments and expansion of the scheme have stimulated improved interest in the competitions. For Competition (A), a miscellaneous collection of woven fabrics, 16 entries have been received. There are 12 entries for the Yarns Competition (B), whilst the Special Fabric Competition (C) has yielded no less than 30 entries. For Competition (D), open to students whose specimens of fabrics have been produced in connection with examinations of the City and Guilds of London Institute, 15 entries are recorded. Knitted fabrics are introduced this year for the first time, and in this section, Competition (E), 15 entries have been received. The specimens are to be forwarded so as to

reach the Institute not later than the 17th October next. The presentation of prizes, to the total of £150 offered, has been fixed to take place at the Institute, Manchester, on the afternoon of Saturday, 3rd December next.

Institute Employment Register.

The Employment Register maintained at the Institute for the benefit of members seeking employment and for employers desirous of getting into touch with suitable applicants, has contributed useful service in recent months. Inquiries for services have latterly been a little more frequent than usual and effective response to inquiry has been secured in several instances. The following is a recent entry of offer of services :—

No. 81—25½ years of age, Public School education. Seven years experience of knitting—underwear, outerwear and bathing costumes. Held position of assistant manager. Knowledge of yarn spinning, dyeing and finishing. Excellent testimonials and certificates. Willing to travel or go abroad.

Textile Institute Diplomas.

Elections to Associateship have been completed as follows since the appearance of the previous list (May issue of this Journal) :—

ASSOCIATESHIP.

BLEASDALE, Robert (Blackburn).
BREW, Harold Edmund (Cadishead).
GREENWOOD, George (New Zealand).
JOHNSON, Arthur (Keighley).

REVIEWS

The New Draw Loom. By Luther Hooper. Published by Sir Isaac Pitman & Sons, Ltd. (217 pp. Price, 25/- net.)

This is the latest of a series of books written by Mr. Hooper dealing exclusively with the art of handloom weaving as practised in Arts and Crafts centres but not in technical colleges or schools for weaving. It is confined to a minutely detailed description of the construction of a new draw-loom developed by the author. For all practical purposes the draw-loom became obsolete when Joseph Marie Jacquard finished the development of the shedding mechanism, known the world over by his name, some 130 years ago. There does not appear to be any adequate reason for its revival, even for the purpose of handicraft weaving at the present time. The weaver on the new draw-loom has also to insert his weft in the primitive fashion used before John Kay invented his picking peg and fly-shuttle in 1733. The book is an excellent example of the printer's art and the illustrations are perfect reproductions of the original drawings and fabrics. There are 43 full-page plates of illustrations many of which are detailed drawings for the construction of a hand-loom and its accompanying harness and lifter bar. The remaining illustrations show the method of designing and types of fabrics which can be woven on the new draw-loom. The new volume cannot be of much service to the general student of weaving but will no doubt appeal to those who have the time to practise hand-loom weaving as a hobby. J.R.

Report on the Organisation of Wool Marketing. Prepared by the Ministry of Agriculture and Fisheries. Published by H.M. Stationery Office. (6d. net.)

This is No. 35 of the Ministry's well-known Orange Books on marketing. It is the second in this series on the subject of wool marketing. While, however, the first was largely confined to a descriptive survey of marketing methods, the present Report not only takes a wider view of the subject but aims at presenting, as a basis for consideration, the outline of a constructive programme of marketing organization. The Report opens with a short survey of production conditions in England and Wales and their bearing upon the problem of marketing. It is pointed out that the underlying factors which must condition the approach to organization are the small size of flock which is typical of this country, the large number of breeds and crosses, and the great diversity of wool quality to be

found within very small areas and within individual flocks. A very brief description of the wool textile industry is then given and attention is drawn to the significant features of the structure of its organisation in relation to the marketing problem. There follows a statement and analysis of world and home production, consumption and prices. Trade in wool is international and British wool, unlike most home-grown agricultural commodities, is exported in large quantities.

Part II of the Report is devoted to examination and consideration of the various methods of marketing that prevail in this country, in part in an attempt to estimate their relative efficiency, in part as a basis for comparison with the methods that have been adopted overseas. Except for the small proportion of wool that is marketed co-operatively, the significant feature of the predominant system of marketing British wool is that each producer's clip is sold individually and that broadly speaking, it has failed to induce the farmers to exercise care in the get-up of his clip or to regard wool as anything but a by-product of mutton production.

In Part III, the organized wool marketing systems found in the more important wool-producing countries are described and examined. There are two main systems. In the Southern Dominions of Australia, New Zealand and South Africa, the central auction system prevails. In the United States and Canada, selling is by private treaty, organisation taking the form of co-operative marketing societies, originally local in character federating later into highly centralised units.

The suggestions put forward in this Report do not claim to be more than tentative. The purpose of the Report will have been fulfilled if it assists the home industry to see clearly its own problems and to propound a solution for itself. T.

Forecasting Business Cycles. By Warren M. Persons, Ph.D. Chapman & Hall, London (284 pp. and Index. Price 25s.).

The world depression, which was started by the rise in money rates early in 1929 has now lasted two and a half years. At the end of 1930, Professor W. M. Persons made a statistical examination of the seven major business depressions in the United States since 1875. In all of these the index of industrial production fell 20 per cent. below normal, the sub-normal period in all but two cases, which were complicated by the gold situation, lasting about twenty-four months. He considered that the depression most similar to the present one was that of 1884-85 when the prices of American farm produce fell 40 per cent. from the level of 1882, accelerating the long-term fall in world prices, and when unemployment in the English trade-unions averaged 9 per cent. for the years 1884-87, as compared with a normal of less than 6 per cent. for the twenty-year period 1876-95. Notwithstanding the special features aggravating the present slump, the reparations and debt impasse which discourages international lending, and the 4,000 million dollars reduction (no less than 85 per cent.) in Wall Street loans, Dr. Persons predicted a rapid recovery in 1931. But such a recovery, he insisted, would depend on the co-operation of bankers, of producers and of consumers :—

> " The consumer must rank the preservation of his current standard of living above his desire for leisure, or above his desire to maintain his current rate of saving, or even above his desire to keep intact his former savings. The function of the producer is to formulate a plan of industrial expansion, and to convince investment bankers that his project is sound. The banker stands between the prospective seller of commodities on the one hand, and the prospective buyer, whether he be producer or final consumer, on the other. Boldness, not timidity, in the use of bank reserves is required by bankers if they would save our credit structure and themselves."

The most important factors affecting the course of business in Dr. Persons' opinion are, first, the attitude—rate policy and open market operations—of the Federal Reserve Banks towards the extension of credits at home and abroad by investment bankers, the timidity or courage of domestic bankers in the extension of credit, and the attitude of foreign bankers in these respects :—

> " Money is said to be ' easy ' at the present time, but it is easy only for the person or corporation of super-financial strength with no need to borrow."

His forecast of recovery does not seem to have made adequate allowance for the very different position of the United States in regard to world depression now,

as compared with what it was half a century ago. In the '80's, as a result of immigration, the American population was increasing at about double the present rate; its excess of exports over imports was then only about a twentieth of what it was before the present slump; and there were far more obvious opportunities for the profitable investment of eastern capital. The United States is no longer in a position to make rapid recovery from a severe depression when the trend of price is heavily downward. Moreover, the composite index of production, the trend of which shows a fairly steady increase of about 4½ per cent. a year from 1875 to 1895, does not in the least represent world conditions during a period which provided five years of depression for every two years of prosperity. The Federal Reserve Board's index, which shows a violent interruption in the upward trend from 1882 to 1895, is in much closer accord with world prices and production for those years. Prosperity only returned to Europe with the expansion of credit following the great increase in the supply of gold after 1891, and present prospects of expansion through the co-operation of central banks, formally agreed to by the representatives of twenty-two governments at Genoa ten years ago, seems rather slight.

Useful addenda to the statistical work are two re-published papers, " A Classification of Theories of Business Fluctuations " and " Statistics and Economic Theory." Dr. Persons classifies the theorists emphasising the effects of economic institutions into those stressing (1) the development of private property, (2) the capital system of production, (3) maldistribution of income, (4) fluctuations of money profits, (5) the flow of credit under the present monetary system. Among the latter, it is rather surprising to find included some quotations from Major C. H. Douglas and one of his followers :—" because of the popular attention given to their theories in England." It would have been more interesting to have had extracts from such writers as Rudolf Stucken, Emil Lederer and Wilhelm Ropke. In this respect, Dr. Persons' selection is less satisfactory than Professor Wesley Mitchell's, which was fairly up-to-date, nor apparently, has he been able to provide the " critical examination " of the theories which he announced in 1926.

G.B.

Textile Analysis. By S. R. and E. R. Trotman. Published by Charles Griffin and Co., Ltd., London. (301 pages. Price, 21/- net.)

Analytical methods for Textile Chemists would perhaps better describe the contents of this book since most of the work treats of the analytical methods for substances used in the textile industries. The subjects dealt with in order are :—Identification and Determination of Textile Fibres; Physical Tests for Textile Materials; Determination of Specific Gravity and Viscosity; Standard Volumetric Solutions; Analysis of Organic Compounds; Acids; Indicators and their Hydrogen Ion Concentration; Alkalies; Bleaching Agents; Water and Effluents; Analysis of Fibres; Oils (including soaps); Organic Solvents; Formaldehyde and Tannins; Blueing Agents; Glycerol; Starch, Dextrin, Glue, Gelatin, Casein, Metallic Salts; Nitro compounds, Amins, Phenols; The Detection and Analysis of Dyestuffs.

In dealing with the viscosity standards, those of the U.S. Bureau of Standards might have been included. Viscosity measurements in cuprammonium for works control are rather elaborate and it would seem simpler to revert to the viscosity of the nitrated products in ether-alcohol or acetone as recently recommended by Japanese workers.

There are better methods for determination of acetic acid in cellulose acetate than given (p. 176). In the determination of formaldehyde (p. 211) it is stated that normal caustic soda is added and followed by excess of decinormal iodine—that is sufficient to give the solution a distinctly yellow colour. While these directions are suitable for the analysis of commercial formalin for the estimation of formaldehyde in textile materials, only present in small amounts, it is essential to have a *very large* excess of iodine, as shown by Signer (*Helv. Chem. Acta.*, 1930, 13, 43-46), and it is better to add the iodine before the alkali. In this case also Schryver's colorimetric method is very useful.

The neat differentiation of mineral acid from organic acid in textile materials by determination of *p*H (p. 148) at two dilutions should convince the sceptic of the value of this measurement.

The separation and estimation of direct dyes would appear to be much more easily and cheaply accomplished by aryl-substituted guanidines which are available in large quantities than by precipitation with alkaloids as given on pp. 283, 294 (*vide* Rose. *J. Soc. Dyers & Col.*, 1932, p. 131). Precipitation of acid colours can be carried out with di-o-tolyl guanidine (*ibid*).

The best solvent for continuous extraction of fatty matter from cotton is given as benzene (p. 145). Chloroform is largely used and recommended by the B.C.I.R.A.

It would be better to give original references (where these are readily available) rather than abstracts (*e.g.*, p. 147, Coward and Wigley) and a uniform set of abbreviations should be adopted. So many references to modern work are given that it seems ungrateful to criticise in this direction ; yet the authors have been rather over-cautious. There are many new products applied to textiles, analytical data for which chemists will look in vain. Presumably this is to be taken as evidence of the slow penetration of new products into works practice.

The book will be found of value to textile chemists but why could it not be issued at 15/– and most of the illustrations (which are quite unnecessary) cut out ? F.C.W.

Chemical Encyclopaedia. By C. T. Kingsett. Published by Balliere, Tindall & Cox. 1932. 5th Edition (1014 pp. Price £2).

It is well nigh impossible for one author to write a work of this character and to expect to attain accuracy unless he has had the collaboration of experts. This work has been written for the benefit of " Politicians, Journalists, Teachers, Lawyers, Merchants, Bankers, Medical Practitioners, Pharmacists, Company Directors, the Professional and Cultured Classes." In view of the fact that the work is mainly addressed to these classes it would have been better to avoid entries such as we find under " acidic "——" In the modern view of electrons, acids are bodies which can part with a proton to bases." Under " Worsted " is written " Woollen yarns such as socks." For " Acid-egg " one is referred to " date sheets " and one half a page is wasted in quoting a table from the Chemical Trade Journal, whereas " acid-egg " could have been explained in one line and surely " Data-sheets " are just sheets of data. There are several mis-statements under " Carbohydrates." We read that " By the action of sodium hydroxide on cellulose an *additive* compound (alkali cellulose $C_6H_9O_4ONa$) is said to be formed." Many statements are meaningless owing to their incompleteness, *e.g.* " A solution containing one gram equivalent of hydrogen ion is the normal one used." In the paragraphs from which this is extracted no mention is made of concentration of hydrogen ions anywhere. In Calico-printing it is stated the " hollow copper rollers are used for the printing, the pattern being etched on the *cloth* . . . (*see* article, Chambers' Encyclopaedia)." Against a large number of entries it would have been wise to write " *see* Encyclopaedia Britannica."

In dealing with " Proteins " the term " isoelectric " is mis-handled. The triacetate is not the most " constituent product " of cellulose acetates neither is it yellowish. The information under " Textiles " is, one might almost say, irrelevant, The author has not grasped the difference between Silicanes and Silicates, for he gives the same formulae to tetraethyl silicate and tetraethyl silicon and thoroughly mixes them up. " Beatl " products receive mention but not " Bandalasta." The entry on " Electromotive Force " is thoroughly unsatisfactory and misleading. Another inexcusable fault here, is the use of the term " resistance " in two different senses.

An excellent feature of the work is the large amount of space devoted to bibliographies but even here it must be remembered that the almost exclusive citation of modern literature need not make a book up-to-date unless this literature has been well digested and discrimination made between important and unimportant matter. Since the work has already been through four editions, it must satisfy the needs of some classes of enquirers and these will find an additional 200 pages in this edition. The conception of the work is excellent and the author owes it to himself to edit the next edition and secure the services of a dozen or so experts to purge it of inaccuracies and thus make it a thoroughly reliable work of reference. F.C.W.

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THE MEASUREMENT OF THE LEVELNESS OF WORSTED YARNS

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INTRODUCTION.

One of the most important characteristics of a good yarn is its " levelness." To the practical man a " level " yarn is one in which there is an absence of thick and thin places, the yarn having a uniform thickness throughout its length. This condition implies equal weight per unit length in every part of the yarn, combined with a uniform twist.

No finishing process can eradicate the effects arising from irregular distribution of counts and twist, and no system of doubling can produce uniform doubling twist if the singles themselves are irregular. The problem of measuring levelness, therefore, becomes very important, and this paper is an attempt to survey the methods at present available in the hope that some of them will come into more general use in the Industry.

As we have seen, any method of assessing the value of the levelness of a yarn must have some relation to the degree of variation of either

(*a*) weight per unit length,
(*b*) twist,
(*c*) both.

The methods to be described will therefore be sub-divided under these headings.

MEASUREMENT OF WEIGHT PER UNIT LENGTH.

The cutting and weighing of short lengths of yarn has been used by numerous workers. A number of good cutting mechanisms have been evolved, the most important consideration being the necessity for constant and reproducible tension in the yarn during the measurement of the fixed length.

The weighing of the pieces presents slightly more difficulty. For this purpose, Balls[1] and others have used a microbalance consisting of a fine glass rod supported at its mid-point by a fine phosphor bronze wire. This type of instrument is rather uncertain in its zero, requires frequent calibration and is difficult to construct to give the desired sensitivity. For small deflections the weight applied to the end of the glass beam is proportional to the angle through which it turns, but for larger deflections the weight is approximately proportional to the tangent of the angle of deflection.

This suggests that the torsional control of the supporting wire is negligible and the effective control gravitational. In one case, however, a microbalance was constructed in which the calculated torsional control was alone of such

* This issue completes the report of this Conference.

a magnitude that it would have given a smaller sensitivity than was obtained by experiment. This pointed to the existence of a negative gravity control, i.e. the centre of mass of the beam system was above the axis of rotation, thus giving the inverted pendulum effect referred to by the Research Staff of the General Electric Co.[2] in their paper on " A rapid weighing torsion balance."

This fact has been definitely utilised in the construction of a microbalance at present in regular use in the laboratories of the Wool Industries Research Association.[3] The glass beam has been replaced by a light aluminium tuan bed the supporting wire by a strip of spring steel which can be put under tension. This latter exerts a torsional control, partly due to its rigidity and partly due to its tension, and this is sufficient to balance out the negative gravity control

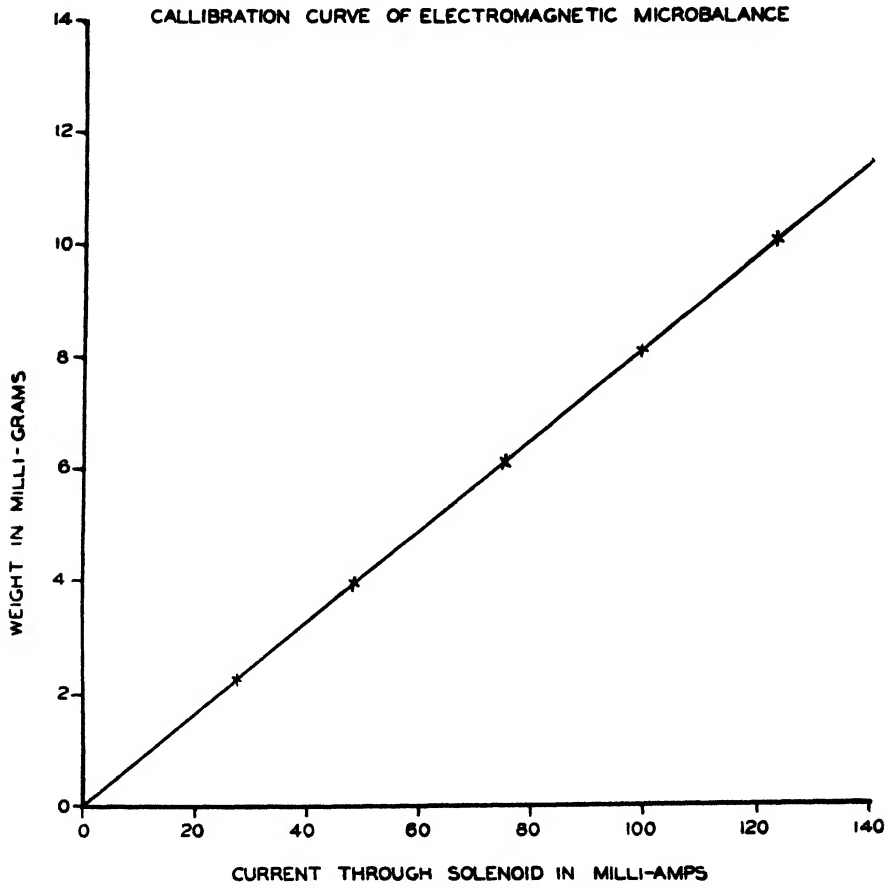

FIG. 2

Curve showing the Relation between Weight and Solenoid Current for the Electromagnetic Microbalance.

of the beam system whose centre of mass is above the axis of rotation. The control component due to the tension can be adjusted over a wide range so that different sensitivities can be obtained. An additional advantage is that although the instrument can be made as sensitive as the previous type, it is very much more robust.

The beam supports a light aluminium damping vane carrying a small convex mirror which, in conjunction with a lamp and scale, enables deflections from the horizontal to be measured. Attached to one end of the beam is a light

aluminium scale pan and to the other a permanently magnetised iron wire which dips into the centre of a solenoid. The force due to the weight at one end of the beam can then be balanced by the force due to the magnetic attraction between wire and coil at the other, by varying the current in the coil. This method has the advantage that measurements are always made with the beam in its horizontal position. An instrument mounted in this way is shown in Fig. 1, and with this it is easily possible to weigh 100 short pieces of yarn to an accuracy of less than $\frac{1}{2}$ per cent. in an hour. All the weighing must, of course, be carried out in an atmosphere of constant relative humidity and sufficient time must be allowed for the fibres to reach equilibrium regain conditions with their surroundings.

Fig. 2 is a typical calibration curve showing the relation between the current in the coil and the weight on the pan.

An indirect method of measuring weight per unit length was developed by Lahouse,[4] but the readings are rather uncertain and the method has never been developed to any great extent. Successive lengths of yarn are passed under a known tension between two clips, at one of which vibrations of a known frequency can be imparted to the thread. The distance between one of the clips and one of the nodes of the vibrating thread is measured and from this the weight of the yarn can be calculated. A very similar method has been used by Richard.[5]

The weight-per-unit-length method of measuring regularity while being excellent for roving in which there is very little twist, is hardly sufficient in itself for yarns, although it furnishes valuable information. In a worsted yarn, the relation between weight per unit length and yarn diameter is not the simple square relation of an ordinary solid wire owing to the effect of twist and accurate measurements of the continuous variation of twist over short lengths combined with the variation in weight per unit length are really necessary to complete the test for regularity.

MEASUREMENT OF TWIST.

Of all the measurements made in textile testing, that of the measurement of twist presents the most difficulties, it being almost impossible to get consistent results as far as single yarns are concerned. The determination of two-fold twist is straightforward, but with single yarns it is difficult to say exactly when all the twist has been removed. Most standard instruments are based on the change in length of the yarn as twist is taken out and put in in the reverse direction. The assumption is that the shortening when reverse twist is put in is the same as the lengthening when the original twist is taken out and that there is no drafting of the fibres while the yarn is in the untwisted state. It has been found, however, that both these assumptions are far from being correct, the turns required to re-insert twist to bring back the yarn to its original length being always greater than those required to take it out. On a long series of tests on worsted yarns of accurately known twist it was found that the results from some of the standard testers were as much as 40 per cent. out.

It appears that the most reliable method is a modification of the old-fashioned inch by inch tester, in which the yarn is watched through a lens while the twist is being taken out, the end point being when the fibres are seen to be lying parallel to one another. An instrument based on this principle and adapted for rapid manipulation was designed by A. W. Stevenson at the Wool Industries Research Association and is shown in Fig. 3. The yarn is held at one end by the spring clip *A*. The other end passes through the small chuck *B* and along the tube *C* which constitutes the untwisting component of an ordinary twist tester. After the twist is taken out and the reading taken, the twist is re-inserted. The jaws of the chuck are then opened and the chuck is moved up towards *A*, against the action of a spring and over the yarn which is held taut by the spring *D*. When the chuck makes contact with *A*, the jaws are closed, the clip *A* is opened

and the chuck allowed to go back to its original position, when the clip A is again closed. In this way successive short lengths of yarn can be examined fairly quickly without any danger of twist running out of the sample and without wasting any yarn between the samples.

MEASUREMENT OF YARN THICKNESS.

The methods grouped under this heading measure, in various ways, a combination of the weight per unit length and the twist and are actually those which are of most use in practice as they assess the actual appearance of the yarn, which is usually what counts most.

(a) Visual Method.

The most common method of estimating the variation in thickness of a yarn is the visual method. A certain amount of yarn is reeled off on to a card or a drum against a suitable contrasting colour, and then examined by eye for thick and thin places. This method will undoubtedly remain the most popular amongst practical men, but is certainly inadequate for research purposes. For instance, a black yarn on a white background always appears to be much more uneven than a white yarn of similar count on a black background, although the two yarns may have the same actual degree of irregularity.

(b) Frenzel's Method.

Frenzel[6] introduced one of the first instruments for the continuous recording of yarn diameters. A small " feeler " is allowed to rest gently on the yarn as it is wound on to a drum ; the " feeler " is attached to a lever whose fulcrum is near the centre of the disc, and it is balanced so as to apply a minimum of restraint to the yarn. With no yarn interposed, the " feeler " swings to the vertical position, but on winding off the yarn the " feeler " is displaced according to the thickness of the yarn and the displacements are recorded autographically. The difficulty in the construction of a " feeler " light enough to follow the variation in thickness of a worsted yarn and yet at the same time to apply no appreciable compression to it, has prevented this method from coming into general use.

(c) B.C.I.R.A. Method

Oxley made use of the inverse correspondence between twist and visual thread diameter, the yarn appearing thin where the twist is high and *vice versa*. The variation of twist under compression of cotton yarns is recorded photographically, by drawing the yarn between a pair of case hardened shoes, the motion of the top shoe recording under high magnification on a strip of photographic paper, the variation in thickness of the yarn. This method, while yielding excellent results for cotton, is of doubtful value with soft compressible worsted yarns.

(d) Electric Capacity Method

Another method has been used by different workers whereby the yarn is made to move one plate of a condenser of an oscillating valve circuit. This change in capacity produces a heterodyne wave with another circuit tuned to the same frequency, and this resultant beat note can be rectified and recorded by some suitable means.

(e) The W.I.R.A. Photoelectric Method

In this method a shadow cast by a short length of yarn affects the amount of light falling on to a photoelectric cell and the resulting current is measured and recorded. This has been found to be the most suitable method for worsted yarns since no constraint is applied to the yarn at all during the recording. The apparatus is shown diagrammatically in Fig. 4. A beam of light from the lamp A, rendered slightly convergent by the lens L_1, illuminates a small hole about 2 mm. in diameter in the brass plate B in front of which the yarn Y passes

in a direction perpendicular to the plane of the paper. A magnified image of the yarn is formed by the lens L_2 on the slit S, the width of which is adjustable and can be determined from the reading on the micrometer head of the adjusting screw. The light transmitted falls on to the ground glass plate G and is thus diffused over the whole of the active surface of the cell. The current from the photo-electric cell, which is proportional to the amount of light falling on it, is measured by observing the potential drop across a high resistance, a Lindemann electrometer being used for this purpose.

The suitability of this instrument for measuring continuous changes of potential accurately, and the optimum conditions for its use in practice are discussed at length in a paper by the author, entitled, " Some further notes on the Photoelectric Method for measuring Yarn Levelness."[8]

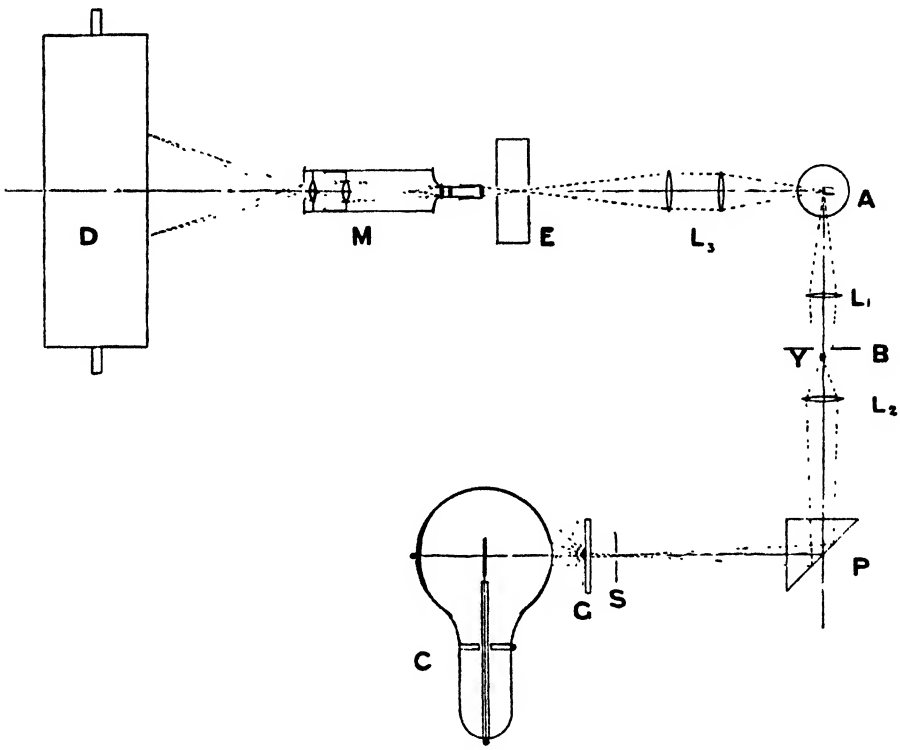

FIG. 4

Diagrammatic View of Photoelectric Levelness Tester.

The movement of the needle of the Lindemann electrometer is examined by means of a projection microscope. The needle can be illuminated separately or from the same source of light A which is used to operate the photoelectric cell. The light is concentrated by the lens L_3 on to the electrometer needle E, a magnified image of which is projected by the microscope M on to the screen of a standard curve tracer or on to the cylindrical lens of a recording camera, the direction of motion of the sensitive paper being at right angles to the movement of the needle image.

A constant speed induction motor, through a 400 to 1 reduction gear, is used to drive both the rollers which pull the yarn across the slit, and also the recording camera, so that the relation between the length of yarn and the length of record remains constant. The motor and gearing are mounted on a separate

board from the rest of the apparatus and this again is supported on sorbo pads to prevent any mechanical vibration from being transmitted to the electrometer. The width of the slit is adjusted to be about twice the width of the shadow of the yarn and the voltage on the cell and on the electrometer plates is adjusted to give a maximum deflection on the record when the slit is completely exposed to the light. The instrument can thus be used for a large range of counts of yarn, with the same sensitivity of record.

A general view of the apparatus is shown in Fig. 5.

The way in which the peaks and depressions in the curves correspond with the variations in thickness of the yarn is shown clearly in Fig. 6. This is a photograph of a demonstration card in which the actual yarn used in making the autographic record was mounted above the record itself. Each of the eight V-shaped sections of the yarn correspond to each of the eight main divisions of the record. The recorded diameter of any part of the yarn can then be found by drawing a line perpendicular to the length of the record, such as *CD*, the actual diameter at this point being proportional to the distance between the curve and the base line *AB*. It will be seen how well the record follows the variations in the diameter of the yarn along its whole length.

The relation between a curve obtained with this instrument and the weight per unit length variation was examined in the following way. The normal roller used for drawing the yarn was replaced by another which had a very fine projecting ridge running parallel to the axis along the whole of its length. This roller had a circumference of 1·19 inches and it was arranged that the ridge could be moistened with ink once every revolution, so that a fine mark could be made on the yarn at every successive 1·19 ins. The yarn was afterwards conditioned for several days in a room kept constant at 70 per cent. relative humidity and 73° F. temperature. Successive 1·19 ins. lengths were then cut off and weighed on the microbalance.

Assuming the density of the thread to be constant along its length, the diameter at any point will be proportional to the square root of the mass per unit length. Hence to show the comparison between the two sets of measurements, the square roots of the weights (in micrograms) of successive 1·19 ins. lengths have been plotted over the record, showing the variation in diameter (see Fig. 7). The zero of the readings was made to coincide with the zero of the diameter record and the scale was adjusted so that the square root of the mean weight (156 micrograms) coincided with the mean diameter which had been calculated from the record by measuring up the area between the record and the base line with a planimeter and dividing by the known length. The whole length of the record, which represented 12 feet of yarn, was divided up into 121 equal sections of 1·19 ins. each and the corresponding value of the square root of the weight was plotted at the middle of each section and successive points joined up by straight lines.

The two curves show remarkable agreement considering all the factors involved. The diameter curve, of course, shows more of a point to point variation since it registers the mean diameter of a length of about 0·1 ins. of yarn, whereas the weight method averages up 1·19 ins. of yarn. We should expect the latter, therefore, to show smaller variations and this is certainly the case. Moreover, a thick place in a yarn is usually accompanied by less twist, so that as there are more air spaces in the interior of the yarn, its density will be less and the corresponding weight will be proportionally less. Similarly when the density is above the average, e.g. at a thin place where the twist is high, the weight will be proportionally higher. Hence, all the way along, we should expect the weight curve to be within the diameter curve, and it will be seen that this is so with very few exceptions.

It is interesting to note that the values for the mean diameter and the mean weight per unit length give a value for the mean density of 0·543. The actual

density of wool itself at 70 per cent. R.H. is about 1·32 so that actually more than half the volume of the yarn consists of the air spaces between the fibres.

(f) Thermo-electric Method

A method similar to the previous one has been devised by Steward.[9] In this instrument the variations in the diameter of the yarn are measured by passing it at uniform tension in front of the slit of a thermopile so as to intercept radiant heat. The current from the thermopile is measured by means of a galvanometer by focussing a beam of light reflected from the galvanometer mirror on to the drum of a recording camera. Two thermopiles may be mounted at right angles and the resulting currents combined. The period of an ordinary galvanometer will prevent the method from being accurate for a continuous motion of the yarn past the slit, but this difficulty can be overcome by pulling the yarn through in successive jerks and recording the steady deflection each time.

(g) Diffraction Method

Matthew[10] has very recently applied the diffraction method first proposed by Young[11] in 1824 and extended by Ewles[12] and others to the measurement of yarn diameters. When a light source such as a slit is viewed through a bundle of fibres arranged approximately parallel to one another and to the slit, a series of alternate light and dark bands are seen extending symmetrically on both sides of the source in directions perpendicular to the axes of the fibres. From the theory of diffraction, a known relation exists between the separation of the bands and the diameter of the fibres. The application to yarns requires some modification of the apparatus which has been worked out, but the results so far are not very satisfactory. The experiments so far have been carried out with flax yarns which have definite edges and the method would probably be quite unsuitable for beardy worsted yarns.

(h) Other Methods

A very common and useful method in many cases for measuring the regularity of a yarn is to calculate the coefficient of variation* of a number of single thread strength tests. The factor which is being estimated, however, in this case is the suitability of the yarn to stand up to the various strains and tensions imposed upon it in weaving or knitting, rather than its appearance in the finished fabric. This, however, is extremely important and there is no doubt that there is some relation between these two properties. This will be seen from the following figures for some 1/28s yarn spun from some six months and twelve months Cape wool rovings (dry combed) which were obtained as part of some experiments carried out to test the relationship between roving levelness and yarn levelness. Two hundred successive 1 in. lengths of the roving from which the yarn was spun were weighed on the microbalance and the coefficient of variation worked out. The yarns were then spun into 1/28s with suitable twist, conditioned and tested for strength, 100 tests being taken. The results were as follows :—

Yarn	Coeff. of Variation of Wt. per Unit Length— Tests of Roving	Coeff. of Variation of Single Thread Strength Tests of Yarn
	%	%
6 months	9·8	17·7
12 months	7·4	11·8

A still more interesting set of results was obtained for some 1/36s French spun yarns made from the same material and with the same draft, the only

*Coefficient of Variation $= \sqrt{\frac{\text{Mean square Deviation}}{\text{Mean}}} \times 100$ per cent.

difference being that the rovings had been made differently and had differing degrees of irregularity. The results in this case were as follows :—

Yarn	Coeff. of Variation of Wt. per Unit Length— Tests of Roving	Coeff. of Variation of Single Thread Strength Tests of Yarn
	%	%
A	6·7	12·8
B	7·4	15·3
C	8·3	15·3
D.	10·9	16·8

The actual variation in weight per unit length of the yarn will be related directly to the variation in weight per unit length of the roving, since at this stage there is very rarely any doubling, the yarn being spun direct from the roving, so it is evident that the variation of the single thread strength tests is a guide to the degree of regularity of the yarn. These results have been confirmed by numerous other tests.

One disadvantage of using the coefficient of variation is that it gives equal values from the point of view of irregularity to thick places and thin places. While this is quite sound from the point of view of the appearance of the yarn, it is not a guide to the possible performance of the yarn during weaving. What is most important in this case is the number of places below a certain strength.

Many useful machines have been designed to obtain an accurate measurement of this property. In the Dietz tester for instance the yarn is put under the tension which it is estimated will be used in manufacture and the number of breaks in a given length observed. The average "breakage free" length is then a criterion of the suitability of the yarn. The extensions under the known tension can also be recorded.

The standard Moscrop tester can be adapted to work in this way without, however, recording the extensions.

ANALYSIS OF RESULTS

In all the methods described above in which a record is obtained on a greatly reduced length scale of the irregularity of the yarn (such as, e.g., the W.I.R.A. Photoelectric Recorder) the advantage is that an immediate impression can be formed of the value of the yarn, and for many purposes in experimental spinning, this is sufficient. If a numerical estimate of the degree of irregularity is required, the method which is usually adopted is as follows :—Measure the total area between the curve and the base line with a planimeter, and divide by the length of the record. This gives the mean value and this can now be inserted on the diagram. Measure up the total area above and below this mean line and again divide by the mean length ; this gives the mean variation from the mean, and this expressed as a percentage of the actual mean, is a measure of the degree of irregularity of the yarn.

In dealing with a set of numerical results such as would be obtained from a series of weight per unit length measurements, the most convenient method is to calculate the coefficient of variation, care being taken that there are a sufficient number of readings to reduce the probable error to reasonably small proportions. At least 100, and preferably 200 readings are required in most cases which are met with in textile yarn testing. There are some objections to this method as we have already seen in the case of single thread yarn strength tests, and every individual case must be dealt with on its merits. Usually what is required in practice is a comparison of two or more yarns of the same type and not the recording of a certain number of individual properties of a single yarn.

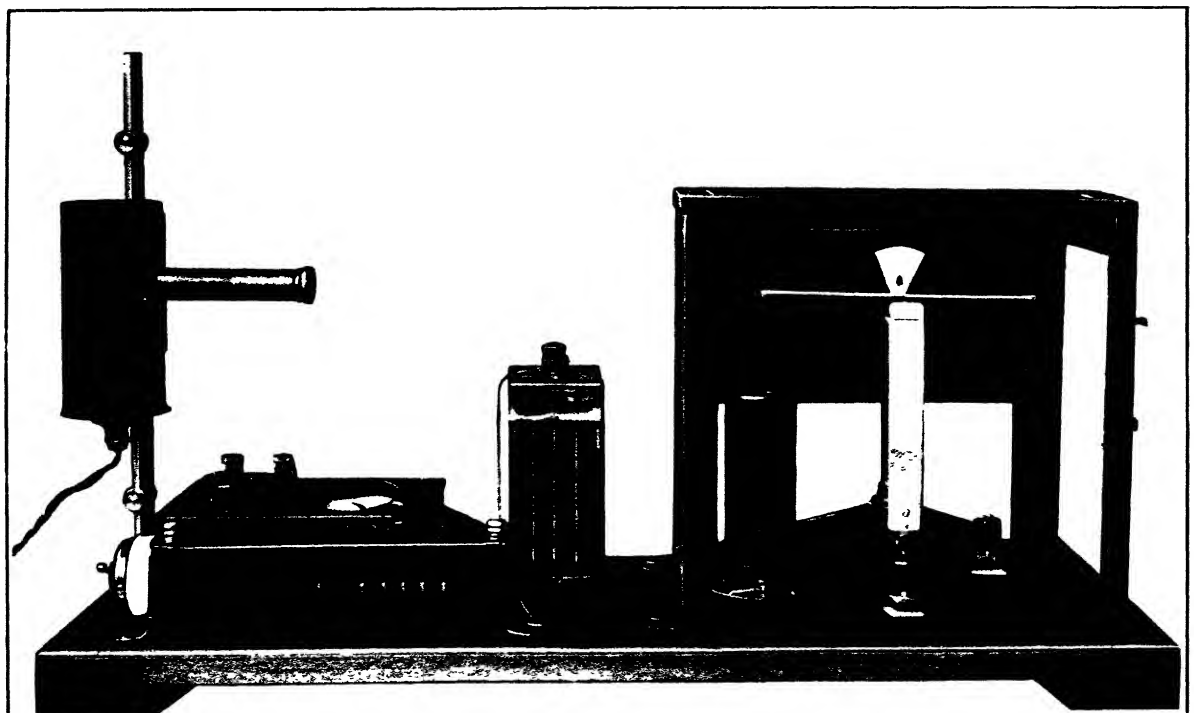

FIG. 1

The Electromagnetic Microbalance

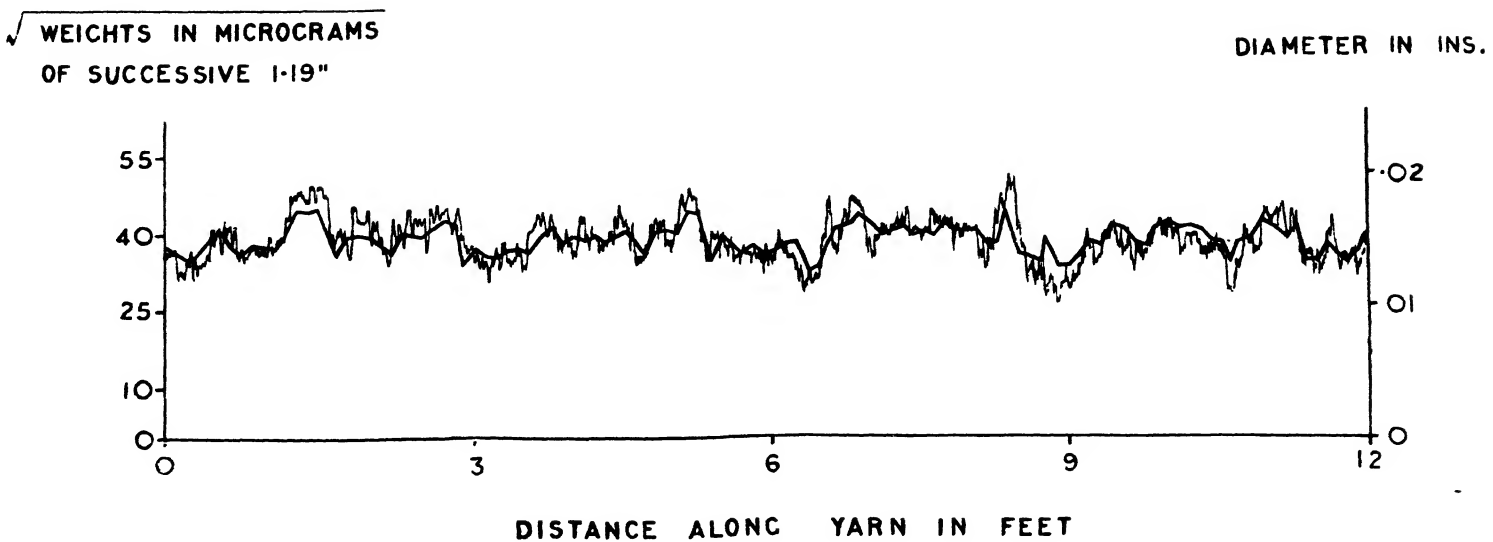

FIG. 7

Record showing Relation between Levelness Curve and Weight per Unit Length Curve.

Finally, it has only been possible in this brief outline of the various methods of measuring yarn levelness to indicate the main features, advantages and drawbacks, but it is hoped that sufficient has been presented to show that measurement of levelness is now on as good a scientific basis as most of the other measurements of the properties of textile yarns.

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DISCUSSION

Professor W. E. Morton, Chairman, said that tests made in America had shown that very few individuals are capable of judging accurately the levelness of silk in the seriplane test, and in connection with the Lecturer's remarks on the effects of colour and backgrounds on visual judgment he wondered whether the relative gradings of white and yellow silks presented any difficulty on that account.

He noted that the Lecturer stated that the ordinary Moscrop tester could be adapted to measure the break-free length. He would be interested to know how this could be done.

Dr. A. W. Stevenson asked whether the modified Moscrop was a constant stress or a constant-strain machine. In other words did it count the places that would not stand a given load or the places that would not stand a given extension ?

Dr. Stevenson also said that in many cases weaving was the ultimate measure of yarn strength and in these cases tests should stimulate weaving operations. Textile technologists had followed too slavishly the tests developed for engineering materials.

Mr. W. E. King said it was a matter of finding breaks below a standard minimum which had previously been determined and the machine was set in such a way that only these were recorded.

In reply to the foregoing remarks the Lecturer suggested that the simplest way of adapting the Moscrop tester to measure the breaking-free length was to draw a line across the chart at the tension value decided upon as the minimum and count the number of breaks below the line. Alternatively the cross-bar which returns the pins to their zero position can be set so as not to allow the pins to travel past the fixed tension value indicated on the chart. The machine then measures the number of short fixed lengths which will not stand a given load and the total length tested divided by the number of breaks gives a figure which corresponds to the average breakage-free length of the Dietz tester.

At the request of the Lecturer, Dr. Stevenson gave some details of the method used in calibrating twist testers. An inking device marked the yarn at regular intervals just in front of the draft rollers. The revolutions made, not by the spindle, but by the actual yarn in the balloon, were also measured over definite intervals and thus the number of turns put into marked lengths of yarn were ascertained. Twist per unit length was not under consideration; the instruments were tested for their ability to declare what turns the spinning frame had put into a given piece of yarn irrespective of its length.

The Lecturer thanked Dr. Stevenson for his remarks and explained that the twist tester described in the paper could be used quite quickly and accurately by ordinary observers after a little practice and was not more difficult to use than the ordinary testers.

THE MEASUREMENT OF THE POROSITY OF TEXTILES

By Guy Barr, D.Sc.
(National Physical Laboratory.)

SUMMARY

It is pointed out that the pressure-difference causing the flow of air through textiles in a porosity test should be specified if agreement is desired between tests on the same material, and that the pressure specified should usually be small (less than 1 cm. of water column). The area of the test-piece may affect the result in view either of edge effects or of the tensions resulting from the application of pressure. A method of clamping is suggested which allows leakage at the joint to be detected and rendered negligible and a gasometer type of apparatus is proposed for routine tests to avoid the inconveniences of the methods hitherto used.

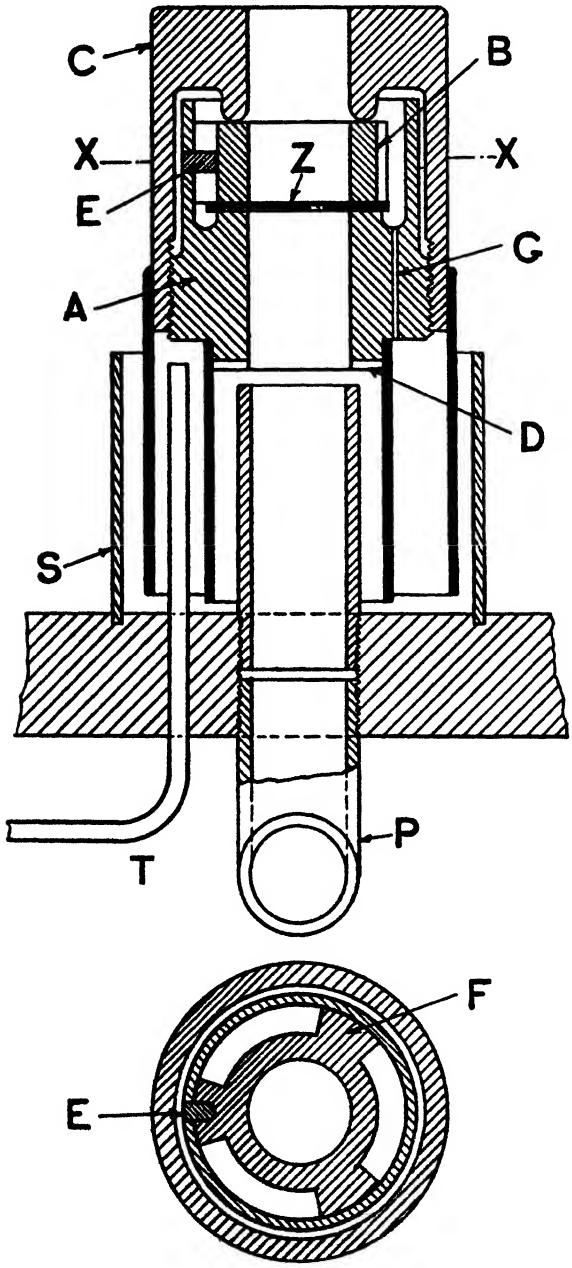
INTRODUCTION

The resistance offered by textiles and other porous materials to the passage through them of air and other gases is a property the determination of which has begun to attract an increased amount of attention during the last decade. The laboratory methods which have been described are not entirely suitable for mill use and there appears to be a need for an apparatus such that no delicate adjustments during a test are required and the manipulation is as simple as possible. It is the purpose of this note to draw attention to certain points which arise in the specification of porosity and to suggest a design for a suitable apparatus. We shall not consider the case in which a sheet of material separates two gases of different composition and the transfer of gas takes place by diffusion, but we confine ourselves to dealing with the transpiration of gas through the pores from a region of higher to one of lower pressure.

The Pressure to be used in Testing for Porosity

For the detection of a few minute pores it is usually convenient to make use of high pressures in order to produce rates of flow suitable for measurement, but the type of material that is here envisaged is one in which the pores are numerous and macroscopic, as in most textiles. It has been found that the velocity with which air passes through a piece of fabric increases with, but is not in general proportional to, the difference in pressure between the two sides.[1] In the majority of the practical applications in which the porosity of textiles is important the differences in pressure are small: clothing or tentage, for example, exposed to a wind of twenty miles an hour, will be subjected to a pressure difference equal to only some 5 mm. of water column. It is thus desirable that tests on such materials should be made under very small heads: Marsh[2] goes so far as to suggest that the slope at the origin of the graph showing the rate of flow of air at several pressure differences should be used to define the porosity (cm.^{3} of air flowing through 1 cm.^{2} per sec. per cm. head of water). For the purposes of investigations such as that of Marsh in which the relation between thermal conductivity and porosity was being studied, there is some justification for the selection of this point on the curve. For the routine examination of any particular class of material it is simpler to test at one fixed pressure difference only: in certain cases the head selected may bear some relation to the conditions of use, e.g., Schiefer and Best's[3] tests on parachute cloths were made under a head of half an inch of water. Higher pressures may be called for in connection with special uses. So long as

CLAMP FOR POROSITY MEASUREMENTS.



SECTION AT XX.

FIG. 1.

comparisons are to be made only between materials of not very dissimilar porosity it is to be expected that the relative values at any fixed small pressure difference will differ little from those deduced from the slopes at the origin.

Area of Test-piece

Most observers have commented on the large variations in porosity which may occur between different parts of the same sample. Marsh gives no indication of the area of his test-pieces, but states that the flow per unit area was found to be independent of the area. This conclusion may be true for closely-woven and densely felted cloths, so far as it can be verified in view of the local variations, but it will obviously break down if the area of test-piece is not a large multiple of the area of a pore. Further, if tests are made with a fixed pressure-difference the tension in a circular sample will increase as the radius is increased: Gale and Hedrick,[4] who use a test-piece of area 175 cm^2. apply a constant tension but the effects of tension do not appear to have been investigated and are probably very variable.

With thick materials it is to be expected that there should be some "edge effect," the effective area being larger than the measured area of the clamping rings. Shakespear[5] has discussed the errors occurring in the nearly analogous case of the testing of balloon fabrics for hydrogen permeability: he showed that there might be considerable error from edge effect with some types of proofed material even when the area of the test-piece was 1000 cm^2., but that the error might be avoided by the use of a guard-ring type of apparatus. The guard-ring principle is not readily applicable to the present problem, as it would involve accurate adjustment of pressure in the guard-rings to prevent excessive lateral leakages.

An edge effect of a different type appears to be probable when felted materials are under test, the compression caused by the clamps causing a reduction in porosity: the influence of the compression may extend somewhat beyond the actual area between the clamps and lead to a measurable decrease in the quantity of air flowing per unit area of test-piece. All these arguments point to the desirability of specifying a fixed area if comparative tests made on different instruments are to show agreement.

Method of Clamping

It has not been usual to take much precaution against lateral leakage at the periphery of the test-piece, reliance being placed on a more or less uniform and heavy pressure on a clamping ring to reduce the lateral leakage to an insignificant proportion of the flow through the free area. The smaller the test-piece the more important will any leakage at the joint become and there are certain types of material for which it is at least not obviously easy to ensure that the leakage shall be negligible when the sample is simply clamped between flat metal rings. The method of impregnating the edges with some viscous or plastic substance before assembling the clamp is efficient but it is not always practicable in view of the possibility of the sealing compound affecting the textile or diffusing into the area which is delimited. The small brass clamp shown in Fig. 1 has been designed with the object of allowing the leakage at the joint to be detected, and rendered negligible. Since the use of heads exceeding an inch of water is not contemplated, an oil seal at S provides a satisfactory method of connection with the remainder of the apparatus through the pipe P. The specimen Z having been placed between the smooth faces of the bed A and the ring B, the necessary clamping pressure is obtained by screwing on the member C: a saw-cut D is provided in the base of A so that it may be held during this operation. The ring B is prevented from rotating by means of the projection E from the wall of the upper part of A, the projection entering a vertical slot in one of the three sector pieces F which serve to centre B. The metal to metal joint where C bears on the top of B is lubricated and made gas-tight by a little vaseline. The air so enclosed around the edge of the sample is in restricted communication along the screw

thread with that between the skirt of C and the tubular extension of A above the oil seal : a more direct path is provided by a few small holes G bored through A. Any leakage at the joint will involve a change in the volume or pressure of this air. The tube T leads to a small aspirator, the difference from atmospheric pressure being observed by means of a two-liquid gauge. Suppose the flow through the sample of fabric is being measured when a reduction of pressure

DIAGRAM OF BALANCED GASOMETER.

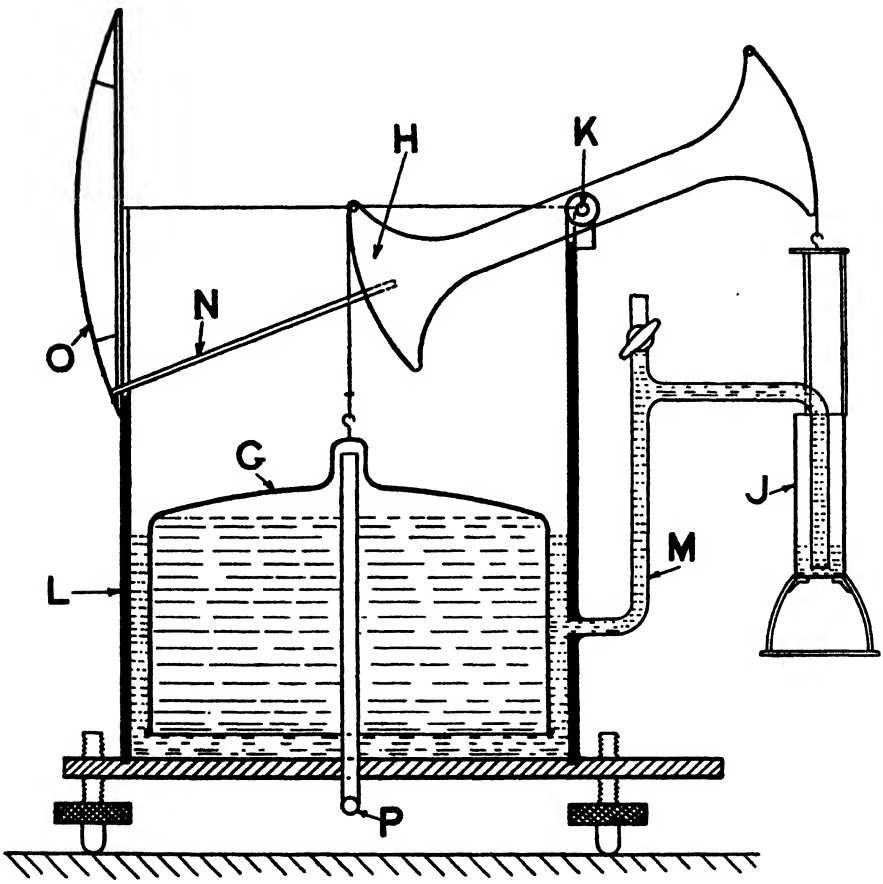


FIG. 2.

equal to 1 cm. of water column is applied at P. The reading of the gauge corresponding with this reduction having been previously noted, by closing the top of C with a cork before screwing it up, the screw is first tightened until the joint will sustain an excess pressure of about 1 cm. without undue leakage and then water is run out from the aspirator to produce a reduction of pressure of 1 cm. of

water below atmospheric : the correct reading of the gauge is maintained during the actual test by running out more water as may be necessary. Under these conditions leakage through the cut edge of the sample or between the sample and the face of A is impossible.

If the test-piece is of large area the external screw indicated will not afford a convenient method of clamping, but the same principle may be applied, e.g., by providing the clamping ring B with a skirt dipping into an annular recess in A deep enough to allow an oil seal to be made below a channel communicating with the aspirator and gauge.

PROPOSED APPARATUS, AND METHOD OF MEASUREMENT

All the methods which have been used heretofore (except the " Densometer " mentioned by Marsh) involve the inclusion of (*a*) a fan, aspirator or other source of compression or rarefaction of the air, (*b*) a sensitive and accurate manometer to measure the small pressure-drop across the sample and (*c*) a calibrated flow-meter or a gas-meter with stop-watch. The method of test, therefore, involves an adjustment of pressure to a suitable value, which must be maintained during the experiment, and a reading of the velocity of flow. In the method here proposed the necessary adjustment may be made once for all and the observation consists merely in observing the time required for the passage of a certain volume of air through the sample. In the form first considered the apparatus is arranged to draw air from the room through the sample : in view of the effect of humidity on the porosity[1] this arrangement requires that tests should be made in a conditioned atmosphere. The diagram (Fig. 2) illustrates the principle of a balanced gasometer suitable for the purpose in hand. A light thin-walled bell G is suspended by a flexible tape from one end of the beam H, and a bucket and scale-pan J from the other end : the extremities of the beam are arcs of a circle whose centre lies on the axis of the bearing K : the beam must be accurately balanced and turn freely. The bell hangs in a tank L, through the floor of which projects pipe P leading to the clamp holding the fabric : a siphon tube M connects the bucket J with the tank. The apparent weight of the bell when nearly immersed is counterpoised by a weight on the scale-pan below J. The rise of the bell is indicated by a pointer N projecting from the beam and two marks on the scale O correspond with definite positions of the pointer and bell, i.e., with the entry of a definite volume of air into the bell if the difference in level between the liquid surfaces inside and outside the bell remains unchanged during the travel. As the bell rises its apparent weight is increased by the weight of the liquid formerly displaced by that part of the wall which has emerged. The bucket J is constructed to have an internal area of cross-section such that the flow of water into it through the siphon compensates for the gain in weight of the bell : the area is approximately equal to that of the cross-section of the wall (see Appendix).

The extra weight to be placed on the scale-pan to produce the desired reduction of pressure in the bell is calculated from the internal area of the bell. If the lower of the two marks on the scale O is placed at such a height that the rate of movement of the pointer after the addition of this weight has become uniform before the mark is reached, the volume entering the bell may be calculated from the internal area when the radius of the arc at the end of the beam H and the distance of the scale from the axis are known. A small error in the measurement of area will be unimportant, since the volume entering is practically proportional to the weight added to the pan and the estimation of each will be similarly affected by the error.

The accuracy with which results can be duplicated in apparatus working on this principle is practically limited by the friction at the bearing K. If the area of cross-section of the bell is about 1000 cm.^{2}, so that the length of the beam is some 36 cm., a head of 5 mm. of water will require a weight of 500 gm. on the scale-pan : for an accuracy of 1 per cent. the beam should then turn when 5 gm.

is added to the pan. This sensitivity can probably be obtained without difficulty by the use of hardened steel pivots if the weights of the bell and beam are kept to a minimum.

The porosities reported by Marsh range from 3 to 1200 cm.^{3} per cm.^{2} per second per centimetre head of water. A gasometer of 10 litres capacity working with a head of 5 mm. of water would be filled in times varying from nearly 2 hours to 17 seconds if a uniform area of 1 cm.^{2} were adopted for the test-piece: but for the less porous materials a larger test-piece would naturally be used, the necessary clamp being readily interchangeable by means of the oil seal S (Fig. 1).

Effect of Humidity

As above described, the apparatus must be used in a conditioned atmosphere if the effects of humidity are to be standardized. Beyond the observation[1] to which reference has already been made, indicating a possible variation of 24 per cent. between tests on one material with dry and with saturated air, no close study of the effect appears to have been made, and it is possible that under ordinary conditions the variation may be small enough to be neglected in view of the non-uniformity of the material. If it should prove advisable to specify the humidity fairly closely, the apparatus might be modified so that air is conditioned in the gasometer and forced out through the fabric. The modifications required are of two sorts:—(*a*) the tank would need to be filled with an aqueous solution (e.g., of calcium chloride) having the required vapour pressure: a construction embodying the use of tin-plate, aluminium, mild steel, etc., which would be permissible in the apparatus sketched in Fig. 2 if a light oil were used as bath liquid, would have to be replaced by one in which only non-corroding materials were included. (*b*) The descent of the bell would become unstable and it would probably be necessary both to provide a guide above the top of the bell and also to lower the centre of gravity considerably.

APPENDIX

Let the area of cross-section of the tank be A and that of the wall of the bell a and let x be the required internal area of cross-section of the bucket which is to ensure that when the bell rises and the bucket falls through a distance l the volume of water V running from the tank into the bucket maintains equilibrium. We assume for simplicity, that the pressure inside the bell is atmospheric, but the calculation is similar if there is a difference of pressure.

When the bell rises a distance l the level in the tank falls by an amount δ such that

$$\delta\,(\mathrm{A} - a) = (l + \delta)\,a + \mathrm{V}$$

hence

$$\delta = (al + \mathrm{V})/(\mathrm{A} - 2a)$$

Now for equilibrium V must be equal to the volume of the wall of the bell which has emerged from the water, i.e., to $a\,(l + \delta)$; hence

$$\delta = 2al/(\mathrm{A} - 3a)$$

If the level in the bucket is always equal to that in the tank while the bucket itself descends a distance l below the original level

$$\mathrm{V}/x = l - \delta$$

Hence

$$x = a\,(l + \delta)/(l - \delta)$$

or

$$x/a = (\mathrm{A} - a)/(\mathrm{A} - 5a)$$

The ratio a/A may become appreciable if the tank is made of annular cross-section to reduce the volume of liquid used. In calculating from the dimensions the volume of air entering the bell it should be noted that a travel l corresponds with the admission of a volume of air equal to $l\,(\mathrm{A} - a)/(\mathrm{A} - 3a)$ times the internal area of cross-section.

If the time occupied by the rising of the bell through the distance l is t seconds, the volume V of liquid from the tank has to flow through the siphon tube in t seconds: this entails the occurrence of a difference of level h between the liquid surfaces in the tank and in the bucket which may be equated approximately,

assuming stream-line flow, to $8\eta Lal/\pi r^4 \varrho g t$ where L and r are the length and radius of the siphon tube and η and ϱ are the viscosity and density of the liquid. The defect in the counterbalancing volume is then hx and one may estimate the dimensions of the siphon necessary to ensure that this defect shall cause negligible error in the pressure or in the measured porosity: for a fixed length of tubing the diameter varies with the square of the wall-thickness of the bell.

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DISCUSSION

The Chairman, Mr. J. H. Lester, said that it was a matter of great satisfaction that the Conference programme contained the names of contributors from Research Associations and kindred organisations. It was to such organisations that the Textile Institute had to look on occasions such as these and in his opinion, since these bodies were, at least in part, supported by public funds there was every justification for so doing. The present speaker, Dr. Guy Barr, was welcome not only because he came from the National Physical Laboratory but personally on account of the work he had done in connection with the Fabrics Co-ordination Research Committee from which so much was to be expected.

Mr. Lester, opening the discussion, stated that this was precisely the type of paper desired by the Institute and that such contributions would enhance its reputation. He wished to know if King's pressure gauge was suitable for use in the measurement of fabric porosity. He thought it could be adapted easily and could be made to work at very small pressures. It appeared that " porosity " measurements might give an indication of " cover " and as no satisfactory and rapid methods existed for this purpose any advance towards a solution would be very welcome.

Mr. P. A. Bentley asked whether the author had devised any " projection " method whereby the measurement of porosity might be associated with actual measurements of yarn regularity and inter-yarn spaces. He had employed such a method in an attempt to measure the irregularities of knitted fabrics with a view to ascertaining whether defects were due to yarn irregularity or to machine movements.

Dr. Barr said he had not associated measurements of inter-yarn areas with those of porosity. Determinations of air-porosity were regarded as a method of summing the effects of the individual irregularities; the nature of the irregularities required to be studied in detail if a more uniform, i.e., a less porous material, was to be produced.

Mr. W. Kershaw suggested that not only were porosity measurements valuable as an indication of the " cover " of a cloth but they had an application in connection with finishing. He would like opinions as to the possibility of using the apparatus on the full width of the fabric.

The general method was quite suitable, said the Lecturer, for use with full widths of fabric, but the small clamp exhibited would need to be replaced by one of different design. The principle adopted for the exclusion of joint leakage might then prove inconvenient in its application but where a large specimen was under test, exactness in the definition of area became less important and rubber or other jointing materials could be employed to reduce edge leakage

to an insignificant proportion of the total. In such a modification it would probably be desirable to use a larger gasometer if the fabric to be tested were at all open in texture.

Mr. Lester asked how far the usefulness of the machine was limited in respect of the area of the samples tested.

Dr. Barr said that the selection of a small test piece allowed conclusions to be drawn as to the importance of visible irregularities. The clamp shown (area 1 sq. cm.) was suitable for a somewhat extreme porosity: for fabric which was moderately dense a larger clamp would be more convenient and could easily be substituted.

Mr. Garnett said he thought that the paper and the ensuing discussion had been deeply interesting. He would like to know if there was any connection between porosity and waterproofness: could a scale of relationship be set up? It would seem that the hygienic properties of fabrics might be associated with either porosity or proofness or with some joint measure of both. Industry would look to science for just this type of measurement.

Mr. Lester said he felt that Mr. Garnett's questions were of real importance and that any significant correlation of porosity with showerproofness should be valuable and should be investigated.

The Lecturer said his first measurements of air-porosity had been made in connection with a test for waterproofness of porous materials. The criterion adopted for waterproofness was the head at which leakage of water was first definitely visible when the head was increased at a uniform and fairly slow rate. It was suggested (second Report of the Fabrics Co-ordinating Research Committee) that such tests should normally be associated with air-porosity tests and that of two materials giving the same waterproofness value the one which was the more porous to air was the more efficiently proofed. His own work had not gone beyond suggesting a principle and indicating experimental methods for the study of the correlation mentioned by Mr. Garnett and Mr. Lester: he thought those directly interested should make regular tests on the lines proposed.

QUANTITATIVE DETERMINATION OF COTTON, WOOL, SILK AND ARTIFICIAL SILKS IN MIXED TEXTILES

By P. Krais and H. Markert, Dresden

The use of mixed yarns and fabrics other than those of wool and cotton or of silk and cotton or wool has increased very much lately and is still in progress. It has, therefore, become an important task to analyze such mixtures as exactly as possible. This is of interest not only for questions of customs and tariff classification, but also for the manufacturer, buyer and user and, last not least for the dyer, when he has to work out his recipes.

We want to give you a short report of the methods we use and of their limits of exactness. We shall be very glad and grateful, if you will criticize this and suggest improvements, because this is a matter of growing importance and we are not far enough advanced yet to be able to say that this is the last word and that the exactness might not be still improved.

Of course it is necessary to remove all non-fibrous materials beforehand as completely as possible. Oils, fats, soaps, size, finishing materials, waterproofing materials, etc., must be extracted from the textiles by alternate treatments with ether, alcohol, enzymes, dilute acids and dilute ammonia, as the case may be, even by benzol and carbon disulfide, when indiarubber is present.

A microscopical examination has to follow in order to ascertain which kinds of fibres are present. In case of doubt this investigation must be completed by the usual colouring and dissolving reactions applied to the decolourized fibres.

Table I—Microscopic Appearance and Reactions

	Microscope	Iodine in Zinc Chloride	Diphenyl-amine in Sulphuric Acid	Acetone	Dye test*
Wool	Scales	Yellow	—	—	—
Silk	Not streaky	,,	—	—	—
Cotton	Bandlike windings	Blue	—	—	—
Viscose rayon ...	Smooth or streaky	,,	—	—	Pink
Cuprammonium rayon	Smooth	,,	—	—	Dark reddish Blue
Nitrate rayon ...	Slightly streaky	,,	Blue	—	—
Acetate rayon ...	Slightly streaky	Yellow	—	Soluble	—

*We recommend to use equal parts of a solution of ·1% Eosine (Colour Index 768) and of ·1% Benzoblue BX (Colour Index 472) in distilled water. Treat the samples for 5 mins. with this mixture at ord. temp., rinse well and dry.

Supposing the impurities have been removed and the kinds of fibres ascertained, then our next consideration will be the correct calculation of the moisture content of each kind of fibre. The usual additional percentages allowed in Conditioning Houses are, of course, different from the real percentages, and also different from the real moisture content we usually find :—

Table II—Moisture Contents

	Standard additional % H_2O	Corresponding % H_2O	Usual moisture contents at 60% rel. Humidity in %
Worsted, worsted yarns noils, recovered wool	17	14·53	14
Wool, combed wool, tops, yarns therefrom	18·25	15·44	
Cotton...	8·5	7·83	8·5
Silk (degummed)	11	9·91	8·5
Cellulose Rayons	11	9·91	11·4
Acetate Silk	6	5·45	4·4
Mixed yarns of Wool and Cotton ...	10	9·09	—
Mixed yarns of Wool and Silk ...	16	13·79	—

This is a difficult question. The most rational way out of it seems to us to be, to weigh the sample after 24 hours' exposure in an atmosphere of 60° or 65° rel. humidity at ordinary temperature, and also to weigh the isolated fibre, portions, having dried them at moderate heat, after the same exposure of 24 hours.

Now we come to the methods themselves. There are four kinds of dissolving methods which we use, according to the fibres we want to ascertain, following the principle, that it is always best, to get the more important fibre or fibres directly (insoluble), the less important ones indirectly (dissolved).

1. *Acetone.* If Acetate rayon is present, this can be dissolved with Acetone as usual at ordinary or slightly elevated temperature.
2. *Caustic Soda boil.* About 5 g. of the Sample (exactly weighed) are boiled with about 30 parts of 2 per cent. Caustic Soda solution to one part of Sample for ½ hour in a flask fitted with a reflux cooler, then the mass is placed in a fine bronze sieve, washed out with flowing cold water, collected and dried. Wool and silk are dissolved, cotton, flax, and ramie remain undissolved.

3. *Sulphuric acid.* About 5 g. of the Sample are put into a glass stoppered flask and Sulphuric Acid of 80 per cent. is added (proportions as before), the mass is shaken vigorously for a quarter of an hour, then again every quarter of an hour. After 3 to 4 hours the mass is placed in a sieve and treated as under 2. All vegetable fibres are dissolved, wool and silk remain.
4. *Calcium thiocyanate.* A solution of the technical thiocyanate is made so that 100 c.c. of it contain 100 g. of the salt. About 200 c.c. of this solution are put into a flask with wide neck, fitted with a vigorous stirring device, warmed in a water bath to 70° C., then about 1·5 g. of the Sample are added and the whole is heated in the boiling water-bath for 1 hour under constant stirring (200 to 300 turns per minute). Then the mass is placed in a sieve and washed as under 2, after the excess of liquid has been pressed off well with a glass rod. We use a copper wire sieve with 2500 meshes per square centimetre, which is fixed in a kind of funnel made of brass sheet.

It is essential, that the residues, after being dried, conditioned and weighed, are also examined under the microscope in order to ascertain that the fibres one expects are really present and in a pure condition.

Small percentages of the fibres which are supposed not to go into solution, are dissolved nevertheless by these methods, and so we give the following table showing the correction factors which must be taken into calculation.

Table III—Percentage Solubility.

	Acetone	Caustic Soda	Sulphuric Acid	Calcium Thiocyanate
Wool unbleached	0	100	0	2·5
,, bleached	0	100	0	3·5
Silk (raw, degummed, weighted) ...	0	100	0	100
Cellulose rayon	0	> 6	100	100
Acetate rayon	100	> 6	100	100
Cotton, raw	0	ca. 3·5	100	4
,, bleached	0	ca. 3·5	100	3
,, raw mercerized	0	ca. 3·5	100	2
,, mercerized, bleached ...	0	ca. 3·5	100	2

Supposing we have to analyze a fabric containing Acetate Silk, Viscose rayon, Natural Silk, Cotton and Wool, then we have the following manipulations :—

(*a*) Acetate rayon to be dissolved out with Acetone. Loss in weight: *Acetate rayon.* The material thus treated is used for all the subsequent operations.

(*b*) A part of (*a*) is treated with Sulphocyanate. Remains: Wool and Cotton. Loss in Weight: *Viscose rayon* and *Natural Silk.*

(*c*) Another part of (*a*) is treated with Sulphuric Acid. Remains: Silk and Wool. Loss in weight: *Viscose rayon* and *Cotton.*

(*d*) A part of the residue (*b*) is treated with Sulphuric Acid. Remains: Wool. Loss in weight: *Cotton.*

(*e*) Another part of the residue (*b*) is treated with Caustic Soda. Remains: Cotton.

(*f*) A part of the residue (*c*) is treated with Thiocyanate. Loss in weight: *Silk.*

(*g*) From the sum of Cotton and Viscose rayon found under (*c*), the Cotton found under (*e*) is subtracted, which gives the amount of *Viscose rayon.*

DISCUSSION

In the absence of the authors, who were unable to attend the Conference, the Chairman, Dr. J. C. Withers, introduced the paper by raising one or two points upon which he thought discussion might be of value. In his opinion

the authors would have enhanced the value of their paper if they had included a number of typical analyses. It appeared to him that the employment of certain of the reagents referred to was of doubtful validity. For example, it seemed inconceivable that calcium thiocyanate would effectively separate viscose rayon and silk from wool and cotton; a solvent that would extract rayon completely without attacking cotton would be remarkable. Dr. Krais had not referred to methods of analysis based upon determinations of characteristic constituents like nitrogen or sulphur nor to the use of cuprammonium as a solvent. The question was worth raising whether a method of analysis that depended on a "count" of the fibres in a mixture as seen in the field of a microscope might not be as trustworthy as "chemical" tests.

In a written reply the lecturers stated that for typical analyses they referred to the explicit publication they made in 1931 (*Monatschrift fur Textilindustrie*, May, 1931, No. 5; *Textile Forschung*, 1931, No. 2, pp. 85-94). Therein they gave eight examples of double mixtures of known composition and the results obtained by the rhodanide method, and also of a mixture of wool, rayon and mercerised cotton, analysed by the combination of the sulphuric acid and the rhodanide method. It was perfectly evident from all these tests that all fibres resulting from a liquid of some kind (rayon, natural silk) were soluble in rhodanide, all others insoluble. The probable reason for this was that the micelles were in regular order in the latter cases and irregular in the former. Methods based upon the determination of the nitrogen or sulphur content could be useful in special cases, but not generally. The sulphuric acid method was simpler and more reliable than the cuprammonia method. The counting of various kinds of fibres in short cuts under the microscope depended, for estimating amounts in weight, on the exact knowledge of the metric number and specific gravity of the fibres present in the mixture. When irregular fibres such as wool or cotton were in question, this method could not be used.

Dr. L. L. Lloyd suggested that the discussion be referred to the authors with a request for written replies which might also be printed. He was particularly interested in the analytical methods as applied to fabrics containing dutiable fibres, e.g., silk and rayon. The nitrogen content method could not be applied successfully to differentiate gummed and de-gummed silk, when the goods had been after-treated with tannin and stannous chloride to increase fastness of dyed shades to washing and perspiration. Similarly mechanical methods are of no use in such cases. It appeared that chemical methods were essential and would have to be evolved. He urged that as much discussion as possible should be promoted upon methods of analysis so that the full significance and usefulness of the various reagents, and methods of employing them, could be ascertained. Yarns were being made containing camel hair, cultivated silk, viscose rayon and botany wool, also angora wool (rabbit fur) along with these fibres, and these yarns were produced in dyed and undyed styles. Quantitative analyses of such mixtures were extremely difficult but certificates of analysis were required and this should give the urge to obtain satisfactory universal methods of analysis. It must also be borne in mind that the different finishing processes through which goods passed had varied effects on the nature of the fibres which again increased the difficulty of analysis. Physico-chemical methods have been suggested but these would have to be standardised with materials that are not of constant chemical constitution. It would be of little use estimating viscose by a viscosity method when it is known how readily viscose is modified by finishing operations.

The lecturers stated in their reply that mixtures of animal fibres such as wool, camel hair, rabbit hair, could be estimated only by microscopic examination. This, however, was always difficult and uncertain, because some camel hair was very similar to wool. The counting of scales per millimetre might be useful. It was necessary to differentiate wool kemp hairs from other animal hairs.

Dr. W. H. Gibson urged that physico-chemical tests ought to prove useful. Viscosity measurements in his view were of marked value as they allowed of differentiation between cotton and rayon and the fact that the fibres were dyed did not affect the viscosities.

Viscosity tests in the opinion of the lecturers were not sufficiently investigated to give reliable results, except for the estimation of the degree of bleaching or of oxycellulose.

Mr. W. Kershaw suggested that the authors should be asked to supply greater detail. He pointed out that if acetate rayon had been hydrolysed in process of finishing this would affect the methods of analysis employed.

The lecturers referred to the original publication for further details. Hydrolysation did not interfere with the exactness of the rhodanide method because acetyl cellulose as well as cellulose hydrate were easily soluble.

Mr. J. G. Williams referred to preferential staining and asked how stripping affected the proposed methods.

In reply it was stated that the methods were not affected by stripping if this was performed in a reasonable manner. Super-bleached natural vegetable fibres showed some solubility in rhodanide. This question was already under investigation.

The President, Mr. G. Garnett, pointed out the practical significance of this work. Fibres were being mixed to secure definite effects and the resulting goods were being exported all over the world. Duties had been fixed—claims were often put forward as a result of analyses wrongly made in many different countries. Uniformity and reliability of methods were essential. In his opinion this work was of the utmost importance.

The lecturers said they were glad their work had proved to be of interest and expressed cordial thanks to their British colleagues.

STANDARDISATION IN TEXTILE TESTING

By J. Lomax, F.I.C.
(Testing House, University of Nottingham)

It is only to be expected that standards of measurement which have been allowed to grow up gradually and without control should in the end become very complicated and confusing.

One could hardly choose a better illustration of this than our British standards of weights and measures. They are so complex that a part of a child's education is to learn them, and a larger part consists in learning to apply them. Everybody is of course familiar with the division of money by money, where each sum is brought to, say, pence, before the division can be made. It is only in later life, however, when actually using these methods, that one realises the colossal daily waste of time and labour involved, a waste which does not occur in countries where the metric system is in use.

This waste is, however, not the only factor to consider; even when our complicated reckonings have been carried out, and we have obtained the results, we are not level with users of the metric system. The fact remains that results expressed in our system cannot be as clearly understood as results expressed in the metric system. To put the matter concretely, a person working in grammes per litre must have a clearer conception of his results than if he were working in ounces per gallon.

With the above mentioned example in view, it is of interest to everyone concerned with textile testing to pause and review the systems of measurements now in use, to consider how they have grown up in the past, to ask whether they are suitable for actual present use, and to see whether they cannot be improved upon in any way. Such an examination is the better carried out by aiming at a fresh view point, and it would be informative to consider how our methods of textile measurements appear to an intelligent student, or to an outside observer experienced in measurements and testing in other industries.

We can commence our review with a very simple consideration, the direction of twist in yarns. One would think that to define the two directions of twist should be a straightforward matter, admitting of no confusion. Actually there is some confusion. The direction of twist which a Spinner calls Right, a Doubler calls Left, and vice versa.

Another very common measurement in textile testing is the count of a yarn. It so happens that there is a different method of expressing this measurement for each different quality of yarn, and in some cases two or three different methods of expressing the count for the same quality of yarn. This peculiar state of affairs exists because each yarn was manufactured in a certain district, which invented its own system of measurement, taking care that the system should not conform with other systems. In former times the discrepancy was not so apparent, Cotton yarn was for Cotton fabric, Linen yarn for Linen fabric, but under present conditions many a manufacturer is dealing with two or three different qualities of yarn, sometimes in the same fabric, and the confusion becomes more apparent. As an example, if a knitter wishes to know what is the Resultant Count obtained by running together a thread of 15 Denier Silk and 75 Denier Rayon the answer is obviously 90 Denier. If on the other hand he wishes to know the Resultant Count in the case of 75 Denier Rayon and 2/60's Cotton the answer is a mathematical problem.

To a student the question of counts is merely something to be learned, and the conversion from one system to another is a perpetual stumbling block. To an outside observer the various counting systems must appear ridiculous, just as ridiculous as it would appear to us if we were told that metal yarns, or wires, were measured by a different gauge according to whether they were made from iron, brass or copper.

When a completely new yarn, Rayon, came into the textile trade it was counted on the same system as Silk. Owing to previous lack of co-ordination in the trade there were at the time at least five different methods of counting Silk, and for a time at least, three of these methods were used indiscriminately for the counting of Rayon. Very fortunately, however, the mischief in this case has been stopped, and an agreement reached, as set out in the B.I.S.F.A. regulations, so that for Rayon there is only one Denier, the Legal Denier. The Silk Association of Great Britain and Ireland have also adopted the Legal Denier for the buying and selling of Silk. Thus for Silk and Rayon the confusion of using different counting methods has now been overcome.

Perhaps the most common of all textile measurements is that of moisture content, or condition. Textiles, like many other commodities, are sold with an unavoidable and allowed percentage of adulterant, water. The method of reckoning the percentage of moisture in textiles is, however, peculiar, and not like methods used for any other commodities. Cotton, for instance, is sold with an allowable percentage of moisture, but this is not reckoned on the weight of goods received, but on the theoretical dry weight of the cotton, and is expressed as a percentage regain. Thus :—

Allowable moisture = 8½% Regain on Dry Weight

which is the same as saying

Allowable moisture = 7·83% of Weight received, or

The weight received should contain 92·17% Cotton.

A typical example of the usual condition test on a delivery of 100 lbs. of cotton is given below

Net weight received	100·00% or 100 lbs.	
% moisture...	9·60%	
Dry weight	90·40%	
Regain (8½% of Dry Wt.) ...	7·68%	
Correct condition wt.	98·08%	98·08 lbs.
Loss	1·92% or	1·92 lbs.
Correct weight to invoice		98·08 lbs.

This method of calculation is rather more involved than would appear at first sight. It is certainly found difficult to understand by students, and it is not an exaggeration to say that some buyers of yarn do not fully grasp it. In some cases where firms test their own deliveries of yarn for condition, the buyer wil arrive at his result in this way:

Moisture Content	= 9·60%
Allowed Moisture Content ...	= 7·83%
Loss	= 1·77% on delivery.

This reckoning is, of course, only approximately correct, but is often used and it is, by the way, not easy to explain where it is wrong.

To look at the question in quite a different way, let us carry out the calculation as it would be carried out by an observer who did not know anything about the question of regain. He would tackle the problem in the same way as for other commodities containing moisture, solid caustic soda for instance. His method would be as follows:—

Guaranteed % Cotton	= 92·17%
Actual % Cotton	= 90·40%
Shortage	= 1·77% on 92·17%
	= 1·92% of delivery
Delivered wt.	= 100·00 lbs.
Shortage of 1·92%	= 1·92 lbs.
Correct wt. to invoice	= 98·08 lbs.

and substantially the same result would be arrived at. The method of calculating the moisture content of textiles by regain is, of course, correct enough, and is too firmly implanted to alter in any way. The above examples are given merely to remind us that the method is peculiar, difficult to manipulate, and might perhaps have been arranged on a simpler basis, in view of the fact that the results have to be used not by mathematicians but by ordinary commercial men in ordinary commercial dealings.

The strength of a yarn or fabric is a frequent measurement, but has no definite meaning unless the size of the sample tested is given. On this important question there are no generally accepted standards; yarn, for instance, is tested on 10", 18" or 20" lengths, according to custom in different districts or trades, and moreover the strength and elongation are expressed in some places in ounces and inches, in other places in grammes and percentages.

There are many other examples which might be given. For instance, why should we weigh in Grains when testing for counts? There does not seem to be any reason for it, but there is one very good reason against it. Pounds, Ounces and Drams must be used in textile testing for weighing large quantities simply because the bulk is bought and sold by these weights. For laboratory work, however, Ounces and Drams cannot satisfactorily be used, the system is too cumbersome, and Grammes are in universal use. We are, therefore, bound to have two systems of weighing and it seems wrong to burden ourselves with a third. That is one reason against the use of Grains. The fact that 7,000 grains weigh 1 pound and 7 leas make a hank does not, of course, facilitate testing, the calculation is just as simple if grammes are used. Naturally no textile tester is forced to use grain weights in his own laboratory; there are many laboratories without these weights, but with students one cannot ignore them. They are widely used, and every published table of counts is based on grains, so that unless some definite lead is given one is forced to saddle a student with three different methods of weighing, one of which, in the opinion of the writer, is superfluous.

We must, therefore, conclude that our systems of measurements are confused, and cause difficulties not only in textile testing, but in the commercial application

of these tests. When we consider that the Textile Industry now engages the attention of workers of the highest scientific training, it is an anomaly that the fundamental measurements in testing should be so unwieldy, and we cannot but think that if these measurements could be re-made they would be much simpler.

How far they can be in any way simplified or improved now is a problem which bristles with difficulties. Some straightening out might be attempted, and in this respect the standardisation carried out by the B.I.S.F.A. Regulations for Rayon is an interesting precedent which might be followed by bodies interested in other textiles, Cotton, Wool, Linen, etc. The Textile Institute, in conjunction with the various Textile research associations and testing houses would obviously form a body upon whom the duty would fall. It should be possible to draw up, at the very least, a Code of Testing which should first define the simpler measurements. This could be followed by the standardisation of methods which at present vary, and the final aim should be a re-casting of measurements so that they can be carried out, and the results understood with the least possible trouble. Such work would be of real value, it would show an immediate return in the time and labour saved, and would confer a lasting benefit upon the trade. The codification of Textile Testing for Fastness is well in hand by the Fastness Testing Committee, and a similar codification of the simpler measurements of count, strength, twist, etc., is perhaps long overdue.

DISCUSSION

The Chairman, Dr. A. W. Stevenson, thought they should divide the subject into a number of separate issues such as (1) Physical nature of standardisation of testing, (2) Change over to the metric system, (3) Reckoning the moisture content.

Mr. J. F. Copley said in the case of grandrelle yarns with two yarns, one of mercerised cotton and one of worsted, it was quite difficult to get a common denomination and they had to go back to the simplest arithmetic.

Mr. F. P. Slater said he did not think they could entirely surmount the difficulty. As far as he was concerned what was wanted was the diameter. Take as an example one part of a mule spinning cotton yarn and the other half spinning staple fibre. They might be spinning exactly to the same count, but measured by the cotton system the diameters were different. The cotton wound tightly and the staple fibre slack.

Professor W. E. Morton expressed the opinion that the units on textile machines should be divided into tenths. There was nothing more irritating than the balance of the machine working in 32nds of an ounce. It resulted in friction and was killing business.

Dr. A. J. Turner did not see there was a great deal in favour of the metric system. It was the decimal system which was extremely useful. When he was fitting up the laboratory at Bombay they had the measures graduated in tenths and the makers were pleased to meet his requirements.

Dr. F. T. Peirce said the trouble with scientific people was that they would never agree about anything. To his mind there was no question to answer, for the only satisfactory procedure was to go over to the metric system. To introduce another system was simply to complicate things further. Decimals in money was the only international money system. The £ in tenths would be reasonable because English money was never equivalent to French or any other money. There was reasonable or scientific reason for common terminology—a common basis of description. They should be against tradition and they ought to be united in demanding one common system of description and surely there was no serious alternative to the metric system. In the standardisation

of conditioning measurements, the work had already been done. The only danger would be over organisation.

Mr. H. L. Dilks, speaking from the point of view of the factory, said they always worked in decimals. The wages were worked out in decimals. They ought to accustom everybody to decimalisation so as to be ready for the day when it became international.

Mr. J. Chamberlain said that from a certain yarn they expected to get a certain width of fabric. This could be done provided they had a standardised yarn. Yarns varied so much in twist and material that they failed to get any reasonable standard themselves. They had to take the blame because the fabrics were supposed to be a certain standard, yet these variations originated in the yarns.

Mr. W. E. King referred to the various systems of counting yarns and said that in Bradford they had different setting systems. It was nice to put questions on them in examination papers, but they were irritating for the practical man. There was no common factor and the industry should scrap the old reeds and obtain new ones.

Mr. A. W. Bayes said he thought the period during the making of such changes would be a nightmare. How long was it going to take to effect the change from inches to centimetres ?

Mr. F. P. Slater supported Mr. Bayes. He wondered what would happen in an Association like that to which he was attached with five and a half million spindles. While he would like to see it for his own particular purposes it would cause a great deal of trouble in the industry to prepare the people who were going to use it.

Dr. A. W. Stevenson said it would be very nice to have the metric system, but there were two things to consider—the enormous expense of changing things and the number of estimations to be made by the operatives. It was not mere tradition that held them, it was the enormous loss and chaos occasioned by changing. Of a number of firms who went on to the metric system, all as far as he knew, except those which had Continental connections, had returned to the British system. The change was difficult for the unskilled man in the workshop.

In the short time left, Mr. Lomax, in reply to the points raised in discussion, agreed with Professor Morton that testing instruments graduated in anything but tenths were unwieldy, and mentioned that he had recently had to re-mark one or two such instruments. He wished his paper to be regarded not so much as an advocation of the metric system of measurement, but as a plea for the adoption of any one consistent standard of measurements throughout. He thought that it was advisable to keep in mind this question of standards, as when new yarns came into use, and the standards of measurement had to be adopted, we should thus avoid increasing the confusion. For instance, when spun silk came into use, it was decided to count it by the cotton system, but for some reason or other the fold number adopted was the reverse of the cotton system, and an unnecessary complication was thus introduced, which could have been avoided.

NOTES AND NOTICES

Institute Examinations

No less than twenty-two candidates presented themselves at the Institute's Examination in General Textile Technology held on the 22nd June, at Manchester, London, and Dunfermline. The report of the Board of Examiners cannot come before the Selection Committee until the next meeting—first week in September. The recommendations of the Selection Committee will then go forward for final confirmation and approval by the Council of the Institute, a meeting of which will take place on the third Wednesday in September. The results of the Examination, therefore, cannot be available until after the Council meeting on the 21st September.

Institute Rooms

For many years past, luncheon has been available in the Members' Room at the Institute Headquarters, Manchester, more particularly on Tuesdays and Fridays. Though this facility has proved of considerable convenience, yet the attendance has not expanded in recent years. At the July meeting of the Council, a recommendation of the Finance and General Purposes Committee was approved whereby the serving of luncheon is now discontinued. For the future, the service of the canteen will be limited to the supply of tea or coffee and light refreshment between the hours of 12 noon and 5.30 p.m. on each full working day of the week.

Lancashire Section Meetings

The Committee of the Lancashire Section of the Institute anticipates the provision of an interesting programme of meetings for next Session. As soon as arrangements are completed, announcement will be issued. The Chairman of the Committee, Mr. T. E. Mitchell (Rochdale) is taking a warm interest in the arrangements and it will be found that many aspects of textile have been considered. In addition to meetings at Headquarters, effort is to be made to promote successful gatherings at Preston, Bolton, and Burnley. The opening meeting of the session has been definitely fixed to take place at Manchester on the evening of Friday, 21st October, when Dr. R. H. Pickard, F.R.S., Director of the British Cotton Industry Research Association, will introduce a discussion on "The Usefulness of Laboratory Tests in regard to the Stapling of Raw Cotton."

Textile Institute Diplomas

Elections to Fellowship and Associateship have been completed as follows since the appearance of the previous list (July issue of this *Journal*) :—

FELLOWSHIP

BLACKBURN, George (Liversedge, Yorks.).

ASSOCIATESHIP

CRYER, Norman (Leeds)

SHERET, N. L. R. (Cawnpore, India).

REVIEWS

Floral Art: Decoration and Design. Text by H. D. Richter, with foreword by Frank Brangwyn. Published by F. Lewis (Publishers), Ltd., Benfleet, Essex. (Price, £5 5s.)

When a lady becomes enthusiastic over a bunch of flowers and shows her adoration by enshrining it in an appropriate receptacle within her home she is only expressing the innate human passion for the brightness of colour and the infinity of combination that flowers can give. Flowers are never out of fashion and the heart of man has always been sensitive to their charm. Hence pictures of flowers are a constant attraction and are welcomed as home decoration. They seem to bring the smile of sunshine into a room and perhaps a reminder of the many occasions in life when flowers may have contributed towards a sense of happiness. Here is a book for the flower lover and therefore with a very wide appeal—Floral Art, published by F. Lewis. Ltd., and issued through Batsford. It is a sumptuous folio volume principally made up of some sixty fine large colour prints of floral subjects. Many of the plates could be effectively utilised as framed pictures and would give a note of colour in a suitable scheme of decoration. Some, however, are less suited to this purpose, representing as they do portions of floral arrangements considered rather in relation to repeating pattern than to a panel shape. These are the work of designers of decorative pattern and are less complete without the follow-on effect for which they were devised. For it must be remembered that designers of all times, serving the human need, have used floral form not only in permanent decoration but for the embellishment of all those fleeting materials coming under the influence of fashion. Even when fashion or custom or even religion may have demanded non-natural or geometric decoration, the designer in his search for interesting and varied form has not been able to prevent suggestions of flowers and leaves from peeping through his mesh of abstractions.

The present volume has in view the designer of the present day who may seek refreshing stimulus and inspiration through a vision of the glories of flower form and colour expressed by artists with profound knowledge of the subject. The writer of the text, Davis Richter, R.I., R.O.I., R.B.C., is well known for his fresh and direct floral paintings. Four of his subjects are included in the volume. There are four by Frank Brangwyn, R.A., four by George Sheringham, an example in Egg Tempera by Maxwell Armfield, and an inlaid wood panel by William A. Chase and A. G. Rowley, in which the vase might have been better treated as a flat object in keeping with the rest of the forms. In the remainder of the volume contributions from painters, craftsmen and designers come together on the common ground of flower worship. Artists rarely present an extreme realistic view such as might be regarded as at least doubtful in decoration and particularly in repeating pattern. There are only two or three examples of this doubtful kind. The remainder are presented each with a considered treatment and composition resulting from the knowledge and skill of the individual artist designer. They will form a lasting source of pleasure and a valuable inspirational reference.

R.A.D.

Physik und Chemie der Cellulose. By H. Mark. Published by Julius Springer Berlin, in 1932. (330 pages. Price, 45 RM.)

This book forms Part I of Volume I of the ambitious series, " The Technology of Textile Fibres," to be edited by Dr. R. O. Herzog. A few of the other numbers have already been published and the series as projected will contain about eighteen separate parts. The volume now under review is distinguished rather by theoretical insight than by a balanced and critical presentation of all the available facts. It makes little direct contact with the everyday problems of the textile chemist. In the field of cellulose degradation, for instance, the British work on relatively mild changes, such as occur in technical practice, is largely ignored, whilst a great deal of space is devoted to the ostensibly mere theoretical German work involving violent disruption of the structure. The degradation of cellulose by mineral acids is a case in point. The careful and fundamental work of Birtwell, Clibbens, and Geake on the early stages of acid hydrolysis of cellulose is neglected, whilst Freudenberg's work using sulphuric acid sufficiently concentrated to dissolve cellulose is discussed in full. The importance of fluidity and of copper number in following the earlier stages of acid action is not made clear and

criteria such as percentage of glucose produced are made use of instead. Indeed, a glance at the author index suffices to show that very scanty use is made of the British contributions to our knowledge of cellulose. Urquhart's comprehensive work on moisture absorption is represented only by one graph which is apparently anonymous. Pierce's work on mechanical properties seems to have escaped attention and justice is hardly done to Clibbens and his co-workers in the field of cellulose degradation or to the work of Neale on the action of alkalis and on the properties of "swollen" or "mercerised" cellulose. "Hydrat cellulose" appears to escape with half a page so far as its chemical properties are concerned.

A general criticism of the book arises from its highly theoretical standpoint from a tendency to theorise far in advance of experimental fact—perhaps, compared with our more cautious viewpoint, a national characteristic. Thus at first glance one is pleased to note that Professor Mark has done justice to the essential quantitative nature of his subject by the incorporation of a very large number of graphs. On closer examination it is perhaps a little disturbing to find that a very large proportion of these represent not so much what actually happens as what theoretically ought to happen. They are in fact aptly described as "schematisch." Whilst no doubt this approach is useful if its limitations are borne in mind, it is unfortunate that in some cases no absolutely clear distinction is drawn between the schematic and the actual, so that the reader is left in doubt as to whether a diagram represents experimental fact or theoretical surmise. Even where a representation of fact is apparently intended, a reference to the source of the information is sometimes lacking. In a branch of knowledge so highly controversial as cellulose chemistry, this cannot be regarded as altogether satisfactory. It is even more unfortunate that in a few instances the "schematisch" curve is in opposition to experimental evidence of which no mention is made. Thus on page 214, a curve is given representing the absorption of caustic soda from dilute solution, without a reference to its origin, whereas the recent work of Neale has shown that the actual curve is of quite different shape and the absorption from dilute solutions some four times as great as that indicated in the illustration.

The discussion of the copper number test affords another instance of the neglect of work done in this country. Considerable space is devoted to the "Fehling's solution" copper number test involving the use of caustic alkali, and its various modifications, but there appears to be no mention of the Braidy test using carbonate bicarbonate; no account is given of Clibben's clear demonstration of the great superiority of the latter on the grounds of low blank and much higher sensitivity to cellulose degradation, and of the fact that caustic alkali is really quite inadmissible here because it destroys the reducing power of oxy-celluloses.

The section dealing with mechanical properties is, with the omission already referred to, reasonably adequate. The data are, however, not always presented in the most assimilable form. Thus in adjacent tables for the tensile strengths of various natural and artificial fibres the units employed are breaking length in metres, breaking stress in kilogrammes per square millimetre, breaking load in grams per denier. The breaking extension of cotton fibres is given as 1·4 to 2·0 per cent. Surely this is an injustice to Lancashire's raw material.

The use of X-rays is, as one would expect, discussed in considerable detail. Whilst it would be rash to criticise such an authority as Professor Mark on this aspect of the subject, the textile chemist may perhaps be pardoned if on general grounds he is not quite convinced of the reality of discrete micelles separated by sharp surfaces of discontinuity. Whilst the X-ray evidence apparently necessitates the assumption of certain areas of localities of high orientation and low activity, it would be more in accord with the general behaviour of natural fibres to assume that these areas are separated without sharp discontinuity by regions of similar structure in which the orientation is less perfect and the reactivity higher. Swelling would then take place largely in these areas, but the essential continuity of primary valency chains would be preserved, thus accounting for the high cohesion of greatly swollen cellulose fibres.

Professor Mark's book is a good and reasonably critical introduction to the German work on cellulose, perhaps the best that has yet appeared. It is, therefore, unfortunate that it should be so highly priced as to make it essentially a library book. The binding is, however, such that it ought to survive hard work in this sphere.

S.M.N.

Empire Marketing Board Report, May, 1931—May, 1932. Published by H.M. Stationery Office (1s. net).

The change which has taken place in the buying habits of the British public and the growth of the demand for Empire goods are clearly brought out in the Annual Report of the Empire Marketing Board. For twenty-five Empire products new records in quantities of imports have been established, and for more than half of these the record now surpassed was made in the previous year. There is an upward tendency at work in spite of the diminished buying power of the public. The Report quotes as instances wheat and wheat flour, frozen pork, butter and eggs from Australia, frozen lamb and butter from New Zealand, eggs and sugar and wine (a 50 per cent. increase for wine), grapes and grape fruit from South Africa, bananas from the British Indies and canned pineapples from Malaya. The Report contains the story of the "Buy British" campaign of November and December last, and gives the facts both about the campaign itself and about the response it called forth from all sections of the community. The Report also describes a new side of the Board's work, that of market promotion. The importance of this work was specially emphasised at the Imperial Conference in 1930, and the Board has met with much success in approaching local authorities and other large scale buyers, so that some 1,250 institutions have revised their forms of tender in the interests of the Empire producers. As in previous years the bulk of the Board's income has been devoted to Scientific research. Some 70 out of the 100 pages of the Report describes the immensely varied fields of research which the Board's funds have helped to irrigate. The Imperial Conference of 1930 urged the value of joint programmes of scientific work which should be agreed upon between the various countries, so that effort and expense might be concentrated and economised. Acting upon this suggestion the Board has initiated an interchange of views on what problems of economic importance to the Empire most urgently need the further application of scientific research. The mineral contents of pastures and other aspects of animal husbandry have been the subject of continued investigation in the past year, and the Board is advancing £ for £ with the Pastoral Research Trust in Australia for close study of sheep diseases. Throughout South Africa, New Zealand and Great Britain, as well as throughout Australia, the larva of the greenbottle, or blow-fly, causes enormous damage to sheep. In Australia alone this damage is estimated at £4,000,000 a year. Recent investigations have been concentrated on the digestive methods of the blow-fly larva and its digestive juices have been minutely scrutinised. In spite of the extreme difficulties of this microscopic work, great advances have been made and the relation between maggot and bacteria are more fully understood. T.

The Methods of Statistics. By L. H. C. Tippett. Published by Williams & Norgate, Ltd., London. (222 pp. Price, 15/-).

The science of statistics may be defined as a study of the mathematical methods of analysing observational data. Science, pure and applied, depends on observational data for its existence, and the quality of the methods employed to secure observation is of great importance. In spite of this, it may be said with well supported justification that correct interpretation of data is the hall-mark of the best in scientific investigation, and that progress is largely determined thereby. In applied science generally, and particularly in biological work, the task of drawing significant conclusions from observations varying over a wide range is extremely difficult. The task is often beyond the mathematical equipment of the actual investigator, and the co-operation of the experienced statistician is both desirable and essential.

The reader may be thinking this is far removed from textile technology, unless he happens to be an active textile technologist, in which circumstance he will often have felt the need of reliable information on the methods of statistics and probably of a trained statistician. It is to such that this book will make strong appeal, for it covers in concise form much of the modern methods of statistics. The earlier part of the book is orthodox, following lines similar, though more condensed, to general introductory text-books, but in the latter part the needs of the experimentalist are met by deliberate choice of Fisher's method of treatment as the guiding theme. The book thus has a double purpose: it serves as an introduction to statistics by dealing with frequency distributions and

constants on normal simple lines, and also as a guide to the research worker whose difficulties lie not only in the great variation of the properties of even the purest materials with which he has to deal, but also in the size of the representative samples available. By giving mathematical proofs only when simple and merely stating results when difficult, the author has simplified the task for investigators of scanty mathematical knowledge who wish to apply sound methods of analysis to their observations and to draw reliable conclusions from them. While it may be dangerous to use tools without completely grasping the theory of their action, expediency often demands such a course. An industrial research worker is compelled to handle tools in this manner simply because he is so often called upon to adapt himself to the varied needs of commerce.

By means of this book, Mr. Tippett supplies a useful tool to the investigator and, from what has been said before about variable materials, particularly to the textile technologist. Though it is almost humanly impossible to make a treatise on statistics easily readable, the author has gone a long way towards this desirable end, and at the same time he has been able to collect between its covers an extensive survey of his subject. We heartily commend the book, both to students and research workers in technology, and we welcome its appearance on our own shelves. F.P.S.

Worsted Combing and Spinning. By John R. Hind, A.T.I. Published by Sir Isaac Pitman & Sons, Ltd. (Price, 7s. 6d.)

This work describes the whole of the processes involved in worsted carding and combing in a practical manner for practical people. Although there is an extensive literature on these subjects the author may justly claim that the book will " fill a gap " in textile literature, particularly as it includes a very useful chapter on the rectilinear comb. The descriptions of the machines and processing routine are well balanced and a pleasing feature is that the matter is presented in sections or chapters, each section dealing with some mechanical or material point involved in the preparation of long and short wools for worsted drawing purposes. It is stated that " the chapters are arranged to cover the syllabus for worsted carding and combing issued by the City and Guilds of London Institute." While not complete in this respect the work will be useful to students preparing for such examinations and provide teachers of the subjects with another helpful text-book. The many good diagrams with which the work is presented might have been made additionally useful had the dimensions of the non-variable factors been included in those referring to the calculations, and an additional chapter given to indicate the principle on which the dimensions have been classified into numerators and denominators. A complaint may be made that the work is too definite and assertive—concerned with expounding the common, though by no means perfect system of working—and one looks in vain for an explanation of " the basic principles which underlie the processes." Some blemishes occur in the book. Amongst these may be mentioned the mistake with regard to the pinning of the large and small circles on page 118, and the contradictory statements respecting the placing of new leathers on Noble comb rollers, on pages 131 and 194. Also, many fine wool combers will disagree with the author's opinion as to the use of condensed steam for backwashing purposes. The book is exceedingly well printed and bound and is in handy form and will repay study by students, those engaged in the industry and all interested in wool manufacture. J.D.

Annual Directory of Trade Marks and Trade Names, 1932. Published in Association with " Style for Men," by the National Trade Press, Ltd., London.

This Directory, which should be most useful, covers Trade Marks and Trade Names in connection with such commodities as Gloves, Pyjamas, Sewing Silks, Sports wear, Mending wools and the thousand and one fabrics and made-up goods available for Men's wear. It contains an article on " What is a Trade Mark ? and on the registration and protection thereof." It is well-produced and printed. A copy may be consulted in the library of the Institute. T.

Scheikundige Grondslagen van het Bleeken, Verven en Drukken van Textielstoffen. By Dr. H. B. Holsboer and R. de Lange (of the Higher Textile School, Enschede, Holland). Published by the Authors. (317 pages. Price, 11.50 fcs.)

The authors have succeeded in producing an excellent text-book for students on the chemical principles underlying the operations of bleaching, dyeing and printing. The information is up-to-date, stated concisely, and set out in a clear and orderly fashion. The ground covered may be judged from the following list of contents. *Chapter* 1. The nature and composition of cotton, rayons, flax, wool, and silk and their behaviour towards chemical agents. *Chapter* 2. Wetting agents. *Chapter* 3. Water and its treatment for boilers, bleaching, and dyeing. *Chapter* 4. The "*p*.H" concept and the measurement of *p*.H. *Chapter* 5. Bleaching of cotton, including desizing, kier boiling with lime and with caustic soda, white and coloured goods, bleaching, and faults. *Chapters* 6, 7, 8, 9. Bleaching of rayon, linen, wool, and silk, respectively. *Chapter* 10. Dyeing, including theories and the application to various fibres of direct, acid, basic, mordant, sulphur, vat, ice oxidation, natural, and mineral colours, concluding with the special methods for cellulose acetate rayon. *Chapter* 11. The German recommendations for fastness tests and standards. *Chapter* 12. Printing in direct, mordant. discharge and reserve styles.

The book does not give descriptions of machinery but keeps strictly to its title. We should like to have seen a chapter on mercerisation and finishing processes that may be regarded as "chemical," such as parchmentising and similar treatments with acids. The printing is good and the volume is handy. It is essentially a student's text-book and any who would wish for some practise in Dutch would find it very suitable. W.

Das Bleichen der Pflanzenfasern. By Dr. W. Kind. Third revised edition. Julius Springer, Berlin. (339 pages. Price, 24 M.)

The second edition of this book appeared in 1922, and in the intervening ten years so much research work has been published that the author considered a new and revised edition to be called for. He has carried out the revision with Teutonic thoroughness and produced an excellent manual of bleaching from the chemical point of view. The book follows the orthodox plan. The first section gives a detailed account of the chemical substances used in bleaching. In the next section the action of these chemicals in bleaching is discussed. Then follows an exposition of the various methods of bleaching—the chlorine bleach, grass and ozone bleach, oxygen bleach and permanganate bleach. Finally there is an account of large scale methods employed in bleaching, but the fact that only twenty-five pages in all are devoted to the bleaching of linen, jute, hemp, ramie and paper suggests that the title of the book needs revision. The section on materials used in the bleaching industry is very comprehensive. The chapter on soaps for instance gives a long list of proprietary "wetting out agents" with their chemical composition, unfortunately nothing is said about their respective properties. There is also more information about hydrogen peroxide and other peroxides than is usually found in text-books on bleaching, which is probably an indication of the attention that the oxygen bleach is receiving nowadays. In the discussion of the theories of the chlorine bleach ample space is given to the recent researches on the subject. The accounts of large scale processes, although clear, are too meagre to be of much assistance to the practical man. The statement on page 214, that a lime boil is no longer used, will come as a surprise to English readers, as bleachers in this country believe the lime boil to be absolutely necessary for some finishes. A list of patents pertaining to bowking is an informative chapter. An excellent account of faults which may occur in bleaching and a final chapter on the examination of bleached goods make the book a useful addition to the textile chemists' library. R.G.

Liesegang Rings and other Periodic Structures. By E. S. Hedges, D.Sc. Published by Chapman & Hall, London. (122 pages. Price, 10s. 6d. net.)

Dr. Hedges has performed a very valuable service in writing the book under review, for although it is now thirty-five years since Liesegang described the phenomena which bear his name, and there has been considerable amount of research on the subject since, Liesegang's rings are still apt to be regarded as a chemical curiosity. Nevertheless, the forces which produce Liesegang's rings are the same forces which come into play in the chemical treatment of textiles and

the attempt (page 93) to correlate a natural periodic structure such as crimp in wool, would indicate that the subject is worth the attention of textile scientists. The book is an eminently readable and clear account of the work which has been done on the subject up to date, with an impartial discussion of the theories which have been evolved. The excellent bibliography at the end will be appreciated by anyone wishing to carry out any research on the subject. R.G.

Kingston's Sterling Fluctuation Tables. Issued by Kingston's Translations Institute, Leadenhall Street, London. (Post free, 1s. 1d.)

These tables have been re-issued and give Sterling figures as measured in currencies on a Gold Standard. They give percentage depreciations of ¼ per cent. to 40 per cent. over intervals of ¼ per cent., together with corresponding rates of exchange for Dollars, and French, German, Swiss, Italian, Belgian, Dutch, and Czech currencies. T.

Wool Survey: A Summary of Production and Trade in the Empire and Foreign Countries. Compiled by the Empire Marketing Board. Printed and Published by H.M. Stationery Office. (221 pages. 2s. net.)

Nearly one-half of the world's raw wool, and over two-thirds of the wool entering world trade, is produced within the British Empire. The world's sheep population is estimated at nearly 800 million head, of which about one-third are in the Empire. They produce between 3,500 and 4,000 million lb. of wool per annum and of this amount about 1,500 million lb., including much of the best wool in the world, comes from the British Dominions of Australia, the Union of South Africa and New Zealand. Among the other important producing areas, consisting of South America, the United States of America and Russia only South America has a surplus for export. The United States of America is largely self-sufficing as regards merino and crossbred wools, but imports carpet wools; Russia produces almost entirely carpet wools, and imports both the finer wools and wools of the carpet type. Neither of these countries seems likely to assume any importance in the near future as an exporter of raw wool. After reviewing the development of the sheep population, the wool production and the wool trade of each of the principal countries concerned, together with the course of raw wool prices over the past 40 years, the Survey reaches the following conclusions.

There has been no exceptional increase in the sheep population or the Wool production of the world in recent years; indeed, between 1928 and 1930, there appears to have been a small decrease in wool production, and although the year 1931, according to the partial estimates at present available, probably witnessed an increase in production over 1930, it is not anticipated that the record level of 1928 will be appreciably exceeded. British Empire countries have maintained their share of the world's sheep population at about one-third, and their share of the world's production of raw wool at about one-half. In the export trade, in which the share of Empire countries is over two-thirds of the world total, there has been, on the whole, little variation since 1926 in the consignment of raw wool from producing to manufacturing countries, and there would appear to be no abnormally large accumulation of stocks of raw wool in the principal exporting countries. At the end of the 1930-1931 season, when stocks in certain of the principal producing areas were higher than usual, they still formed only a very small part of the aggregate annual production. No large stocks have been allowed to accumulate through efforts to maintain prices and proposals to restrict the sales or stabilise the prices of raw wool have been vigorously opposed. T.

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PROCEEDINGS

CARPETS: THEIR ORIGIN, HISTORY, AND VARIETIES*

By Professor F. BRADBURY (Fellow)

THE MANUFACTURE OF CARPETS

The Manufacture of Carpets is reasonably included among the first of the Industrial Arts because they were as much a necessity as a luxury. Incidentally their origin is linked with the advent of the violin and hieroglyphics. Antiquarian experts in each of these three Industrial Arts have ventured to locate the period of their advent as approximately 5,000 B.C. Sir George Birdwood traces, in the Vienna Carpet Book, the links of evidence from Adam, the Pharaohs of Egypt, the kings of Chaldea and Assyria to Cyrus the founder of the Persian Empire. In an ancient Jewish legend it is written that Naameh, the sister of Tubal Cain, invented wool spinning and cloth weaving. " From the beginning of things and through the rise and fall of the great nations of the earth, the carpet industry has emerged triumphant." " A judge of common law," said Edgar Allen Poe, " may be an ordinary man, but a judge of carpets must be a genius."

The word " Carpet " is derived from the Latin " carpere," which literally means to pluck. Originally, and always in Persia, the carpet was designed to sit upon, to eat and to sleep. Treading on the carpet in ordinary footwear was prohibited. The carpet was kept spotlessly clean and sacred. In "Samuel Pepys' Diary," 1660, we read that it was customary to use carpets as table cloths and also for billiard table coverings. All genuine antique carpets of whatever origin should be preserved as examples of the skill of workers of the past. In accordance with this thought I have selected for description two outstanding classic Persian carpets, viz., (1) The Ardebil, and (2) The Shah Abbas Carpet.

The Ardebil Carpet (Fig. 1)

In the year 1502 A.D., Ismail I, Shah of Persia, decided to have a " holy " carpet specially woven for the mosque at Ardebil. The production of the carpet was entrusted to Maksoud of Kashan. The size of the carpet was $34\frac{1}{2} \times 17\frac{1}{2}$ feet. It contained 380 knotted tufts per square inch, equivalent to a grand total of 33,307,200 hand-tied knots. The period occupied by Maksoud in weaving this carpet was approximately 35 years. When complete it was placed in the Mosque at Ardebil and for many years screened the tombs of the Saint Sheik Sefi, and Shah Ismail I, the founder of the Sophi dynasty. The colouring, design and texture of the carpet are considered to be almost perfect. The design suggests that it was evolved as the work proceeded. The whole design, however, is held together; "there is no dominant ground," the Oriental artists abhor a " ground." The Ardebil carpet was, in 1893, purchased for the nation for the sum of £2,500. It is now housed in the Victoria and Albert Museum.

The Shah Abbas Carpet—"Device" (Fig. 2)

Shah Abbas of Persia was born in 1557. He began to reign in 1587 and died 1628 A.D. He is reputed to have done more for carpet manufacture in Persia

*Abstract of a lecture delivered to the London Section of the Institute, 17th March, 1932.

than any other monarch before or since his reign. He was the creator of the magnificent city of Isphahan, and during his reign Persia became the most flourishing Empire in the world.

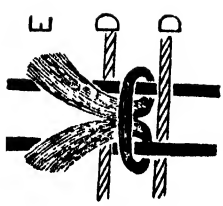

FIG. 3. Oriental and Hand-tufted Carpets.

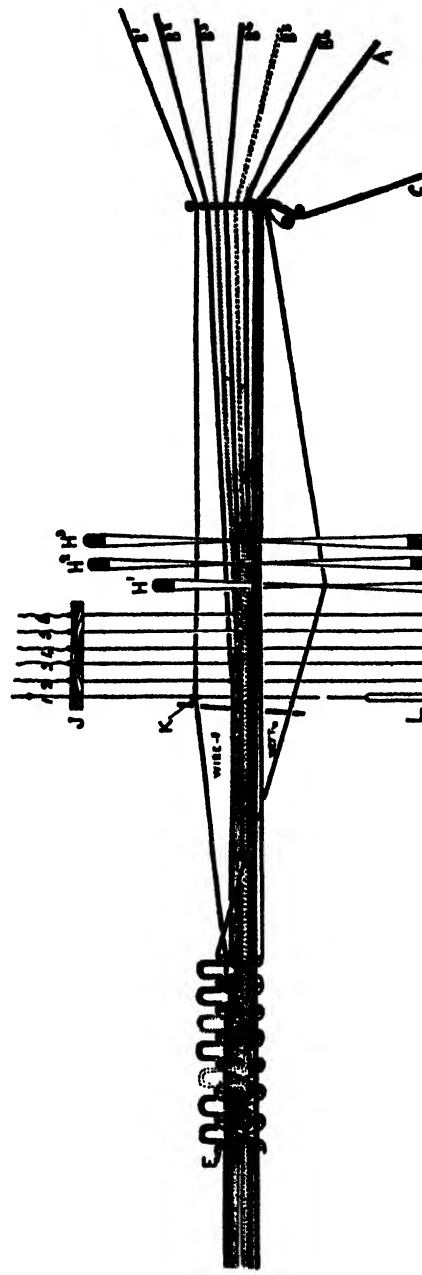

FIG. 4. Brussels Carpets.

The Shah Abbas' Device is a reproduction of a medallion woven upon the *background* of a beautiful example of a 16th century Persian carpet. The design of both field and border is immensely rich and varied. The device is set slightly out of centre and does not " turn over " both ways. The carpet is one of the

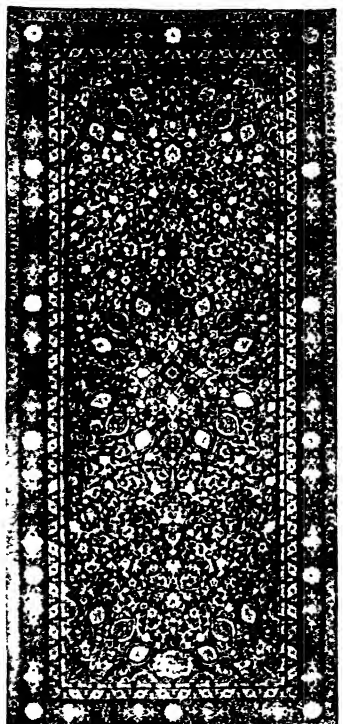

FIG. 1.—The Ardebil Carpet

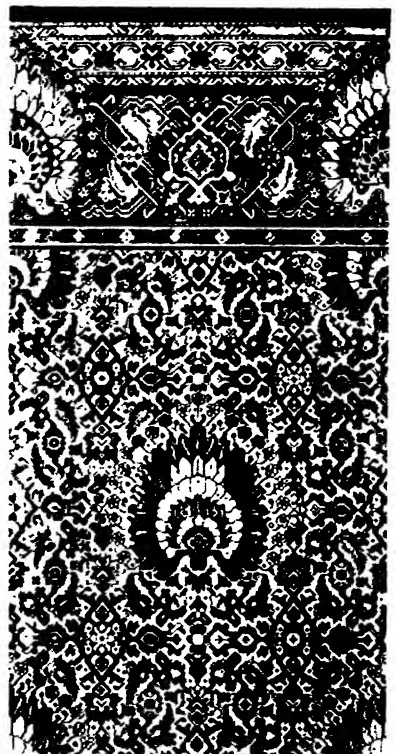

FIG. 2.—The Shah Abbas "Device"

examples of the golden period of Shah Abbas' reign. It is classed as one of the wonders of the world.

Modern Carpets : Design and Colour

Modern carpets belong to a class of woven fabrics in which many distinctive qualities of decorative art may be displayed. The structure of a carpet is not so complicated, by any means, as to forbid any person of average ability, from thoroughly and readily comprehending it.

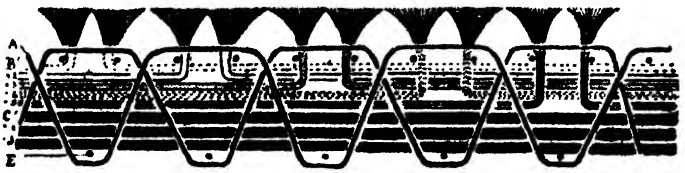

FIG. 5. Wilton Carpets.

The merchant, factor, or dealer practically dictates what must be made, and the dealer in his turn is governed somewhat by the tastes and inclinations of his customers and therefore orders only the class of goods which experience teaches him will "sell." Nevertheless, in each succeeding season, better designs and schemes of colouring are submitted to the purchasing public.

Further, many of the choicest designs for high-grade carpets of a past season are frequently reproduced in a lower grade of carpet, e.g., the design of a valuable Axminster is sometimes reproduced in a simple Tapestry carpet. Unfortunately

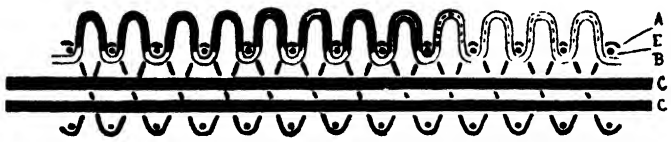

FIG. 6. Tapestry Carpets.

customers are often reluctant to pay a relatively higher price for better designs, when the material, quality and structure are correspondingly the same. It is here perhaps where the Oriental carpets possess an advantage over their machine-made competitors. The Oriental rule is reproduction ; the designs are of slow growth. They pass from weaver to weaver receiving various modifications in the process of reproduction, and the best, being most prized, have survived to the present day. In this sense each pattern is a survival of the fittest ; many of them are examples of what a perfect carpet should be in respect of material, structure, design and colour.

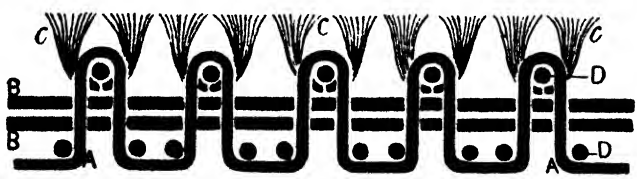

FIG. 7. Royal Axminster Carpets.

The decorative ornament of all carpets, irrespective of material or structure, is divisible into three chief classes :—

First, the Geometrical, which is evolutionary and mechanical.

Second, the Conventional treatment of natural forms—vegetable, and animal.

Third, the Oriental and past-master productions.

Variety and Structure of Carpets

Woven carpets are divisible into two chief classes : Pile and non-pile fabrics.

The pile class is further divisible into loop and cut or velvet piles.

The non-pile class is also divisible into two types of woven fabrics :—(*a*) a compound of two or more fabrics, reversible in whole or part at will, (*b*) an alternative plan for this group of ornamentation embodies the use of two or more coloured wefts supplemented by the colour of the ground warp.

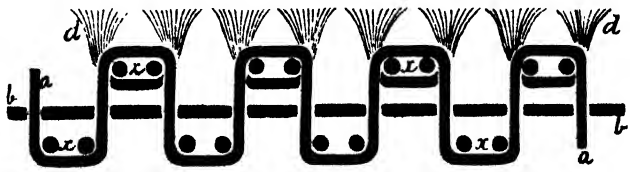

FIG. 8. Royal Axminster Carpets.

Oriental and Hand-made Carpets. Eastern and like carpets are hand woven. The foundation structure may be separately woven without any fur, a sufficient space being left between the threads for the separate and subsequent interlacing of the pile. Alternatively the foundation structure and pile ornamentation may be produced simultaneously (Fig. 3).

Machine-made Carpets are divisible into three classes :—

(1) Those in which the ornament is produced with the aid of a Jacquard machine. Brussels, Wilton and Ingrain carpets belong to this class.

(2) Figured pile carpets which are woven without the aid of a Jacquard machine. Chenille, Royal Axminster and Moquette carpets are in this class.

(3) Tapestry carpets, in which the ornament is printed either directly upon the woven pile or previously in an elongated form upon the pile yarn.

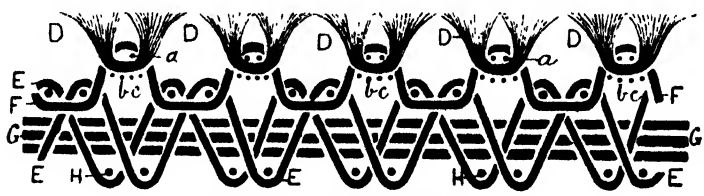

FIG. 9. " Chenille " Carpets.

Brussels Carpet. Wilton in Wiltshire claims the distinction of having first made these carpets in England. The Brussels loom and the first weaver are both importations from Belgium. The Brussels carpet is a loop pile fabric. The best contains 90 or 100 points per square inch. (Fig. 4.)

Wilton Carpet. Wilton carpet is a velvet pile structure. It is woven on the Brussels loom. The method of binding the pile differs somewhat from the Brussels principle. (Fig. 5.)

Tapestry Carpets are essentially pile carpets and are classified as such. Compared with its contemporaries it is simple in construction, economical in weaving and in the quantity of the figuring material used, owing to the fact that there is only one pile figuring thread as compared with five or six in Brussels and Wilton carpets. (Fig. 6.)

FIG. 10. Ingrain or Scotch Carpets.

Royal Axminster Carpets—" Moquette." These belong to the richest and costliest of machine woven carpets. There are several methods of binding the tufts into the fabrics. (Figs. 7 and 8.)

Chenille or Patent Axminster Carpets. These are the product of two separate and distinct weaving processes—(1) Chenille weaving, and (2) Weaving the carpet. The pile or fur is first woven separately and in colours according to pattern ; next it is cut into narrow strips and then woven into the carpet proper, somewhat after the manner of inserting weft in the ordinary way. (Fig. 9.)

Kidderminster, Scotch and Ingrain Carpets are synonymous structures. (Fig. 10.)

Roman Carpets are based upon a principle common in Tapestry weaving.

NOTES AND NOTICES

Obituary Notices

In the current year, the Institute's loss of Members by death has been severe. In the latter part of July, the demise of Mr. Frank Arrowsmith, of the Eccles Spinning & Manufacturing Co., Ltd., Patricroft, near Manchester, had to be recorded, and the Council, at the first opportunity, expressed its deep sense of regret. For many years, Mr. Arrowsmith had been a consistently warm supporter of the Institute and its movements, and for one or two years he served as Chairman of the Lancashire Section Committee. During August, the Institute received intimation of the death of a member occupying an important position on the Continent—Mr. Frank Moc, of Nachod, Czecho-Slavakia. Mr. Moc was a frequent visitor to our own country and enjoyed a wide circle of friends in Manchester and district. Mr. Moc had quite a distinguished career as a textile mill manager and became Managing-Director of the firm of Joseph Barton and Sons, at Nachod, at the early age of twenty-four years, continuing in this capacity up to the time of his death at the age of fifty-two years. Mr. Moc was awarded the Fellowship of the Textile Institute in 1929. He had served as a delegate to International Cotton Federation Conferences since 1905 and in 1927 attended the Crompton Centenary Celebrations at Bolton. A further loss to membership was recorded in the latter part of August by the death of Mr. Reginald H. Wilmot, M.Sc., who had held the position of Chief Lecturer in Electrical Engineering at the Leicester College of Technology since 1929. Mr. Wilmot was only 28 years of age at the time of his demise. For three years prior to appointment at Leicester, he was engaged as Chief Assistant Textile Engineer for Messrs. Metropolitan Vickers, Ltd., at Trafford Park, Manchester, his work comprising planning of electrification schemes for textile mills both in this country and abroad. He was a valued and fairly frequent contributor to the Transactions Section of the Journal of this Institute and in 1928 figured as the author of " Theoretical Expressions for the Power Required to Drive Plain Cotton Looms," and " The Individual Electrical Drive of Plain Cotton Looms." In October issue of 1929, he contributed a communication on " The Electrical Drive of Weaving Sheds Equipped with Plain Cotton Looms." From Castlemaine, Victoria, Australia, intimation has been received of the death, on 26th July, of Mr. Ellis F. Wyrill, A.T.I., at the age of 48 years. Prior to emigration, about seven years ago, Mr. Wyrill held the position of Lecturer in Cloth Structure and Pattern Analysis at the Bradford Technical College. In Australia, Mr. Wyrill was engaged as assistant manager and designer for the Castlemaine Woollen Company, Ltd., and he was a successful applicant for the Institute's Associateship in the early part of 1930.

Institute Employment Register

The Institute's Employment Register is available for the use of unemployed Members seeking engagement and to employers generally who may desire to secure applications for vacancies. The following announcement refers to a recent registration as to offer of services :—

No. 82—Twenty-four years of age ; good education (six scholarships) ; 9 years practical experience of spinning and preparatory processes ; held official position in cotton mill ; excellent testimonials. Accept any position of trust.

Exhibition at Leicester

In connection with the Exhibition of Textile Machinery, Accessories, Yarns, and Fabrics, which is to be held at Leicester in October (7th to 15th), there is to be a special visit of members of the Midlands Section of the Textile Institute, on Thursday, 13th October. The arrangements include luncheon and the delivery of a paper in the afternoon on " Winding for The Hosiery Trade," by Mr. T. A. Purt, of Leicester, one of the representatives of the Universal Winding Company. In due course, invitations will be issued to Members of Institute in the Midlands area. We are authorised to state that Members of the Institute in districts other than the Midlands would be accommodated as far as possible and receive invitations for the special visit if they communicated request to the General Secretary of the Institute. In this connection, it is announced that all persons holding invitation cards will be able to travel any distance by rail at a charge of a single fare and third for the double journey. Vouchers for securing the cheap travel facilities will be issued along with invitation cards.

" Communications "

In the July issue (page P190) a communication was published from C. O. Clark relating to an article in a previous issue : " An Observation on the Comparative Resistance of Dry and Oiled Wools to attack by Dermestidae," by H. Hartley. In a letter to the Editor the author regrets that being now in South Africa he has not access to his records, but that from observations extending over nearly five years in Egypt it is perfectly safe to store wool yarns in oil even when no other source of food is available. He also says that he had arranged for a further series of experiments, with graduated percentages of oil, to be carried out in the laboratories of the Royal Entomological Society of Egypt. The publication of an account of these experiments will be awaited with interest.

REVIEWS

Les Soies Artificielles. By H. de Leeuw. Published by Librairie Polytechnique Ch. Beranger, Paris. (445 pp. Price 120 frcs.)

The first chapter gives a concise but fairly comprehensive history of artificial silk up to modern times. The constitution of cellulose and its derivatives is dealt with and the recent work with X-rays is described, several X-ray photographs being given. The third chapter deals with cellulose and its preparation for the manufacture of artificial silk from wood pulp and from linters.

Chapter IV deals with apparatus used in connection with the manufacture of artificial silk, spinning pumps, and means for testing the same, candle filters, jets, dry spinning machinery with solvent recovery apparatus, wet spinning machinery by bobbin and centrifuge methods, pots and motors for driving the same with notes on power consumption at various speeds. A comparison of costs between bobbin and centrifuge is given. Machinery for twisting and reeling and for washing and bleaching artificial silk is described also stretch spinning machinery for cuprammonium silk. The various methods and machines used in drying artificial silk are given together with useful calculations of efficiency. Delustring and testing of artificial silk are dealt with. Refrigerating machinery, compressors, and vacuum pumps suitable for artificial silk manufacture are described. The purification of water by the lime and soda process

and the Permutit process forms the subject of Chapter V and the removal of noxious fumes and purification of air are dealt with in Chapter VI.

A complete description of the manufacture of viscose silk is given in the 80 pages of Chapter VII. The formula of Mortgat for spinning is given on page 288, which formula seems to bear no relation to the important work of Bronnert in deducing his well-known square root law. Notes on the Lilienfeld process are given on page 294.

Eleven pages are devoted to the cuprammonium process; 15 pages to the nitrocellulose process; and 10 to the acetate process. Various methods of analysis of viscose, spinning baths, physical properties of artificial silk, etc., are given in Chapter XI, whilst Chapter XII deals with the dyeing of artificial silk. The last chapter deals with economic and statistical information.

The book forms a useful addition to the literature on artificial silk, particularly of the viscose type and while it necessarily covers old ground it contains some information not available in other books on the subject. W. H.

"Bleaching, Dyeing, Printing and Finishing for the Manchester Trade." By J. W. McMyn and J. W. Bardsley. Published by Sir Isaac Pitman and Son. (2nd Edition. 224 pages. Price 6/- Net.)

This is the second edition of a book published in 1928. In a review which appeared in these columns the present writer congratulated the authors and publishers on their success in producing a handbook, at a low price, describing for those with little technical training the principal industrial processes in the bleaching, dyeing, printing and finishing of cotton fabrics. The appearance of a second edition may be regarded as evidence that the book has served the purpose for which it was intended. Very little modification of the first edition appears in the new volume. In the words of the Preface, " Few corrections and additions have been made, and the chapter on the Vat Dyes extended." The present reviewer regrets that the authors did not take the opportunity of amending some of the doubtful statements, to which attention was drawn in the original review. In the writer's experience, the book has been useful to students, and the recommendation contained in the original review is here repeated. F.S.

GENERAL ITEMS AND REPORTS

Lancashire Education Committee

PRIZES FOR WOVEN FABRICS COMPETITION (1932)

In accordance with the recommendations of a committee of the Textile Institute appointed to adjudicate in regard to the above competitions for the current year, awards are announced as follow :—

COLLECTION OF WOVEN FABRICS: Gold Medal and £10—Stanley Potts, Radcliffe Technical School; Silver Medal and £10—James H. Wilson (Briercliffe), Burnley Municipal College; Prizes of £10 each—John M. Dunderdale, Nelson Technical School, and Robert O. Eccles, Clitheroe Technical School. Prizes of £5 each—Harry Davis, Nelson Technical School; John Anderton and Norman Pearson, Chorley Technical School; Fred Lonsdale (Little Lever), Radcliffe Technical School.

SPECIAL WOVEN FABRIC: First Price (£5)—James H. Wilson (as above); Second Prize (£3)—Harvey Adams, Burnley Municipal College; Third Prize (£2)—Harold Rothwell, Church and Oswaldtwistle Technical School.

The Adjudicating Committee's report states :—The quality of the specimens submitted, both as to design and structure, represents appreciable advance over similar productions of only a few years ago. The improvement is especially marked in relation to the general level of merit when the albums are considered as a whole. Many effective patterns have been produced by discriminating use of fancy yarns. It is obvious that appearance of coloured stripes might have been improved in several instances if the student had had the advantage of availability of striped warps and not been compelled to produce these weft way.

There is evidence that some of the students have devoted a considerable amount of their spare time—due to industrial depression—in the utilisation of facilities placed at their disposal by weaving schools. Acceptance of facilities of this description should be encouraged in these days so that young men might prepare for more advanced work when trade revives.

In the matter of costing and calculations, the work of this year's competitors reveals a decided improvement, and a much greater measure of accuracy is established.

The response to the offer of prizes in the Special Woven Fabric Competition has been satisfactory. Particular attention appears to have been directed to the production of furnishing fabrics, and, in the case of a fabric for upholstery purposes, the competitor has evidently appreciated the need of a closely-woven material to meet the claim of dust-proof or down-proof quality.

It is clear that both students and schools are more keenly appreciating the finer requirements of modern fabrics both in production and in characteristics which appeal to the user. The Committee consider that the development of the production of new lines in Lancashire cannot but be favourably influenced by the existence of a large number of students brought into contact with production of finer and more artistic fabrics by means of these competitions.

Improvements to the Handloom

Reprints* of five articles appearing in the *All-India Trade Magazine* (March-July, 1932), by U. Sridhar Rao, proprietor of the Shivaram Weaving Factory, Ullal, India, have been fowarded to the Institute library with a letter in which the author claims that his inventions are not only definite improvements to the handloom but also, to some extent, worth consideration in application to the power loom. These devices are :—

(1) Two-shuttle Drop-box Sley	Indian Patents 16,673 of 15/10/30 and 17,568 of 1/5/31.
(2) Tappet Dobby	Indian Patent 17,757 of 8/7/31.
(3) Solid Border Sley	Indian Patent 18,542 of 1/12/31.
(4) Multiple Drop-box Sley	Indian Patent 18,541 of 1/12/31.

For these appliances the inventor makes claims in brief as follow :—

Two-shuttle Drop-box Arrangement. In India, in spite of the efforts of the various Provincial Industries Departments, it has so far not been possible to evolve a Two-shuttle Drop-Box Arrangement, worked by shedding treadles alone. Usually, the Box apparatus is controlled by a lever pressed by the hand by the weaver to change the boxes. In the new arrangement, shedding treadles enable the box apparatus to move either up or down. The weight of the box apparatus is reduced to nil by a counter-balancing weight on the side or back lever.

Tappet Dobby. These dobbies are, in fact, big tappets made up of from 32 to 80 sections, each section standing for two picks of weft. There are two different kinds of pegs incorporated ; one a raising peg and the other to keep the jack lever in the raised position for the next two picks. When the jack lever is down, the corresponding hole in the lattice is left empty and the lever falls by its own weight, and hence the function of the pegs in this arrangement is quite different from that of the pegs in the powerloom dobby. The object of this dobby is to put extra warp figures in the borders when the cloth to be woven is plain. The alternative to this device in India, is the old draw-boy system, which is used where the pattern requires 10 to 32 healds or levers and 48 to 300 picks.

Solid Border Sley. This is a contrivance by which the body weft weaves with the body only and the border weft with the two borders only, so that three shuttles are required. It has been found impossible to manufacture this type of cloth in power looms. The inventor is of opinion that this device may give some clue to the evolution of a power-loom device for a similar object.

Multiple Drop-box Sley. It has been found possible to work pick and pick cloth by this contrivance without much difficulty with 9, 11 or 13 shuttles.

* These can be borrowed from the Institute Library in accordance with the Library Committee's rules—EDITOR.

Imperial Economic Committee: A Survey of its Work

The project of an Imperial Economic Committee dates from the Imperial Economic Conference of 1923. The Committee, appointed by the Governments of the United Kingdom, the Dominions, India, the Colonies, and the Protectorates, was brought into being in March, 1925. Its terms of reference, at first restricted, were as follows:—" To consider the possibility of improving the methods of preparing for market, and marketing within the United Kingdom, the food products of the overseas parts of the Empire with a view to increasing the consumption of such products in the United Kingdom in preference to imports from foreign countries, and to promote the interests both of producers and consumers." At each succeeding Imperial Conference—in 1926 and again in 1930—the functions of the Committee were extended.

The development of these terms of reference was significant. There was first a suggestion to appoint an Imperial Economic Committee with wide general terms. This did not materialise. A little over a year later the Committee was formed, but its work was restricted to enquiries into the marketing of Empire food products in the United Kingdom. At the succeeding Conference (1926) the scope of the Committee's work was extended to include not only industrial raw materials of the Empire, in addition to foodstuffs, but also surveys of Empire industries and trades. The next Conference (1930) specified the mineral resources of the Empire as a survey which might be usefully undertaken. In addition, it entrusted to the Committee an entirely new class of enquiry raising new issues fundamental to Empire trade, namely, an investigation of the best lines of approach, first towards what is now generally known as Imperial Industrial co-operation, secondly towards a common recognition throughout the Empire of the principles underlying the definition of Empire content in merchandise traded between the Member States of the Commonwealth. It instructed the Committee to continue any investigation arising out of recommendations made by the General Economic Committee of that Conference. Finally, it brought within the terms of reference of the Committee any economic question which the Governments concerned might agree to refer to it. Such a course of events being eloquent of over-caution in undertaking a project designed to benefit Empire populations or of lack of appreciation that such wide powers must ultimately be accorded to the Committee.

Textile interest in the whole work of this Committee, even in that period which its investigations were restricted to food products, should be awakened when it is stated that in 1924, 60 per cent. of the Meat consumed in the United Kingdom was imported and of that 60 per cent., one-third only came from Empire sources. As such imports have to be paid for by exports, any exporting industry must perforce study the reports of this Committee in its own interests. The First Report says, " The study of trade in any small community shows how frequently buyers give their custom to those who in turn buy from them. We think that within the Empire there is a very complete basis for discrimination of a similar kind."

Neither the functions nor the position of the Imperial Economic Committee will have been made clear without reference to its relationship to the Empire Marketing Board. During the Conference of 1923, His Majesty's Government in the United Kingdom had intimated that they intended to submit to Parliament certain proposals for Imperial Preference which would entail new duties on a few specified food products. The course of political events immediately afterwards made it no longer practicable to give effect to these proposals. It was, therefore, decided to propose to Parliament that " the full money equivalent of the advantages which would have been conferred on the Empire in respect of all those duties which are not retained should be devoted to a scheme for developing the trade of the Empire and in the first case developing schemes of marketing." For this purpose the Government proposed to allocate a round £1,000,000 a year. The Imperial Economic Committee in its first report recommended that this sum of money should be administered by an Executive Commission, owing direct responsibility to the British Parliament, which should carry out those recommendations of the Committee applying specially to the United Kingdom. It further expressed the hope that means would be devised such that the views of Overseas Governments of the Empire might, as occasion arose,

be brought to bear in an advisory way on the problems involved. The Home Government, May, 1926, established the Empire Marketing Board, an official, non-political body, presided over by the Secretary of State for Dominion affairs, to administer the fund in question. On the Board, no part of the Empire was left unrepresented. The two bodies—the Imperial Economic Committee and the Empire Marketing Board—are distinct and differ functionally and constitutionally. None the less they are, in fact, closely related partly because they have certain members in common and partly because the Empire Marketing Board is charged with the endeavour to give effect within the terms of its Vote to many of the recommendations of the Imperial Economic Committee.

To whatever extent one might commend the policy of Voluntary Preference, recommended by the Committee and described in its eighth Report, some misgivings will perhaps naturally arise in an industrial area on reading that " by action and reaction the Home Country and the Empire overseas would build up one another. This process, moreover, would continue when, *as was inevitable*, industry and not merely primary production took root in the Empire overseas." Even though the Committee aver that " it would be a long time before the more complicated industries—could be effectively established in the newer—countries, and that the growth of the simpler industries in them would only increase the demand for the products of the higher industries of the United Kingdom," these misgivings must surely persist except among those whose natural lethargy or short-sightedness leads them to contemplate with equanimity the rapid industrialisation not only of the Empire but of the world. One is tempted to consider whether such development will result in the United States using all its own Cotton and Australia and New Zealand manufacturing all their own wool. But perhaps the spinners, weavers, and dyers of Lancashire and Yorkshire will be then engaged in " the more complicated industries " such as the manufacture of wireless installations and of electric-hares. It is hoped that this general survey will serve to indicate the vital importance of these reports; though such a mass of material cannot well be pictured in brief. These reports as a series or by themselves repay close study. T.

Two Studies in the Psychological Effects of Noise*

The publication of this Report recalls the interest taken in the subject of noise—more particularly that in Weaving Sheds—by the Research and Inventions Committee of the Institute in 1919-20. The Committee published its report in November, 1920 (this *Journal*, Vol. XI, p. 312) and a summary of its conclusions may be of interest in conjunction with a review of the Industrial Health Research Board's latest report.

The Institute Committee appears to have commenced its investigations with the premise that noise has a detrimental effect upon the workers in a weaving shed from the point of view of their efficiency and resistance to fatigue. In addition it was reported to the Committee that " there was a growing tendency on the part of young operatives in cotton mill districts to prefer occupation other than in the weaving shed. In most cases, objection was taken to the noise."

The conclusions reached may be summarised in the following terms.

No great reduction of noise can be effected without a revolutionary change in the system of picking, nevertheless the cumulative effect of improvement in a number of details might justify effort in that direction.

One phase of remedy would appear to be the better training of the tackler with respect to methods of adjustment.

It was desirable to express the results of all observations on the intensity of noise in quantitative form and to employ suitable apparatus and a trained observer.

It was desirable to determine whether there is any lower limit of intensity of noise which is unobjectionable and if so to determine its magnitude.

Consideration as to the quality of noise was important.

This work was well begun and—despite the obvious need to examine the premise first—on the right lines. It is regrettable that it could not be followed up there and then. But the two Studies now under consideration carry the matter a good deal further and, in the opinion of the writer, deal with the subject from a more basic consideration—i.e., Does Noise, as such, affect the performance of various industrial processes and if so, do noises vary in their effect and to what extent ?

* Report No. 65, Industrial Health Research Board. H.M.S.O. 1s. 3d. Net.

The experiments described and discussed in Study No. 1 by K. S. Pollock and F. C. Bartlett were carried out partly at the Cambridge University Printing Press and subsequently in a laboratory. The report states at the outset that " There appears to be a widespread opinion that noise directly diminishes efficiency, leads to increased liability to accidents, and provides a persistently favourable background for the development of nervous and mental disorders of many kinds. For all these opinions there is very little evidence . . . It was therefore with no great hope of discovering anything sensational that we set about trying to determine in a more exact manner than usual what actually are the psychological effects of noise."

These investigators make the very logical point that " in everyday life the noise factor is inextricably intermingled with a mass of other determining conditions . . . We have made an attempt to isolate and consider the specific effects of noise simply as noise." They indicate clearly the limitations of their work and disclaim any desire or attempt to draw conclusions not strictly justified by the conditions under which the experiments were conducted.

The experiments described progressed from tests of manual performance made in a printing room through tests demanding partly manual and partly mental activity to tests almost entirely mental in character. Of the first experiments they record that the initial effects of noise (and vibration, which factor was subsequently eliminated from the tests) very speedily disappeared. Change from " noise " conditions to " normal " conditions was also accompanied by initial drop in efficiency; in other words, change of conditions influenced performance rather than continued conditions whether, in this case only of course, noisy or normal.

Fuller description of these experiments cannot be undertaken here and indeed summarisation of them would be unfair and perhaps open to misunderstanding; the report itself should be studied. But the conclusions at which Messrs. Pollock and Bartlett arrived should be grasped. They conclude their report with two paragraphs that should be carefully noted.

" On the whole all the experiments agree that noise in general tends to produce slight and readily recoverable diminution of efficiency. We think that its direct effects upon non-auditory performance are commonly greatly exaggerated. It remains possible that, noise being very generally disliked, its effect upon a social group may be strikingly different from those upon the individual performer."

" Finally it should be stated once more that the whole of the work herein described, and the bulk of other work done upon noise, concerns the effects of a noisy environment upon non-auditory performance. This is perfectly legitimate, for relatively few tasks of daily life have a direct and fewer still an exclusive auditory basis. But far more interesting and important theoretical problems arise when we begin to investigate the effects of continuous sound stimulation upon auditory tasks. These are the questions which we propose to make the topic of our next investigations."

The second part of this Report was carried out by H. C. Weston and S. Adams and is a study of " The Effect of Noise on the performance of Weavers." The first study would seem to indicate that if the " Young Operatives " in cotton mill districts referred to in the Institute's investigation would give the Weaving Shed a trial its noise effect would not permanently affect their efficiency and would probably have little or no effect upon the majority of them so far as irritation is concerned. The second study deals with another aspect of this very interesting subject but of more direct importance to textiles.

These experimenters also indicate that there is little experimental evidence regarding the objective significance of noise and that what there is, to some extent, conflicts. Their investigation carried out in a Lancashire weaving shed, was undertaken to obtain further data under industrial conditions.

The conditions under which the experiments were carried out were carefully recorded but space does not admit of setting them out here. The weavers chosen to perform the experiment (three males and seven females) were supplied on alternate weeks with ear defenders (Mallock-Armstrong type) and during the whole period record of the individual output of one loom per weaver was kept by means of a pick recorder. Counts per hour were made—with certain modifications described—and the results tabulated.

Conclusions drawn may be summarised as follows :—

The average hourly output per weaver shows an increase of approximately one per cent. when ear defenders were worn.

This conclusion must be modified by consideration of the variations recorded in temperature and humidity throughout the period, though these were not great.

The results as a whole suggest that noise is detrimental to personal efficiency.

In occupations, comparable as regards intensity of noise, depending less upon the mechanical and more upon the human factor than weaving, it is probable that the effect of noise upon output may be greater.

The hourly variations of output suggest that even experienced and skilled weavers are not permanently adapted to noise but go through a daily process of adaptation.

With reduction of noise, output becomes consistently more regular and less variable from hour to hour and from day to day.

These conclusions, in the light of the Institute's previous work, are definitely significant. It may be, probably it is, impossible to make the loom silent or even to materially reduce the noise made by the loom, but it would appear that the matter is one worth attention either in the direction of changes in loom construction or by supplying weavers with some form of ear defender. T.

Textile Research in Canada

In 1928, the Legislative Assembly of the Province of Ontario passed a Research Foundation Act establishing a Corporation, known as the Ontario Research Foundation, having as its objects the following :—

(*a*) The improvement and development of manufacturing and other industries by the introduction of advanced methods and processes ;

(*b*) The discovery and better development of the natural resources of the Province and the discovery and utilisation of the by-products of any processes in treating or otherwise dealing with the mineral, timber and other resources of the Province ;

(*c*) The development and improvement of methods in the agricultural industry and the betterment, welfare and progress of farm life ;

(*d*) Scientific research and investigation for the mitigation and abolition of disease in animal or vegetable life and the destruction of insect or parasitic pests ;

(*e*) Generally the carrying out, with the approval or under the direction of the Lieutenant-Governor in Council, of any other research work or investigation which may be deemed expedient.

In seeking to secure these objects, naturally the Canadian Textile Industry came into consideration. The 1928-1929 Report of the Foundation (p. 11) says : " Shortly after the Foundation was established the Director was asked to meet a representative deputation from the Executive of the Canadian Woollen Manufacturers' Association to discuss a possible working relationship." As a result of these discussions the Laboratory, previously conducted by the Association in Toronto, was transferred to the Foundation, and the Association regularly contributes to the work of the Laboratory.

Mr. C. W. Ewing who had been in charge of the Laboratory was transferred to the Foundation Staff. In the main the work to be undertaken by the Laboratory was to be along routine lines rather than work of a research character. Such policy being determined by the fact that a large section of the industry not only required the services of a routine laboratory, but also had to be convinced of the value of even the simpler type of scientific control. The report suggests that " experience in Great Britain and in other countries has shown conclusively that one of the easiest ways to create a lack of confidence in the work of the research laboratories is to allow the work carried out to get too far in advance of the general technical and scientific outlook of those engaged in the industry." The report continues that its textile work has been modified and increased as there were " no facilities for education in textile technology and no professional society to act as a clearing house for information."

The development of this work is revealed in the Second and Third reports, that for 1930 recording an increase in staff to secure which the Foundation made an appeal for assistance to Leeds University Textile Department and to the Wool Industries Research Association. The 1931 report, most recently to hand, records an increase in the work of the textile laboratories of nearly 50 per cent. and emphasises the importance of close contact between the staff of the Department and the various subscribing firms and Associations. It is to be hoped that the work done by the Department will to some extent be made generally available on the same lines as are adopted by the Textile Research Associations in this country. T.

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PROCEEDINGS

THE COLLOID ASPECTS OF TEXTILE MATERIALS

A General Discussion organised by the Colloid Committee of the Faraday Society, 21st to 23rd September, 1932.

THE INDUSTRIAL AND TECHNICAL SIGNIFICANCE

The general discussion on the colloidal aspects of the experimental study of textile materials and allied subjects organised by the Faraday Society, was opened at Manchester University on Wednesday, September 21st, 1932, under the chairmanship of Sir Robert Mond, supported by Mr. George Garnett, J.P., the President of the Textile Institute. There were some 160 members and visitors present, including some of the best-known authorities in this branch of study from at home and abroad.

Although it is difficult, in the many papers contributed, to point to any pronouncement likely to prove of outstanding value in its immediate technical applications, yet it is equally difficult to single out any paper that did not merit the serious attention of those interested in the application of scientific methods to investigations of the problems of the industry. The discussion, considered as a whole, could be said to give a distinct picture of the main directions taken by the scientific investigation of the fibrous materials that has been carried on so vigorously in the past few years. The subject matter, with a few exceptions, centred round the attempts that have been made to determine more accurately the structural and constitutional properties of matter in the fibrous form, and the inter-relation of these properties with the mass properties of the material (qualities of strength, elasticity, absorption relations, chemical resistance, etc.), which are of such fundamental importance. Nor can it be denied that such subjects, however abstract their treatment, are of far-reaching technical importance to-day. We are no longer content with taking the fibrous raw materials as they are offered by Nature, and using them with some relatively superficial purification. We have set out to manufacture the fibres, by artificial chemical and mechanical methods, to definite specifications of mechanical properties, and to deliberately-set standards of appearance and chemical behaviour. Obviously, synthetic operations of this nature are not assured of inevitable success unless the architecture of the organised material is thoroughly understood, and the connections between structure and technical properties traced out. From this general aspect, every paper had its technical interest. Some of the papers, as, for instance, the paper upon swelling phenomena by *J. R. Katz* should provide very valuable summarised introductions to important theoretical aspects of the study of fibres and save a great deal of extensive reading by those who have already too much to get through in the day. At the other end of the scale there were detailed considerations of the more strictly experimental and technical problems, as, for example, the paper by *P. Krais* on difficulties in Yarn Mercerisation.

Apart from the general papers, the subject matter of the discussion divides itself conveniently into studies interested in cellulosic and protein materials respectively.

The early papers revealed a variety of suggested methods for the determination of the molecular weight of the native and regenerated forms of cellulose and their derivatives. Provided a round figure of plausible dimensions is arrived at, this may not be thought to have any overwhelming technical importance, but it must be remembered that the chain length of the fibre molecules has influences of primary importance upon the mechanical properties of the fibre, and may be taken as a criterion of the extent to which degradative influences have been at work during treatment designed to purify the native material or to transform it into chemical derivatives. *W. N. Haworth* and *M. Hirst*, in their paper on the molecular nature of polysaccharides, summarised some extremely interesting recent work which must command admiration for the skilful way in which complete methylation of the cellulose molecules in native materials appears to have been accomplished with negligible breakdown of the primary linkages. (The fact that the subsequent discussion revealed a difference of opinion as to whether no degradation at all had taken place does not detract from the importance of their work.) The fully methylated material is then hydrolysed and fractionated and the products reveal a small quantity (0·6 per cent.) of tetra-methyl glucose among the main bulk of 2 : 3 : 6 tri-methyl glucose showing quantitatively the presence of chain terminal groups in proportions which correspond reasonably with other estimates of the lengths of the cellulose chains. Considering the difficulties of this direct chemical method, the accuracy of estimation is sufficiently great to promise that we shall in time have a valuable instrument for the examination of the degree and course of degradation of cellulose chains. Some progress is reported in this direction with products (the cello-dextrins) where the breakdown is hydrolytic, and it may not be too much to hope that a similar method may in time be amenable to the study of the very important technical problem of oxidative degradation. It is also probable that *W. N. Haworth's* gentle methods of methylation may, upon examination, yield valuable information for those engaged upon the technical etherifications and esterifications of cellulose.

One very important aspect of the constitutional study of cellulose is the correlation of fibre structure and the primary mechanical properties of strength, elasticity, extensibility, and torsional rigidity, and it has been here where the study of the orientation of the long molecules collected in their micellar bundles has been of such great utility. *H. Mark* attempts the correlation of strength, extensibility, and orientation from a statistical treatment of the amount of supposed side-to-side contact of congregations of ideal rectangular prisms in various states from zero to complete orientation, postulating that the ultimate strength of cellulose fibres will depend upon the side-to-side adhesion of their units. By very slow stretching of swollen fibres, one can produce an increasing orientation at will, and measurement of the strengths of such fibres and comparison with the statistically computed ideal strength-orientation curves leads Mark to believe that his postulation of the predominating influence of side-to-side adhesion is substantially justified. A study of rather similar problems of orientation by *J. M. Preston*, using a method based upon the simple determination of the refractive properties of cellulose fibres along the different principal axes was also presented.

The measurement of the viscosity of standard solutions of cellulose or cellulose derivatives in appropriate solvents or dispersing media is, of course, an old established method in a number of industries for ascertaining the degree to which depolymerisation has been brought about in the original material by chemical influences during technical treatment or in use. So far, most of the studies on the subject have been concerned with the experimental difficulties of accurate

determination, and the rendering of arbitrary values in a reproducible form capable of interpretation from the technical point of view. The more fundamental treatment of this subject of viscosity by *H. Staudinger* and its exact application to constitutional problems will command great respect because of his unrivalled knowledge of polymerised substances of all kinds, both natural and artificial. His generalisations were drawn from the whole range of high-molecular substances with long chains. He put forward the idea that in limiting concentrations the viscosity of paraffinoid substances is strictly additive and is independent of purely spatial considerations. With an increasing number of polar groups in the chain, and an increasing molecular size and complexity of linkage some qualifications must apply, though even here there exists an unmodified connection between chain length and viscosity that is apparently undisturbed by the nature and size of substituents in the chain molecule. There was some rather lively discussion over the universal validity of *Staudinger's* generalisations, but in some cases contradictory views appeared to be based upon experimental data that ignored the condition of limiting concentration stated quite explicitly by *Staudinger*.

À propos of this subject, *Mark* mentioned a principle that may be of great technical importance, that is, that one may obtain solutions of relatively low viscosity by the mixture of materials of different molecular weights, each having an individual high viscosity, so that workable solutions could be obtained without the need for excessive degradation.

Because of their greater ease of experimental utilisation, since they are so much more easily dispersed or dissolved in simple media, the cellulose ethers and esters are the subject of a greater amount of attention in the constitutional investigations. When in the state of solution or in thin extended films, they appear to be in an unusual condition of aggregation as far as technical applications are concerned so that papers like that of *Buchner* on an osmotic method for the measurement of molecular weight, or the extension by *N. K. Adam* of his trough method to the study of cellulose derivatives may be dismissed with this mention.

Naturally, such important esters as the nitro celluloses have received a great deal of attention, and they are also very amenable to experimental treatment since the end products of nitration can be altered so widely with variations in the nitration conditions. Three papers were devoted to such studies, all working on much the same lines, i.e., an X-ray analysis being applied to the materials nitrated under different conditions and at different stages of the process, or as the esters are reprecipitated from solution or recovered therefrom by evaporation. *F. D. Miles* collects the information from the great body of work carried out at Ardeer on the influence of the nitrating conditions upon the constitution and on the configuration of the resulting esters. He deals in particular with the interrelation between the swelling or " mercerising " action of the strong acids used and the course of substitution with nitro groups. These results point to the existence of a preliminary stage in which the penetration of the acid groups between the micellae causes swelling without much nitration, and this stage is followed by the nitration of the relatively few hydroxyl groups at the surface of the micelle, this is followed in turn by the breakdown of the micelle into its constituent chain molecules and more thorough nitration as the severity of the nitrating conditions increases. This paper is supplemented by the paper of *M. Mathieu* in which the conclusion is reached that nitro groups are introduced at rare irregular intervals along the chain molecules, and that the spaces are only filled in as the nitration approaches finality. It is interesting to find that *Miles*, *Adam* and *Sheppard*, and *Mathieu* and *Trillat* are all, from the results of their respective methods of attack, agreed about the deep-seated changes in structure which take place as the nitration passes the stage at which the nitrogen content reaches 12·7-12·9 per cent.

Before leaving the cellulose section we must mention the papers of *S. M. Neale*, *C. R. Nodder* and *P. Krais*. *Neale's* paper was a very able summary of work contained for the most part in Shirley Institute publications. It occupied a somewhat unique position among the papers on cellulose because it laid the greatest stress upon the chemical reactivity of cellulose structures as opposed to purely configurational questions and as such comes nearest to the behaviour that is of extreme importance in the processing of cotton. It was to be regretted that this was the only paper representative of the work done by the Shirley Institute where this question of the reactivity of cellulose with special reference to technical problems has been so extensively studied. An account of attempts to interpret the actual course and causes of degradation in linen materials from a consideration of results given by the three cardinal tests of copper number, cuprammonium viscosity and solubility number came from the Linen Research Association through *Nodder*, this being followed by an attempt to formulate a topographical picture showing which parts of the linen fibre structure were degraded by hydrolytic and oxidising attack. A paper by *Krais* emphasised briefly the extreme sensitivity of mercerised cotton (in so far as its subsequent dyeing properties were concerned), to modification of drying treatment and to the drying in of minute traces of acids.

The protein fibres comprise, of course, wool and silk but in this discussion there was an extension to the collagen fibres of hide and to muscle fibres. These are receiving analytical study chiefly through X-ray analysis which seems to give the most informative results when it is carefully considered in relation to the behaviour of the fibres under the influence of tensile strain. *W. T. Astbury's* brilliant pioneer work in this field is well known. In his paper he recapitulated some of the main features of it, putting forward again the theory that the protein fibres are built up round a backbone of polypeptide linkages with the remaining part of the amino acid molecules which form the structural units of the fibre branching out laterally from the main chain. His remarkable theory of how the fibres of keratin owe their high elastic extensibility to a straightening out of normally contorted polypeptide chains was again given. But the interest of protein chemists appears to be swinging away from these problems of the main chains which lie parallel to the fibre axis, and of which a more or less complete picture seems to have been constructed, and to be focussed upon the inter-relation of chain with adjacent chain as they lie together in the fibre. The units of the protein fibres, especially the keratin fibres, have chemically many more possibilities of complexity than their cellulose analogues. In cellulose the primary linkages of the structural units appear only to take place along the backbone or chain-molecule axis, and the substituent hydroxyl groups in the glucose units give no promise of any but subsidiary valencies being available for attaching the chains side by side. In the keratin complex there is a wide variety of chemically distinct groups, and the side chains may be of relatively great length compared with the space taken up by a unit linkage in the main chain. Furthermore the side chains may contain such active groups as amine, imine and carboxyl, which leads to the possibility of chemical cross linkages between adjacent chains. The strength of these linkages may range from the amine-carboxylic acid-salt electro-valency, through conjugated valencies to the strong co-valent CO-NH binding. All these may be at the mercy of mechanical strain, the electro-valencies may be seriously modified by the presence of hydrogen and hydroxyl ions, and all will exercise very far-reaching effects upon such fibre properties as moisture- and dyestuff-absorption. Different aspects of these problems were discussed by *Astbury* himself, by *J. B. Speakman*, *D. J. Lloyd*, *E. Elöd*, *W. S. Denham*, *A. H. Hughes* and others.

Speakman's paper and that of *Elöd* were concerned mainly with the salt or electrovalent type of cross linkage. Its influences are reflected particularly in

the chemical and physico-chemical properties of the material, especially in the reactions to environment, though the work of *Speakman* seems to show that these valencies have also a very great influence upon the mechanical property of irreversible extension. For instance, the work required to perform a given amount of extension in the fibre is very much diminished by the presence of acid, which fits in very well with the simple theory that, the salt linkages being broken, the polypeptide chains can slide past each other with less restraint. Since this effect is reversible, except in the event of nitrous acid being used (where diazotisation of the amine groups puts them out of action), and since the work of extension rises to near its original figure when the acids are washed out, we have a strengthening of the evidence that a great proportion of the cross linkages are of the type that allow easy recombination to take place, that is, they are electrovalent linkages. *Lloyd's* paper speculated in a more general form upon the influences that might be expected to ensue from the highly polar nature of the amino acid units. In particular, the influence upon swelling in water and in salt solutions was considered in detail from two points of view; firstly, the influence that these polar groups would have in attracting water or hydrated ions and bringing about hydration, and secondly the influences of the cross linkages formed between the chains in resisting swelling.

The paper by *Elöd* described a large amount of most admirably-conceived work designed to elucidate the mechanism by which acid dyes are taken up by protein fibres. From his results, *Elöd* declares uncompromisingly for a chemical process as the main factor in the dyeing process. In acid baths, he is able to show the preliminary rapid combination of the anion of the strong acid with the amino groups of the fibre and its slower replacement therefrom by the anion of the colour acid. Nevertheless pure absorption of dyestuff does appear to take place to some extent, and the way in which the physical and the chemical mechanisms are disentangled is worthy of special mention.

There was a short note from *Wo. Ostwald* in which he brings forward evidence that small concentrations of neutral salts may, contrary to most preconceived ideas obtained from technical experience in dyeing, lead to an increase in the solubility and dispersibility of substantive dyestuff. The effect was studied with specially purified dyestuffs and the effect was found to be manifested with the addition of M/1000 solutions of sodium sulphate to solutions of pure benzopurpurin 4B. In the discussion strong emphasis was laid on the need for rigid purity of the dyestuff before acceptable results could be obtained from experiments with such low concentrations of salts.

From the economic point of view, the relation between fleece properties and breed on the one hand, and the nature of the pasturage and food of the animal on the other is of extreme importance in controlling the quality of the woollen raw material available. Such relations raise large questions in animal physiology and require an investigation of metabolic processes in many places from the alimentary system to the hair follicle. A very consequential survey by *A. T. King* dealt with one side of the problem, the matter of sulphur metabolism. While considering these studies of fleece quality mention must not be omitted of the unusual and very interesting mathematical treatment by which *S. G. Barker* has shown that the rhythmical crimp of fleece hairs can be traced to the superposition of two simple periodic influences operating probably in the follicle.

The exact measurement of the conductivity of textile fibres is an interesting field of study because of the increasing exploitation of fibrous materials as electrical insulators, their normally high resistances, and the peculiarly rapid variation of electrical properties with change in the relative humidity. The reliable measurement of fibre conductivity on a quantitative technical basis has many pitfalls and there is a great deal of misleading data in published work on this account. *M. G. Marsh* and *K. Earp* in their paper on the electrical properties of wool fibres

describe a method for the determination of conductivity which may be of value to other workers, though they too have the usual troubles of faulty insulation when the resistance of their fibres becomes very high at low humidities. They also put forward a theory of fine irregular canal structure in the fibre where the bulk of the conducting water is situated, and are thereby able to explain certain discontinuities in the conductivity-moisture-content relationships.

MANCHESTER, *October*, 1932.

(*Signed*) H. A. TURNER.
F. C. WOOD.

NOTES AND NOTICES

Institute's Associateship and Examination

Persistence of misunderstanding in regard to the conditions of candidature for the annual Examination in connection with applications for the Associateship of the Institute was reported to the October meeting of the Selection Committee. The Examination is now arranged in two parts. Part II represents the previous single examination, and Part I has been devised and added in order to provide for applicants unable to comply completely with the provisions of the Regulations in regard to General Education. Provided that other requirements are satisfactorily met, applicants for the Associateship may be offered the Institute's Examination (Part I and Part II). Applicants referred to Part II (General Textile Technology) only, are thereby exempted from Part I. The Selection Committee has decided to issue a special leaflet on the whole subject and it is proposed to supply copies to the textile departments of technical colleges and schools. The object of such leaflet is, of course, the removal of doubt or misunderstanding as to candidature in respect of the Examination, both parts of which are available only to applicants for the Associateship whose applications have been approved for reference thereto.

Annual Competitions: Fabrics and Yarns

The specimens of fabrics and yarns in connection with the Institute's Competitions for the current year are now to hand and adjudication will proceed so that the presentation of prizes will take place on the afternoon of Saturday, 3rd December. Further announcements will follow. The exhibits on this occasion are likely to prove exceptionally interesting inasmuch as there is a considerable increase of draping lengths of materials and made-up articles accompanying the patterns. For the first time, there is a separate competition for knitted fabrics and a satisfactory response has accrued in this section. The somewhat formidable task of adjudication, which is carried out by the members of the Competitions Committee, is now proceeding, a meeting having been called for the 26th October for the completion of arrangements.

Mr. William Howarth

The prolonged illness of Mr. William Howarth, of Bolton, Managing Director of the Fine Cotton Spinners' and Doublers' Association, and Past-President of the Textile Institute, has been a matter of deep concern to officers and members of the Institute for a considerable time past. The widespread and affectionate regard for his welfare has been abundantly evinced by the large number of inquiries received at the Institute. An announcement appeared in the daily Press recently to the effect that owing to his long continued ill health he has felt compelled to resign from the important posts he holds in the cotton industry—an announcement which was received with the utmost regret. Throughout the Institute membership the best wishes for an early return of good health will be readily extended to Mr. Howarth.

Institute Library Facilities

At a meeting of the Library Committee of the Institute held on the 17th October, Mr. J. Read was unanimously re-elected Chairman and warmly

thanked for his services. The facilities of the Library and Reading Room and the extent to which the arrangements for the borrowing of books and other publications are in effective operation were reported upon. The service of the Library in regard to the loan of books, by post and otherwise, had developed greatly in the last three years. In 1931 there were 245 loans of publications whilst already in the current year the total exceeds 300. The borrowings during the present year have referred to the following publications:—Books, 102; periodicals, 198; pamphlets and catalogues, 16. In the matter of the postal service of lending books, etc., the borrower covers the cost of postage. The facility is obviously greatly appreciated, and one instance is recorded to the meeting of the Committee in which the member urgently requiring the loan of a book asked for the volumes to be dispatched by passenger train so that collection could be effected at the time of arrival—an arrangement which was duly carried out. The Committee has recommended the purchase of a new horizontal file cabinet for the more convenient housing of current periodicals in the Members' Room at the Institute.

Exhibition at Leicester

Leicester is fortunate in regard to the accommodation available for the holding of a modern industrial exhibition. The recent exhibition of textile machinery and fabrics was excellently staged, and formed a striking demonstration of the advances made in recent years by the knitting industry of which Leicester is so important a centre. Members of the Midlands Section of our Institute paid an official visit to the Exhibition on Thursday, 13th October, when there was an attendance of about forty. Mr. Tom Morley, Chairman of the Section, presided at luncheon and subsequently over a meeting at which Mr. T. A. Purt contributed a Paper on "Winding for the Hosiery Industry." Mr. Purt's effort was highly appreciated and his assertion that "The Proof of the Winding is in the Knitting" was certainly not inappropriate. Mr. Morley, supported by Mr. F. Nasmith, thanked the Exhibition Directors and Manager for their invitation and hospitality, and Mr. Frank Prout responded. Mr. Purt was warmly thanked for his paper, on the motion of Mr. A. Stoppard, seconded by Mr. W. E. Boswell, and, finally the Chairman was thanked by Mr. Purt (Secretary of the Leicester Chamber of Commerce), seconded by Mr. Edwin Wildt. The visit was a successful event for the organisation of which Mr. J. Chamberlain, Hon. Secretary of the Section, was responsible.

Textile Institute Diplomas

Elections to Associateship have been completed since the appearance of the previous list (August issue of this *Journal*) as follow:—

ASSOCIATESHIP

ALDRED, Frank (Bolton).
BABBAGE, Alfred Gilbert (Cheadle Hulme).
BAYES, Alfred Walter (Hyde).
BANCROFT, George (Bradford).
DRAKE, Raymond (London).
EMMS, John Robert (Saltaire).
JONES, Arthur (Silsden).
HEMINGWAY, Geoffrey Wilson (Halifax).
LLOYD, Thomas (Manchester).
LORD, Wilfrid (Rochdale).
MARSDEN, William Ackroyd (Heckmondwike).
ROBBIE, Norman Walter (Dundee).
SHORROCK, Stanley (Bolton).
SMETHURST, William (Bolton).
WARD, Thomas (Bolton).
WHITE, George (Bolton).

REVIEWS

The Industrial Revolution in Scotland. By Henry Hamilton, M.A., D.Litt. Published by the Oxford Clarendon Press. (xii + 300 pages). Price 15/- net.

This book is published at an opportune moment, for it should serve as a reminder that our modern civilisation is but of very recent growth and that the present economic crisis is but a phase in a very late development in the history of the world. Since the beginning of the present century and more especially since the end of the war, industrial and commercial relationships have been regarded as international and world embracing. There has been a tendency to regard the breakdown of the very complicated machinery of production and distribution as a catastrophe, all the more terrible when compared with the apparent security, solidarity and efficiency of the machine in the years before the war.

Yet, this machinery is, historically, very new. Two hundred years ago industry, trade, commerce, and agriculture were carried on very much in the same way that they had been conducted for centuries. Within a century conditions of life were revolutionised by the introduction of organised thought in the control of matter and energy—the age of machines had begun.

Dr. Hamilton has carefully traced the history as it affected Scotland. In a comparatively short book he shows, first of all, the state of Scottish economic life prior to the change. He then proceeds to trace the changes in agriculture and in the various branches of industrial activity including the manufacture of linen, cotton, iron and steel and the mining of coal. Chapters are also added on communications, banking, and finance. The parts played by individuals and aspects peculiarly national in character are clearly shown.

With such arrangement there is bound to be a certain amount of overlapping and repetition in each chapter with subjects so closely correlated, but this is by no means a serious defect. To the general reader, as well as to the student of Economic History, the treatment of the various branches of activity separately is convenient and greater clarity is obtained. The addition of a chapter dealing with the changes as a whole and showing their inter-relationship, as well as one dealing with some of the very important social and political results of the revolution would greatly increase the value of this work.

The documentation is very good. There is a comprehensive bibliography of manuscript sources, official publications, books, pamphlets and articles. The index, whilst not exhaustive, is sufficient. A useful map of industrial Scotland prior to 1860 is appended. M.

Davison's Textile Blue Book (including Dockham's American Report and Directory). Published by the Davison Publishing Co., New York. (Office Edition, $7.50; Handy Edition, $5.00. Salesmen's Directory, $4.00 Foreign postage, 50 c. extra.)

This handy-sized and comprehensive directory has been thoroughly revised and brought up-to-date not only by personal checking but in co-operation with the U.S. Department of Commerce. It covers Cotton Mills; Woollen and Worsted Mills; Silk Mills; Knitting Mills; Jute, Linen, and Flax Mills; Canadian Mills; Mexican Mills; Dyers and Finishers; Mills with Dye Houses; Commission Merchants; Converters; Yarn Dealers; Raw, Thrown and Rayon Silk Firms; Cotton Dealers (both domestic and foreign); Cotton Warehouses; Wool Dealers; Linter Dealers; Waste Dealers; and Manufacturers; Wholesale Rag and Remnant Dealers; Textile Supplies; New Textile Mills; Classified Directory of Mills; Textile Maps, revised to date, show towns where there are textile plants, dyeing, bleaching or finishing works.

Two editions are issued—the Deluxe Office Size, and the Handy Edition on thinner paper. A Salesmen's directory giving a reclassification of the same information is also available. T.

British Colour Council. Autumn, 1932, Colour Cards. Issued by the Council, Castle House, Wells Street, London.

The following cards have been received at the Institute and placed in the Library.

Autumn Season Colour Card, 1932. For Cotton, Silk and Rayon goods.
Autumn Season Woollen Card, 1932.
Autumn Season Hosiery Card, 1932.
Autumn Season Leather Card, 1932, and a Supplementary Card. T.

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PROCEEDINGS

ASSOCIATESHIP OF THE TEXTILE INSTITUTE

Examination: Part I (Auxiliary Subjects) and Part II (General Textile Technology)

EXPLANATORY NOTES

In view of misunderstanding on the part of textile students and others in reference to the above-named Examination and to the requirements for election to the Associateship of the Institute, the following explanatory notes are issued by the Selection Committee :—

(1) The requirements for election to the Associateship are set forth in printed Regulations, copies of which may be obtained at 1/- each, post free, on application to the Institute. The Regulations should be carefully studied by prospective applicants.

(2) Application for the Associateship (A.T.I.) is restricted to Members (Junior or Ordinary) of the Textile Institute of at least six months' standing at the time of the application.

(3) Institute Members applying for the Associateship must do so on the special Form provided and the application must be accompanied by a Registration Fee of 10/6, which amount is deducted from the Entrance Fee of Two Guineas on admission to the Associateship but is not returned in the event of unsuccessful application. On the Application Form, the statement of qualifications should be presented completely under the respective sections.

(4) The qualifications of each candidate for the award of the Associateship are considered in relation to the requirements set forth in the printed Regulations, and applications may be dealt with as follows :—

(*a*) Applicant exempted from Examination and recommended for election to Associateship ;

(*b*) Applicant referred to Examination, Part II (General Textile Technology) and exempted from Part I (Auxiliary Subjects) ;

(*c*) Applicant referred to Examination, Part I (Auxiliary Subjects) and Part II (General Textile Technology) ;

(*d*) Application declined.

(5) The Institute's Examination is not an examination the passing of which, in itself, secures admission to the Associateship. No person may sit for the Institute's Examination until his application for the Associateship has been considered by the Selection Committee and, as a result, he has been definitely referred to Examination. Success in the Examination is not the first qualification necessary but the last.

(6) If referred to Part I and Part II, the applicant must pass both parts in order to complete the requirements for the award. The applicant may take the complete Examination in one and the same year on the appointed dates in the month of June ; or, he may take each part separately in different years. In either case a candidate will not be certified as having passed Part II until he has passed Part I.

(7) Students in Technical Institutions should consult the Principal or the Head of the Textile Department before proceeding with an application.

PRESENTATION OF THE INSTITUTE MEDAL

On his retirement as Chief Inspector for Technical Education at the Board of Education, the Council of the Institute decided to award the Institute Medal and Honorary Life Membership to Mr. A. Abbott, C.B.E., M.A. The ceremony was performed at the Midland Hotel, Manchester, on Wednesday, 16th October, in association with a luncheon given to Mr. Abbott and other guests. At the luncheon there were present Messrs. George Garnett, President; B. Palin Dobinson, Past President; W. Frost, H. P. Greg, J. H. Lester, E. Midgley, Vice-Presidents; F. Nasmith, Vice-President and Hon. Secretary; H. Binns, Chairman of Council; F. Wright, Vice-Chairman of Council; H. C. Barnes, F. W. Barwick, R. J. H. Beansland, W. T. Boothman, H. Bromiley, H. G. Greg, W. Kershaw, W. E. Morton, J. Read, H. Richardson, F. P. Slater, T. S. Stott, G. H. Thompson, W. Vernon, S. Watson, W. Wilkinson, Members of Council; R. H. Pickard, Director, British Cotton Industry Research Association; S. G. Barker, Director Wool Industries Research Association; A. Frobisher, Secretary, Wool Industries Research Association; Councillor Wright Robinson, Chairman, Manchester Education Committee; J. E. Dalton, Staff Inspector, Board of Education; H. Salt, H. J. Shelley, Inspectors, Board of Education; A. Crickmore, F. T. Peirce, R. Roberts, F. Scholefield, C. F. Sixsmith, A. J. Turner, Members; J. D. Athey, General Secretary; H. L. Robinson, Editor; and representatives of the Press.

Mr. H. P. Greg, introducing Mr. Abbott, said he had a very difficult task to perform, and if he failed they must put it down to his incompetence. "We have Mr. Abbott here this afternoon," he continued, "and it is quite clear he is known to most of you, and that we are drawn here to-day by ties of remembrance and affection. Mr. Abbott is Lancashire born and bred; he did well at school and then took first class honours at Oxford, which is a very good beginning. He started teaching soon after he left Oxford at various secondary schools, but though he apparently gave up the teaching profession to join the Board of Education after two years. But he never really gave up teaching; he has been teaching all his life, and he has taught to an ever-widening constituency. Then he did a great deal of work in inspecting in Lancashire and Cheshire and up and down the country—technical work and elementary education to some extent. He got a thorough grasp of the technical side of education, and began to make his mark in the Board of Education. I want now to draw a brief curtain for two years because I will deal with that period more fully later.

"After this brief period he become Assistant Secretary to the Department of Scientific and Industrial Research, and he got his chance of making use of his accumulated knowledge. He was concerned with the establishment of research associations for all kinds of industries from silk to motor cars. I have no hesitation in saying that it was because he was brought into touch with this wide variety of things, that, taken all round, scientific research in industrial matters has developed so well in this country.

"I want now to get back," continued Mr. Greg, "to the period I am most interested in; the two years during which Mr. Abbott worked in connection with the establishment of the Cotton Research Association. I went to see Dr. Heath, Secretary of the Department of Scientific and Industrial Research, on 24th June, 1916, and when I asked Dr. Heath why he had sent for me to undertake the formation of a research institution, he did not tell me why, but I had a shrewd suspicion that the root cause of my being up in London that day was my friend on my left. I said to Dr. Heath, 'I am prepared to do any job you like but I shall want very able help now' He said, 'We will give you that help.' After some fencing he said, 'Well, of course, there is Abbott, but we could not spare him.' I said, 'But Abbott is the man I must have.' I told him how important it was that we should have the very best possible

Mr ALBERT ABBOTT

Awarded the Textile Institute Medal, November, 1932

person at our disposal. He ultimately said, 'Agreed,' and so I was able to bring about the foundation of the Cotton Research Institute.

" After that I was in constant communication with Mr. Abbott, and I have no hestitation in saying that the qualities which Mr. Abbott brought to bear on his tasks have been invaluable to the cotton industry. What were these qualities ? I think it is not possible to give a complete list, but it is interesting to try to enumerate some of them, and I am not sure I do not put as the first his capacity for hard work and clear thinking. Another characteristic of his is, reliability, which is a comparatively rare virtue, but tremendously valuable when starting something like the Cotton Research Association. His knowledge of men and books is very wide and very thorough. His memory seems to be absolutely perfect, but I think one of the most valuable of his qualities is vision. He is always looking forward ; trying to improve matters. I got hold of those articles published in the *Manchester Guardian* in 1917 from which I read the words, ' Come, my friends, it is not too late to seek a newer world.' I think that is exactly the spirit in which Mr. Abbott has acted and always will act. However late it may be, it is not too late to seek a newer world.

" I should like to testify also to his truthfulness. It may seem a simple thing to tell a man the truth to his face. It is comparatively hard in this world to tell the truth. Perhaps scientific men may be able to talk of the truth. I want to say that Mr. Abbott's truthfulness was a very high standard, a truthfulness which impressed me immensely.

" Lastly, he has the saving grace of humour ; we are all happy in Mr. Abbott's company ; we cannot help it.

" I must ask you, Mr. President, to present the Institute Medal and Honorary Life Membership of the Textile Institute to Mr. Abbott. You could not possibly bestow these honours on a man who is more deserving of such recognition. We owe a very great debt of gratitude for all the work Mr. Abbott has done for the Textile Industries."

The President, Mr. George Garnett, said he would like to associate himself very definitely, indeed, with Mr. Greg's remarks. He had known Mr. Abbott for many years ; his marked and attractive personality was such that it was always a pleasure to meet him. He (the speaker) always found a great deal of pleasure in his company and in Mr. Abbott, he thought he might be bold enough to say, he found a sympathetic spirit. He held high ideals in life, and some of his virtues enumerated by Mr. Greg were undoubtedly rare among men. It was a very great pleasure to ask Mr. Abbott to accept the Medal of the Institute carrying with it life membership. " We believe," said the President, " that the honour is really ours ; that the fellowship is ours ; that the benefit of the work he has done and will do, will be ours. He is a man with whom we like to be associated.

" At the present time there is need for the highest qualities in the young men entering Industry. I am sure that the prestige of the Institute has had and is having to-day immense influence not only on the textile trades but on the country. We have the example of Mr. Abbott's personality and qualities which have been used for the advancement of not only education but in the wider sense for the benefit of industrial work generally."

The President here formally handed the Institute Medal to Mr. Abbott.

The medal recipient, Mr. A. Abbott, having received the award at the hands of the President, first thanked the Council of the Institute for the honour conferred upon him. He found it difficult, he said, to imagine anything that could have given him more satisfaction at the end of his official career. He then referred briefly to the interest he had, since a young man, taken in the Textile Industries, and said that that interest had become for its own sake all-absorbing. On the subject of Textile Education, he continued, he was perhaps able to contribute something of interest.

" Textile education began about 1879 with the establishment by the City and Guilds of London Institute of examinations for textile students. All of us are familiar with the magnificent work done for textile students by this Institute; but I am not sure that the present generation always realises clearly what skill, what energy, and what thought were put into the task of framing syllabuses and schemes of instruction by the pioneers of textile teaching. They had no guidance whatever from precedent and had to drive a road through country entirely unexplored, since the notion of providing technical instruction relating to industries with no known scientific basis was completely new. I have known most of these men, some of them very well indeed, and I believe that as long as the textile industry is carried on in this country, their names should be held in grateful remembrance by textile students and by the Textile Institute.

Technical education is divided rather sharply into two types, first, that which started in the universities many years ago and is working slowly downwards towards the needs of the craftsman; and, second, that which began with the needs of the craftsman and is working slowly upwards towards the standards of the university. Education for the engineering and chemical industries belongs to the first type, while that for the textile industries belongs to the second, and it is this only with which we are here concerned.

" In the earliest stages, textile education included nothing more than a careful description of existing processes and current practice, together with such instruction in drawing and calculations as was found absolutely necessary. As it became more highly organised, what are called ' grouped courses of instruction ' were developed and every textile student was encouraged—or even required—to attend classes in one central textile subject and in several ancillary subjects, such, for example, as mathematics, machine drawing, mechanics, and the elements of textile design.

" As regards the central textile subjects, the criticism which might have been made twenty years ago of the instruction in spinning was that it devoted too much attention to the mechanical side, to the neglect of the textile side, of the process. It showed in great detail how the complicated machines worked, but took little note of the effect they were exercising on the fibres and on the arrangement of the fibres. This was not very satisfactory, since in fact the permanent matters for consideration are the functions of opening, cleaning, attenuating, regularising, and so on. The arrangements for performing these functions may be transitory: they certainly have not been settled for all time by the designers and makers of spinning machinery, but are capable of improvement—and possibly of great improvement. As regards the teaching of weaving, exactly the opposite criticism might have been made. The instruction devoted too much attention to the structure of different cloths and too little to the mechanism of the loom. Further, the very important operations between spinning and weaving, that is, winding, warping and sizing, were almost entirely neglected.

" You will realise that, in saying this, I am not detracting in the least from the value of the work done by the pioneers of textile education, but am merely describing a phase in the evolution of this type of education, a phase which was inevitable and is now disappearing.

" The steady encouragement of scientific research into textile problems by the Textile Institute since its foundation, and the establishment of great Research Associations for the cotton, woollen and worsted, silk, and linen industries about fourteen years ago mark a fresh period in the history of the textile industries. Until recently, the whole of the processes which precede the various operations of finishing were carried on by traditional methods into which modern science had scarcely begun to penetrate. Now, organised research on a large scale is being conducted for every branch of the industry; and this circumstance has a most important bearing on the education provided in the

textile schools. It is obviously no longer sufficient to give those responsible for the future conduct of the industry a full and accurate knowledge of the processes now in use, since some of these may at any time become uneconomical and therefore obsolete. The future responsible officers of the industry, that is, the managers and managing directors of textile factories, must be able to see readily the relation to textile practice of every new discovery made by their research organisation and be swift to apply it in the mill or works ; they must also have the knowledge and ability to distinguish clearly between the problems which it is their own business to solve and the other problems of general interest and importance which ought to be referred to their research organisation. The mill and the Research Association should in fact be complementary organisations, each furnishing the other with appropriate knowledge and each benefiting by the other's experience.

" This relationship between the scientific and the producing organisations does not exist ; and it cannot come into existence until there is a clear recognition by the industry of the far-reaching consequences of the educational changes that have taken place during the last few years.

" This country began to organise its educational affairs at a later date than did most of its continental neighbours. It was not until 1870 that it began to create a real system of elementary education, which was not substantially completed until the end of the nineteenth century. In 1902, it entered upon the task of establishing on the basis of its system of elementary education a wide-spread and effective system of secondary schools ; and this task, like the first, occupied about thirty years. What is to be the third step in our educational progress ? In my opinion it will probably begin by making the Secondary School a more flexible instrument, but the main task will be the building up of a real system of technical education on the sound foundation of a satisfactory and complete scheme of general education, both elementary and secondary. Technical education will thus tend to be differentiated into two grades—one post-elementary and the other post-secondary in character. This differentiation already exists in a number of countries on the continent of Europe, whose educational systems have been highly organised for generations.

" It is impossible to suppose that an industry which has established four great Research Associations for the scientific investigation of its problems will remain contented to have its mills and works staffed by responsible officials who are not fully competent, from their abilities and attainments, to utilise the results obtained by these associations. It ought to demand, and I believe that it will demand, that these officials shall have received a technical education of the very best type, namely, one based on a prolonged general education. Unless it does, much of the expenditure on scientific research will have been wasted, and the industry in which we are all so greatly interested will not increase in efficiency. This is a prospect which none of us can contemplate with equanimity.

" You will see that what I am suggesting is that the method of recruiting the personnel of the textile industry shall be reviewed and modified in order to be in harmony with modern educational conditions ; in my opinion, this review and this modification are overdue.

" For let us look at the facts. A generation ago, the elementary schools of the country sent into industry and commerce every year a great stream of boys and girls of every grade of ability, and an industry which recruited mainly, or even entirely, from the elementary school was fairly certain that out of this stream there would emerge a sufficient number of young men who, by reason of their diligence, their capacity and their physique, would eventually reach positions of responsibility—in some instances of the highest responsibility. It is known to all of us that many of the leaders of the industry finished their full-time education at the age of thirteen or fourteen and were greatly helped in their

efforts to add to their qualifications by attendance at technical schools during the winter evenings.

" But the elementary school no longer sends out the same kind of stream of boys and girls that it did a few years ago. The very best of its pupils are now transferred at the age of 11 or 12 to Central schools with a leaving age of 15, or to secondary schools with a leaving age of at least 16; and it is amongst these pupils so transferred that the future leaders of many of the activities of the country will be found. It is certain then that any industry which fails to reorganise its methods of recruitment and selection in accordance with modern educational developments is likely in a few years to find itself with an inadequate supply of young people of first-rate ability, who will ultimately be fit to take upon themselves the responsibilities of leadership. In saying this, I am most certainly not suggesting that the responsible officers of the industry should come in future from a different stratum of society, since, if the policy I have described were adopted, they would come from exactly the same social strata as before, but would arrive at their positions after following a different and a better path.

" I have hesitated a long time before speaking so plainly about this matter, but I am sure I should not be treating you very well if I did not take this opportunity of acquainting you with the facts and of indicating to you that the recent changes in our national organisation of education are far more than educational achievements; they have inevitable economic and social consequences which are of profound importance to your industry and to those dependent upon its prosperity. In my view, the future prosperity of the industry depends in a very great measure on its clear realisation of what these consequences are and on its determination to act resolutely and promptly when once it has grasped their significance. The problem is difficult and delicate; it is one for the industrialists and not for the educationists, who can only watch with interest and sympathy the progress of the attempts to solve it.

" Finally, let me once more offer my thanks to the President and Council of the Textile Institute for the honour they have conferred upon me. I am indeed proud to be considered worthy of it."

Mr. Frank Nasmith, proposed a vote of thanks to the Chairman, whose enthusiasm in Institute service, he said, they must all appreciate. He recalled an example of their President's work in the direction of an attempt to set indigo standards. Mr. Garnett had always been in the forefront of their work: his had been the role of a pioneer. Mr. Abbott had spoken of the pioneers in textile technical education. In the early days of his (the speaker's) life, he was closely identified with a great deal of that work; his father having been associated with the movement. He thought it fitting to recall such workers as Mr. J. H. Reynolds and Mr. S. Watson, who was present that day. It was a particular pleasure to move the vote of thanks to the chairman as he had taken such an enormous amount of interest in work of this character.

Councillor Wright Robinson, Chairman of the Manchester Education Committee, seconded and said that Mr. Garnett's work reminded him, of a recent speech by the Lord Mayor who had said that while many of them, busy with municipal work, imagined that all good work was done within the bounds of the Council, there were associations outside the municipal confines, which, like the Textile Institute, were always working for the community's benefit. He knew that Mr. Garnett had done a tremendous lot of work to build up the Institute during the 23 years of its existence. It was done at a great deal of personal sacrifice and inconvenience. For all this they were deeply indebted to him.

Mr. Garnett, in reply, said he had enjoyed the event immensely. He felt that it had been one of those gatherings where each had gained more than he had given.

TEXTILE MACHINERY EXHIBITION, LEICESTER

The Textile Machinery, Yarns, and Accessories Exhibition held in Leicester from October 7th to 15th, affords a striking demonstration of the progress which has been made, since the last exhibition was held three years ago. Particularly impressive are developments made in fancy fabrics, undoubtedly due to the attention machine builders have paid to the development of multi-purpose machines and the realisation that fashion changes soon cause the obsolescence of those built for a single purpose.

Whilst rapid strides have been made in the building of flat machines, the circular machine enthusiasts are attempting with some success to knit a range of products on both bearded and latch needles hitherto producible on flat machines alone.

There is apparently a tendency to increase the speed of machines in knitting, together with a definite leaning to finer gauges, one being a natural corollary of the other. It is particularly refreshing to see that at least 75 per cent. of the machinery displayed is of English manufacture and then to turn to an adjoining stand where there is an attractive range of fabrics produced by them. The demand for fine-filament dull rayon yarns, so evident in the past few years, shows no indication of waning, whilst high twists and grenadines are still the feature of pure silk displays. There is a marked increase in the number of coning machines built for surface drive, and little doubt exists that this feature, by giving constant yarn speed, permits the more accurate control of tension, apart from the consideration of increased speed. All these machines are characterised by the absence of " pattern," until recently considered the hall-mark of good coning. This is brought about by the design of the traverse motion. Something of a novel character in winding machines is to be seen in a vertical circular rotatory machine. The cones are driven by drums arranged in pairs vertically, around the machine. The thread traverse guide arms are fulcrumed at one end, and about midway are situated the control lugs which work in the groove of the eccentric. It is obvious that by this means the pitch of the cam is halved. And again, by the employment of one common cam which revolves at high speed inside the machine the pitch is still more reduced. This machine can be built to be slowly rotating so that each spindle comes before the operative in turn for attention. The maker's claims are absence of torsion, longer life, and economy of space, but it is debatable whether the stationary position of the operative is conducive to the reduction or to the increase of fatigue.

The general tendency is to obtain higher yarn speeds by means of ball bearings, vibrationless spindles, enclosed gears with forced lubrication, and overhead frictionless centres. A honeycomb wind is featured for cone-dyeing or lubrication. This is remarkably regular and must undoubtedly tend to give even distribution of liquor.

In hose and half-hose machines the drive towards finer gauges is still being pursued, 340 needle $\times$ $3\frac{1}{2}$ in. diameter being exhibited in seamless hose and 60.G full fashioned, whilst 220 $\times$ $3\frac{1}{2}$ in. half hose only foreshadows the 240 and 260 needle machines on which experiments are in progress.

The trend of fashion towards the fish-net or mesh hose is evidently anticipated to reach its height next summer. New machines are capable of producing this type of hose, but may also be used for the production of plain hose when fashion veers round again to this type as it always does after each novelty type has had its day.

It was gratifying to see the range of BRITISH Seamless Hose machines as well as Children's Sox machines with all modern features. Surely now is the opportunity for British machine builders to capture the trade which has been in the hands of other countries. This range was from 300.N to 340.N $\times$ $3\frac{1}{2}$ in. diameter. Mesh or fish-net hose are produced with shadow clox or plain hose with neat lace clox, mock fashion marks, well designed Cuban heel splicing, and

slipper foot sole reinforcements, with toe guard. The special features of these machines are as follows:—they are capable of graduation of stiffness from knee to ankle, the same speed is maintained through heel and toe as for the rest of the hose, viz., 210 r.p.m. They quickly restart after a "press-off," without racking through heel and toe, the chain and drums are readily accessible, and there is selective mechanism for every needle. The most recent machines from the U.S.A. displayed novel features. In seamless hose a 300 × 3½ in. machine produced the new "Square" heel, which makes a very creditable imitation of a full-fashioned hose when incorporated with the "Gussetoe" which is now quite familiar. This new heel is obtained by a re-arrangement of the picking and depressing of the needles during the making of the heel. A comprehensive lace design in the welt, which has also a picot edge, helped to produce a hose which was a good imitation of the full-fashioned type.

At the same stand was exhibited an 80 wrap, 220 × 3½ in. half-hose machine, capable of plated as well as solid ground and individual selection of 80 needles for patterning with 80 different coloured threads if desired. All the fingers wrap, and needles that are required for pattern are selected by trick wheel control. This machine which also incorporates the "Gussetoe" has a trapper and scissors mechanism to cut off floating threads during the high splicing and sole splicing and the whole of the superstructure is hinged, to allow easy access to the needles and cylinder. Very neat patterns may be obtained with judicious choice of colours for the wrap.

No full-fashioned machinery was displayed, though here again, by the information obtainable on the stands, the tendency to finer gauges also exists, 60 gauge being provided by one exhibitor. For many years provisional patents have been taken out for producing leg and foot on the same machine in one process, and to-day a very creditable hose is being made in this way. The advantages claimed are that the same texture can be obtained below as above the ankle, and that female shift workers used for running-on are eliminated, and a day-work operation of single thread linking substituted. The method used is that of a divided needle bar, the middle portion of which may be withdrawn at the division for heels and the main thread carrier put out of action. When the heels are "pressed-off," knitting is commenced on the side portions again for the necessary roving waste and the middle needle bar section is restored, the procedure then being the same as for normal French footing. Nearly all features hitherto solely to be found on continental machines are now obtainable on those of English build.

When plain circular fabric machinery is considered from the British machine builder's point of view, the production of interlock fabric appears to be the main attraction. Special attention has been paid to the fact that these machines require finer counts per gauge than the ordinary machines. New stop motions and compensating devices to minimise yarn drag when starting and running the machine; hinged guides to facilitate cleaning; inserted tricks and automatic lubrication all help to avoid stoppages and maintain a 20 per cent. increased speed. It is also claimed that rayon, cotton, or wool may be knitted on the same machine with only the necessary stitch adjustment. Another notable feature is the 4-colour horizontal striping attachment to these machines.

The advantages of the manufacture of garments or parts of garments on circular machines are particularly marked in the fancy circular latch needle machinery section. What are known as 2 × 2 ribs, with 1 × 1 welt and draw thread, can now be produced on circular machines with 4-colour striping attachments, and a dial racking device. The production in this case amounts to four or five times that of a flat machine. On these same machines an automatic change from the 2 × 2 rib border to 1 × 1 rib fabric is possible.

The patterning scope on the circular jacquard machinery has been considerably increased. It is now possible to obtain from the same machine true 3-colour

jacquard fabric with a single needle selection; imitation lace and hand-knit effects, together with roll welt fabrics. It has been found possible to obtain the various novelty stitches by the introduction of new cam selections which are operated in conjunction with the particular jacquard selecting device used.

In view of the fact that circular machine builders are focussing their attention on the fancy trade, flat machine builders are developing their greater patterning possibilities, and at the same time exercising greater economy in the use of selecting elements. The latter have in the past been one of the most expensive items in the cost of flat fancy fabrics. The control of operations other than needle selection, by pasteboard cards has become almost universal. In some instances these cards may be racked in either direction, for a given length, thus obviating the use of duplicate cards. The racking of the steel jacquard cards in either direction together with the racking of the back needle bed presents unlimited design scope with very little extra cost. One system of card economy was carried out by the employment of sliding bars, movable from both or either ends, to bluff the selective action of parts of the steel jacquard.

With regard to the increased patterning possibilities special cams have been introduced to produce royal stitch effects combined with the jacquard base of the design, together with lace stitches, chenille effects, racked welt effects, and a tone intarsia fabric all on the same machine. The fact of being able to select on both needle ends, together with the production of an automatic welt and 2 × 2 rib change to pattern when desired, still leaves the flat machine in the front with regard to outerwear fabrics in the medium and higher grades. Two further features worthy of mention are the increased design possibilities on purl machines. It is now possible to transfer needles backwards and forwards at each traverse of the carriage and this changing of needle position is not confined to changing from back to front in one direction and front to back in the other direction as hitherto. Intarsia effects and 2 × 2 rib with automatic welt combined with new jacquard roller operations have brought the purl machine once more into prominence, especially since the new import duties have been levied.

Some attention has been paid to the increase of production on flat machines by the use of automatic lubrication, chain drives, and special gearing. Owing to the increased speed of the machines, it has been found necessary to install electrical or mechanical stop motions and anti-locking devices on the carriage. Although several attempts have been made to introduce the triple system of knitting, and several successful systems were shown, the double system principle on both the purl and ordinary machines appears to be most in favour. The introduction of sectional tension rollers to obviate the "bow" effect so detrimental to flat fabric is a feature likely to become popular. The final point of interest is that machine builders have realised that one of the great advantages of the flat machine over the circular, is its adaptability to various widths, and additions have been made to facilitate the reduction or increase of width as desired.

Midlands Section

Meeting at the Granby Halls, Leicester, on Thursday, 13th October, 1932, on the occasion of the Textile Machinery Exhibition: Mr. T. Morley in the Chair.

WINDING FOR THE HOSIERY TRADE*

Essentially winding is a non-productive process just as are all those processes which can be classed generally as preparatory and which lie between the spinning spindle and the loom or knitting machine. Yarn when it leaves the spinning mill or the rayon factory is rarely in a form which can be used as a supply for either the loom or the knitting machine. It is wound into cops, on to bobbins,

* This report is an abstract of a paper read to the Midlands Section by Mr. T. A. PURT (Universal Winding Company).

or is made up in cake form, and in such form contains all the imperfections which are inherent to spun yarn. These imperfections must be removed if the ideal form of supply for fabric production is to be secured, and it is in the effectiveness of the processes through which the material passes, and the efficiency of the machinery employed, that the quality and real value of such ultimate form of supply is determined. The point to be emphasised is that good or bad winding has a very decided bearing on the efficiency of the subsequent process of fabric structure and the quality of the material produced.

In the Hosiery Trade many different types of knitting machines are employed, each of which calls for its own particular form of wound supply. It is imperative that the supply should be such that the yarn is delivered to the knitting needles uniformly, and with a minimum of drag or tension. When we take into consideration the action of that delicate piece of mechanism—the knitting needle—it is not difficult to realise that unless material is being fed to it regularly and evenly, it will not function in unison with its neighbours and irregularities are bound to appear in the fabric. In certain knitting machines Sinkers are used in conjunction with the needles and are responsible for the length of the loop drawn to feed the needle, but even then, regular or even loops cannot be obtained if there are any irregularities or unevenness in the winding supply.

Hosiery Machine Builders have gone to considerable trouble and expense in designing a feed device or measuring wheel which is usually embodied in multi-feed Circular knitting machines, to ensure that the yarn is supplied to each feed at a regular tension. Apparently the builders of the knitting machines who introduced these devices are aware that there are methods of winding employed which will not provide a uniform supply, and so they have been driven to fixing feed-wheel devices in order to safeguard themselves and all users of their machines. But even with such a device, if there is any drag or snatch from the supply package, in spite of the action of a compensator, a strain is bound to be imparted to the yarn, and in the case of very delicate fibres there is every possibility that the effect of that strain will appear in the fabric. The moral is obvious—secure perfect winding.

In many sections of the Hosiery Trade it is unnecessary for the manufacturer to do his own winding. He can obtain all his yarns wound on to cones of such quality that, barring the risk of damage in transit, these cones can be placed directly on to the knitting machines with excellent results. Very often the additional cost imposed by the spinner for winding is so small that the operation could not be performed any cheaper in the Hosiery factory. Although, however, no saving may be effected, many manufacturers prefer to undertake the responsibility of doing their own winding in order to have it under their own control and ensure its correctness and quality.

In an attempt to cover as far as possible the winding requirements of the various branches of the Hosiery Trade, I will start with knitted footwear, hose and half-hose ; not forgetting, of course, three-quarter-hose and socks. On the coarser gauge half-hose and similar machines the quality of the winding is not perhaps of so much importance as regards its effect on the appearance of the knitting, owing to the fact that any irregularities may not be so apparent as they would be in finer gauge machines and disappear when the goods are finished. But with plated goods, such as the fancy designed half-hose and plated hose which are in vogue at present, quality plays a much more prominent part, for without good winding perfect plating cannot be obtained.

When considering fine-gauge Hose machines, manufacturing rayon, silk and mixture goods, the manufacturer pays really serious attention to the winding question. When artificial silk was first introduced as a standard textile fibre, a problem of paramount importance arose, and one that has still to be considered

even to-day. The problem is to find a more satisfactory method of winding this material. The words " more satisfactory " are used because there are only two systems of winding to consider—namely, cones and bobbins. The question of single or double process winding will not be discussed for the moment.

In America, it is very difficult to find a mill knitting from anything but cones, whilst on the Continent, I have been informed by a prominent German manufacturer, that this form of supply is practically unknown.

In this country bobbin winding was considered for many years the only satisfactory way of providing a suitable package for a knitting machine. Cones for some unknown reason were taboo, in spite of attempts made by winding machine builders to introduce this system, and it is only within the last few years that manufacturers have begun to realise that cones are an ideal supply for Hose machines, assisting greatly in the production of perfectly knitted goods, and, what is also of great importance, hose of equal lengths. It may well have been that earlier forms of cone-winding machines did not produce a yarn package that ensured even and regular delivery. With the development of precision winding the production of perfect cones became an every-day operation, but considerable difficulty is sometimes experienced to-day in persuading an old-time cone user that this is so.

To meet the Hosiery manufacturer's demand for wound yarn, rayon producers had to send out supplies wound on bottle bobbins. The bobbins had to be accurately made and were fairly costly, especially since enormous stocks had to be carried. This meant capital lying idle, and the cost had to be passed on to the manufacturer as a safeguard against the return of the bobbins. After a time they became unfit for use—except for feeding the furnace. Against this system, with the increasing popularity of the cone, a supply is provided which is not only better from the Hosiery manufacturer's and knitting machine operative's point of view, but also from the point of view of the rayon supplier. The paper cone on which the rayon is wound is better in every way. The first cost is not so great, the cones are considerably lighter, showing a saving in transport costs, and are produced of such a quality that they will give effective service over a very considerable working life.

A recent development is the use of cones as a warping supply for beams for warp knitting machines. For this purpose a creel has been specially designed to carry the cones, which are so mounted that the yarn withdraws freely over the apex of the cone. This obviates all the difficulties and limitations which arise where revolving spools are used. The cone holders are fitted with a felt covered disc, pressed against the base of the cone by means of a spring. This arrangement prevents the yarn from slipping off the conical face of the cone near its base. After leaving the cone the yarn passes through a tension device carefully designed and constructed to provide a uniform tension. The yarn next passes forward to the front of the creel, through auxiliary guide eyes and so to the warper. Stop motion detectors may be applied to the creel at these auxiliary guide eyes. These detectors operate electrically to stop the warper on the breakage of an end. The advantages of using a cone as supply for warping are increased warping speeds, and productions, reduced warping costs, improved warps, with all the ends under more uniform tension, and reduced waste losses. If the " magazine " system is adopted, enabling the creeling to be carried out without stopping the warper, the productive efficiency is considerably increased.

The question of knitted foot-wear cannot be left without referring to the winding requirements of what is probably the most important end of the Hose trade, the manufacture of silk hose on full-fashioned machines. This is an industry which is rapidly growing in this country. For many years the idea prevailed that a bobbin must be used—but conditions have changed considerably in this end of the trade also, with the result that to-day many manufacturers are knitting silk hose exclusively from cones.

The cones used for this purpose have a slightly different taper from those employed for rayon, and instead of a solid cone being wound, one with an open or honeycomb effect is produced ; in fact this type of cone is commonly referred to as having a honeycomb wind. During the winding process the silk travels over a roller which revolves in a trough containing emulsion, in order to condition the silk and render it soft and pliable for the knitting process. As the silk is heavily saturated with the emulsion something more substantial than paper cones have to be used for the purpose, and to get over this difficulty either an aluminium or a solid wooden cone is often used. It is generally recognised that with this form of winding, very even saturation of the silk can be secured, and the evenness is maintained right through from the full to the empty cone ; a very necessary condition for the production of good quality fine-gauge silk hose.

The manufacture of Knitted Underwear is probably one of the largest sections of the Hosiery Trade and has many different branches :—Goods are made from wool, cotton, silk, and rayon, and various combinations of these fibres. Ribbed, plain, fleecy and warp fabrics, and Interlock fabric, which is really in a class by itself, are produced in the piece from which the required garments are cut, whilst another method is to fashion the garment to the required shape on a flat machine before finally making up.

Probably the best way to estimate the winding requirements for all the different knitting processes is not to consider the machine so much as the class of yarn to be used as a supply. Reference has been made to the methods of winding and beaming for warp-knitting machines, and the same system of cone winding for rayon and silk can be employed on circular knitting machines with equal advantage and also for circular hose machines. Cones containing as much as 2 lbs. of yarn can be put on the machine, and as several types of circular machines used in the production of underwear fabric have as many as eight feeds, a 16 lb. piece of fabric can be knitted without a change of supply, and, if the cones are properly wound, without a single stoppage.

For wool and cotton yarns an entirely different type of cone is required, and undoubtedly the best is that known as the increasing taper cone with a convex base and concave top—probably better known as the Foster type cone. Many underwear manufacturers are using this system of winding to-day on yarns varying from fine Single Combed Cotton to heavy Woollen and Worsted Yarns. The production of the machine on which these cones are wound is high, the yarn is mechanically inspected for slubs, knots, and thick places and the finished cone forms an ideal supply for any knitting machine. This type of winding can also be applied to the production of fabrics for Outerwear, for which the knitting process is carried out on similar types of machines to those employed in the manufacture of underwear fabrics.

" Probably by this time," continued Mr. Purt, " you will have come to the definite conclusion that I am an advocate of Cone winding entirely, and I think I can safely say that there is not a single type of knitting machine on which cones cannot be used and used with distinct advantage."

Coning machines used in the hosiery trade can be divided into two classes—machines with positively-driven spindles, and machines where the cones are rotated through frictional contact with a revolving drum. The former type is to be recommended for fibres such as silk and rayon, because whilst a friction drive can be used for winding cotton, woollen, and worsted yarns, if such a system was used for rayon and silk, a grave danger would be incurred of damage to the delicate fibres.

In coning machinery of the positively-driven-spindle type, the spindle speed is constant, which means that as the diameter of the cone increases, so the yarn speed increases, causing greater ballooning of the yarn and consequently increasing the yarn tension. This increase in tension is, however, automatically corrected by a reduction in the tension, applied by the tension device as the cone increases

in diameter. In machines where the cones are driven by a rotating drum, the yarn speed of course is constant. A description of various winding machines (mostly on exhibit at the time) then followed.

" The question of winding for the Hosiery Trade is really a very fascinating one," the lecturer concluded, " and is as important a factor for the production of good hosiery as a sound foundation is for the construction of a solidly built factory, and it is well worth the while of every manufacturer who does his own winding to look to his plant and assure himself that this operation is being done well and economically."

NOTES AND NOTICES

Institute Competitions: Fabrics and Yarns

The distribution of prizes, amounting to £150, in connection with the Annual Competitions of the Institute, has been fixed to take place at the Institute premises, Manchester, on the afternoon of Saturday, 3rd December. The prizes will be presented to the successful competitors by Professor Aldred F. Barker, of Leeds, and the chair will be occupied by Mr. John Crompton, Chairman of the Competitions Committee. The exhibits of the competitors will be displayed and it is possible to state that the display will be of exceptional interest. As a whole, the contributions are excellent and more numerous than usual. In the main competition for woven fabrics, there are 13 exhibits; 11 of yarns; 22 special woven fabric; 12 woven fabric by special students; and 13 knitted fabric. The section for knitted material is included for the first time and the work presented is of a promising character. In regard to the scope of the Institute Competitions, the question of inclusion of a section for designs for printed fabrics is at present under consideration. During the whole of Friday, 2nd December, the day previous to the distribution of prizes, the competitors' work will be on exhibition at the Institute and the attendance of any Members or friends will be appreciated.

Lancashire Section Meetings

The papers secured for the current session of meetings of the Lancashire Section of the Institute are proving of substantial interest, and improvement in attendance of Members is indicated. The opening meeting (21st October) when Dr. R. H. Pickard, F.R.S., opened a discussion on the "Usefulness of Laboratory Tests in regard to the Stapling of Raw Cotton," was of a successful character. The second meeting of the session was held at Bolton on the evening of the 4th November. Unfortunately, the lecturer was prevented from attending by reason of illness, and, at a few hours' notice, Mr. Alfred Bayes, A.T.I., very kindly undertook to give an alternative contribution. An excellent meeting resulted, the event being a joint gathering of the Lancashire Section and of the Bolton and District Managers, Carders, and Overlookers Association. Mr. Bayes supplemented the discussion of " Stapling " introduced at the previous meeting at Manchester, and his contribution on this subject is at present under consideration for publication in the *Journal.*

Retirement

Mr. E. H. Smirk of St. Annes, clerk in charge of Accounts, under the Lancashire Education Accounts Sub-Committee, has just retired after forty years of service in relation to county affairs. Mr. Smirk has been in close touch with technical education in the county. For over twenty years past, he has been in charge of the county scheme of Prizes for Collections of Woven Fabrics, the scheme being organised by the Cotton Industry Sub-Committee which has latterly become the Textile Advisory Sub-Committee. Mr. Smirk has been in close touch with this Institute for a number of years and carried out the arrangements for the Lancashire Education Committee's annual competition for students in weaving. In this connection, the Competitions Committee of the Institute has acted in an adjudicatory capacity for several years past.

Textile Institute Diplomas

Election to Associateship has been completed as follows since the appearance of the previous list (October issue of this *Journal*)—

ASSOCIATESHIP

BARNES, Harry Cheetham (Romiley).

Institute Employment Register

The following announcements are taken from entries in our Register of Members whose services are on offer. Employers may obtain full particulars on application :—

No. 85—Textile Machine Erector ; 38 years ; Mill experience, home and abroad ; certificates in cotton spinning, etc., and author of articles on spinning and cardroom problems and calculations ; desires position in Cotton or Rayon.

No. 88—Cotton spinning, inside manager ; 28 years ; Secondary education ; A.T.I. ; good practical experience, including cotton mixing and testing.

No. 89—Manager, cotton spinning ; 47 years ; first-class experience in yarn production including mixture and speciality yarns.

No. 90—Assistant weaving-manager or assistant in testing ; B.Sc.Tech. ; under 24 years ; would consider any suitable post.

No. 91—Assistant manager, or in administrative capacity ; 27 years ; single ; teaching experience, A.T.I., M.Sc.Tech.

No. 92—General manager or technologist in worsted or woollen industry ; 10 years' practical experience ; Textile Diploma (Leeds), F.T.I., M.Sc., Ph.D., A.I.C.

REVIEWS

Mechanical Fabrics. By G. B. Haven. Published by Chapman & Hall, Ltd., London. (892 pages and Index Price, 62/6 net.)

It is a natural custom, when writing on a subject which one has made a life study, to claim a bright and expansive future. So this book begins with a reference to " The expanding use of strong textile fabrics," and continues through 905 pages to detail sufficient examples to justify the hope implied. Such materials certainly shared in the general expansion of production experienced in recent times but complacent trust in an automatic tendency has a doubtful foundation, nor is it the viewpoint from which the necessity for scientific research is appreciated. Primitive nomads were housed under textiles and used them for construction, storage, and transport to a degree relatively greater than in modern life. The engineer likes materials which he can mould more uniformly and positively to his designs and still counts it as gain whenever he can substitute metal or composition for a textile To check or reverse this tendency, it is necessary to gain equally effective knowledge of the nature and processing of fibres, to realise fully the peculiar advantages of textiles in their combined pliability, strength and lightness, to produce them closely to specification and to let the engineer know about it. This work is a record of great activity in the last two directions, associated with the Massachusetts Institute of Technology, where the author is in charge of Textile Research.

Textile science advances by marauding bands rather than as an organised army and a survey of the field is necessary to appreciate the relation of the scattered groups. The position as a whole cannot be judged from any one of the many treatises which are appearing. Some groups approach from the standpoint of pure chemistry and physics, seeking fundamental knowledge of the fibre materials. This may result in profound changes and development in the use of textiles, of which rayon provides sufficient earnest, but it has a large element of hope, speculation, and academic specialisation. One may reasonably exclude the colloid science of fibres from a treatise intended for the practical engineer and it certainly leaves little mark here.

A second approach is to study the behaviour of the material in relation to the processes and use to which it is subjected—in contrast to the first, where the

material is rather an interesting subject for novel applications of scientific methods. Such a viewpoint disciplines the scientific interest by contact with the realities of human needs and represents a modern development of profound significance to both science and industry. It brings confidence and efficiency in the control and steady improvement of present technique ; evolution rather than revolution. A reasonable claim might be made that this is particularly the characteristic of textile research in Britain. We are, perhaps, not as ready to tell the world as our overseas cousins but enough has been published in the pages of this journal to correct, define, and expand many statements to be found in the book under review.

On questions demanding a scientific understanding of the character and behaviour of the materials, it is necessary to give a general caution, as silence might be interpreted as agreement and detailed discussion of all debatable points would occupy a book of the same order of size. To anyone familiar with British work, abundant examples will be found in the discussion of moisture relations and in the analysis of mechanical properties in relation to those of the fibres, to the fabric structure and to the conditions of measurement. Only the last is treated thoroughly but rather in regard to the testing machine than to the physical study of the behaviour of the material. Indeed throughout, the work develops from a standpoint distinct from either of the two referred to above. The interest lies in the machines, of production, control or test, and the research consists in designing and using them so that their operation is not disturbed by the behaviour of the materials. It is a case of one mechanical engineer addressing an audience of the same ; and perhaps this is a sound line to take in presenting textile questions to outside users. They are concerned with the accomplished technique, content to leave possibilities to the textile specialist, and desire the achievements to be stabilised for their own external applications. To meet this need, Professor Haven brings a rich experience and makes a positive contribution.

Instrumentation, simplification, and standardisation represent ideals appropriate to the extended application of perfected technique and may supply a sound foundation for continuous technical development if applied with discretion. They have a great vogue in America and the value of this book is as a collection of the results of an intense, organised activity in the service of such ideals. It is 100 per cent. American and all statements regarding priority, uniqueness, and incompleteness of work must be taken with this limitation.

The whole treatise is compiled from three sources ; American commercial catalogues, documents of the American Society for Testing Materials, and theses from the Massachusetts Institute of Technology. In consultation, committee work, and teaching, the author has had wide and active practical experience and he brings together a great deal of information, valuable alike to the engineer and textile specialist. It would be no less valuable and more available if the 905 pages were cut down by condensing independent treatments of the same subject, complete with introductory generalities and illustrations (compare Figs 207 and 245) which are scattered almost at random, as they happen to come from the contributory documents. The data of Chapter V might be condensed with advantage and the long tables of Chapter VIII represent rather premature generalisation on incomplete analysis. Some of the work might find a more appropriate home, such as the 20 odd pages on rayon, while many matters of general textile interest, such as opening of cotton and the organisation of textile mills, might be condensed as they cannot be effectively treated in the present connection. By including all the activities of the author, the matter of value to the mechanical engineer is rather overlaid but it will be a useful source book to those who seek to meet the needs of the engineer by more reliable and suitable textile materials. To avoid disappointment it is as well to indicate that on the design, weaving, finishing, doping, etc., of fabrics used by mechanical engineers and on the relation of the measurable properties to the fabric structure and to performance in use, there is next to nothing, beyond some A.S.T.M. specifications. Nevertheless, one hopes that standardising authorities will not take the easy way of adopting first attempts at systematic method, which may become established while the study necessary to mature decisions is still in progress.

F.T.P.

The British Launderers' Year Book for 1932-33. Published by the National Federation of Launderers, Ltd., London.

This Year Book should prove of interest to all users and is certainly a very comprehensive document. There are brief statements of what the Federation has done in the past, of its Service Departments and references to work in prospect. The wants of the Federation's Members have been anticipated as far as possible in regard to information and sources of information and a very real attempt made to supply the requirements. T.

GENERAL ITEM

Depreciation Rates and Income Tax

The *Incorporated Accountants' Journal* for October, 1932, contains an article under the above heading which will be of interest. It records that the following addition has been made to the list of agreed normal rates of depreciation for Income Tax purposes since May last :—

COTTON SPINNERS AND MANUFACTURERS: EXPENDITURE ON ADAPTATION OF PLANT AND MACHINERY.

The Board have had under discussion with representatives of the Cotton Spinners' and Manufacturers' Association the question of the treatment of expenditure upon adaptations of plant and machinery in the Cotton Industry arising out of the introduction of the " more looms per weaver " system. It is understood that such expenditure will usually be susceptible of classification under the following headings :—

(1) New shuttles and shuttle stands.
(2) New pulleys.
(3) Spare cloth rollers and brackets.
(4) Warp stop motions.
(5) Weft stop motions.
(6) Shuttle boxes extended.
(7) Sley repairs and renewals.
(8) Fitting two box motions.
(9) Pick and pick motions.
(10) Conversion of ordinary looms to circular box looms for weaving ordinary cloths.
(11) Pick counters.
(12) Alterations to ring spinning frames (new ring rails).
(13) New ring bobbins.
(14) Alterations to mule frames to make larger cops.
(15) High speed drafting (for use in cheaper cottons).
(16) Re-winding machinery.
(17) Automatic weft feeding attachments.

It has been agreed with the Association on behalf of its members that the outlay in question should, subject to the approval of the Commissioners concerned, be dealt with in the following manner :—

(1) and (13) New Shuttles, etc. ; and new ring bobbins : Outlay under these headings may be dealt with as if it represented expenditure on further supplies of the ordinary type ; surplus stocks of the old type may be allowed to lapse from the stock figure.

(7) Sley repairs and renewals : In view of the difficulty of distinguishing between outlay under this heading arising in the ordinary way and outlay arising in connection with the adaptation, the whole may be regarded as revenue expenditure.

(16) Re-winding machinery : These machines are complete and separate, and the normal rate of wear and tear for process plant is to be applied.

All other headings : The outlay is to be regarded as capital expenditure, but a special rate of wear and tear allowance, i.e., 12½ per cent., or written-down value, is to be applied for the first five years following the date of the outlay. The balance remaining is then to be treated as process plant, on which the ordinary rate (normally 7½ per cent.) is to be allowed, unless some further arrangement is then made. T.

THE JOURNAL OF THE
TEXTILE INSTITUTE
TRANSACTIONS

20—AN APPARATUS FOR SCOURING SMALL SAMPLES OF WOOL AND A MODIFIED APPARATUS FOR DETERMINING DRY WEIGHTS

By W. C. MILLER, M.R.C.V.S. and D. M. BRYANT, B.Sc.
(Institute of Animal Genetics, University of Edinburgh.)

INTRODUCTION

In connection with certain investigations on which we were engaged, involving the determination of the clean dry weights of large numbers of small samples of wool, it became necessary to devise a means of performing the scouring and drying operations as rapidly as possible.

The descriptions which follow of the two pieces of apparatus devised, and the technique developed, are given in the hope that other workers may possibly find the methods, with or without modification, helpful in regard to their own particular problems.

CLEANSING AND SCOURING

We adopted the standard method of scouring small samples of wool recommended by Barritt and King (1926), and later by Roberts (1930), which consists firstly of soaking the samples, slightly teased out, in two or more changes of benzene at 40° C. (according to the greasiness of the wool). The benzene removes wool grease and is not adsorbed by the fibre, King (1926), Roberts (1930). It is recommended that the benzene be allowed to evaporate into the air. The samples are then rinsed and washed in a weak solution of saponin in distilled water to remove adherent dirt, suint and remaining traces of wool grease. Subsequently they are well rinsed, to remove any saponin and remaining foreign matter, in one or more changes of distilled water.

The method to be described aims at employing the same principles of cleansing as those recommended by the authors above, but by using mechanical methods several samples may be dealt with simultaneously in a manner which is economical of time and labour.

After the samples have been separated into fibre-groups, these are packed into numbered containers. During subsequent processes the samples remain in the containers until they have been cleansed and are ready for drying. In this way loss of fibres is avoided and the samples are not contaminated by the hand. The containers are made of brass wire gauze, tinned to prevent corrosion and strengthened by three metal bands which are soldered to them. The uppermost of these bands carries a flange. For small samples of wool weighing up to 2 grammes we found that a suitable size of container was one measuring 5 cms. long, with an inside diameter of about 2·5 cms. A container of this size has a capacity of about 25 c.cs.

If we assume a specific gravity for wool of 1·30, the actual volume of wool in 2 grammes is less than one-tenth the volume of fluid in each container when it is immersed to its rim. This allows of loose packing, even when the length of fibres dealt with is considerable. For samples of larger size, the size of the container must be increased in like proportion.

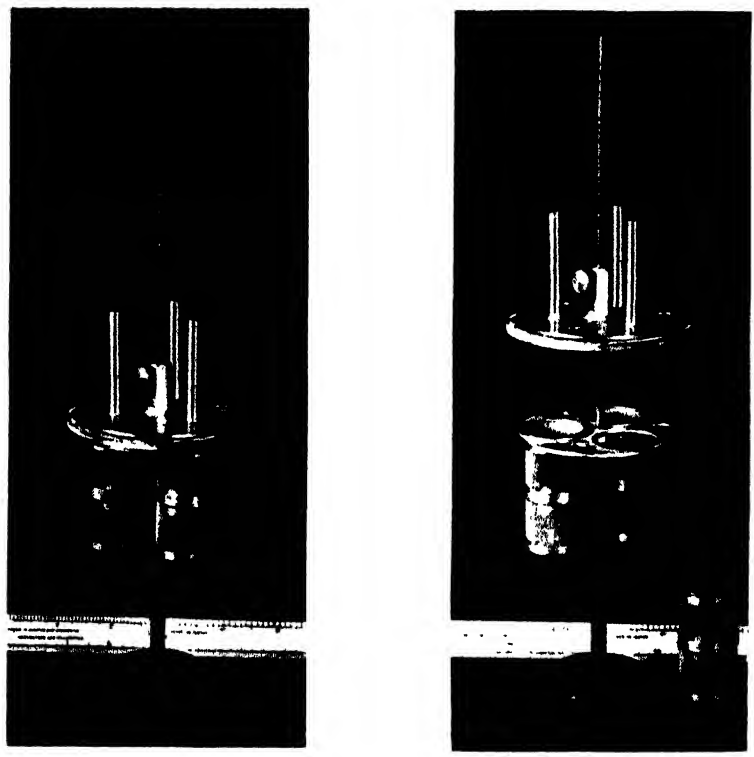
The wire gauze used in the construction of these containers is such that there are 3,750 meshes per square inch. To ensure that the scouring and other fluids had easy entrance and exit from the containers, air vent tubes were fitted to the lids. (The details are shown in Fig. I.)

After the containers have been packed with wool, they are immersed to their rims in benzene in an ordinary electric incubator, kept at a constant temperature of 40° C. Glass vessels, with lids to prevent undue evaporation, make suitable receptacles for the benzene. Three changes of benzene are given, each of fifteen minutes' duration, the samples being allowed to stand for a few moments to allow the excess benzene to drain off before being transferred to each fresh benzene bath. After the final change, the containers are lifted out of the benzene and placed on a rack or board to drain and to allow the benzene to evaporate into the air, or, if desired, they may be centrifuged in an ordinary hand centrifuge which is adapted to take tubes the same size as the containers. When the samples are dry they are ready for the subsequent mechanical scouring process.

Reference to the accompanying photographs will make a full description unnecessary. Three of the containers are carried in suitable holes in a tinned brass disc which has a vertical stem bolted to its centre. Sliding up this stem is a second circular disc of the same material, which is perforated with splash holes and has air vent tubes, 2 inches long, fixed over the centre of each sample container. The function of these vent tubes has been mentioned. The lower surface of the disc has a thick rubber sheet attached to it. This projects about ¼ inch all round, and has holes punched in it corresponding to those in the metal disc above. A set-screw is provided which enables the disc to be fixed rigidly over the rims of the containers to prevent escape of wool fibres during washing. In this way each disc acts as a lid for three containers, the projecting rubber serves as a buffer to prevent the sample containers striking the sides of the receptacles containing the scouring fluids, and the tubes behave as inlets and outlets for air during scouring.

During scouring and rinsing, each set of containers is made to plunge into and out of the fluid in the receptacles by means of a crank-shaft carrying six balanced cranks set equidistant round one revolution. The shaft is driven by a small electric motor, the speed of which is suitably reduced through reducing pulleys.

The air-dried samples are first immersed in distilled water to wet them thoroughly, and then given fifteen minutes' washing in a bath of saponin solution, ½ per cent. The speed of the crankshaft is about 30-40 r.p.m., which gives a sufficient plunging action to each basket to scour the contained samples very thoroughly, each being virtually subjected to some four to six hundred immersions. In practice, when dealing with large numbers of samples, baths 1, 3 and 5 are filled with the saponin solution, while baths 2, 4 and 6 contain distilled water. After scouring in the saponin baths, each set of containers is moved on to the next (distilled water) bath to be rinsed free from saponin and is replaced by another set. In this way, provided a



(*a*) (*b*)

FIG. 1. Photograph of one unit of sample-containers on stand (*a*) Ready for use. (*b*) With lid raised and one container removed

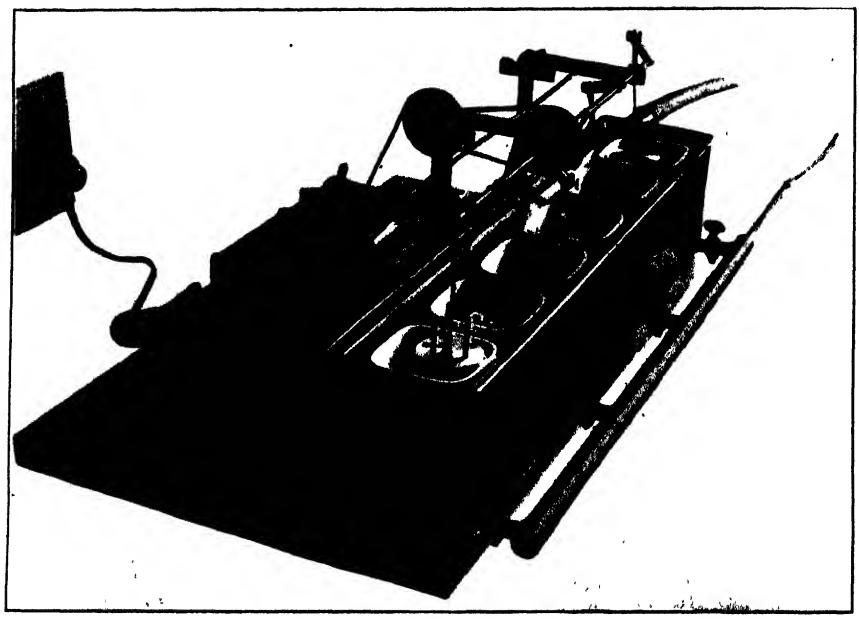


FIG. II. Photograph of Scouring Apparatus, ready for use, with all sample-container units in position.

sufficient supply of containers is available, the apparatus can be kept running for long periods, fresh distilled water being added after each rinsing, and the saponin solution being renewed as required.

After the scoured samples are rinsed, the containers are removed and are either roughly dried in a hot air oven or are stored overnight in a large desiccator over $CaCl_2$. Care is taken not to touch the samples except by clean dry forceps.

The various baths are kept at a temperature of 54°-56° C. by hot water circulating in an outer copper tank with taps at intervals to control the inflow. (See Fig. II.)

A very convenient feature is that the crank-shaft and its bearings, which are carried on horizontal arms, can be raised in one piece to facilitate filling and emptying the various baths.

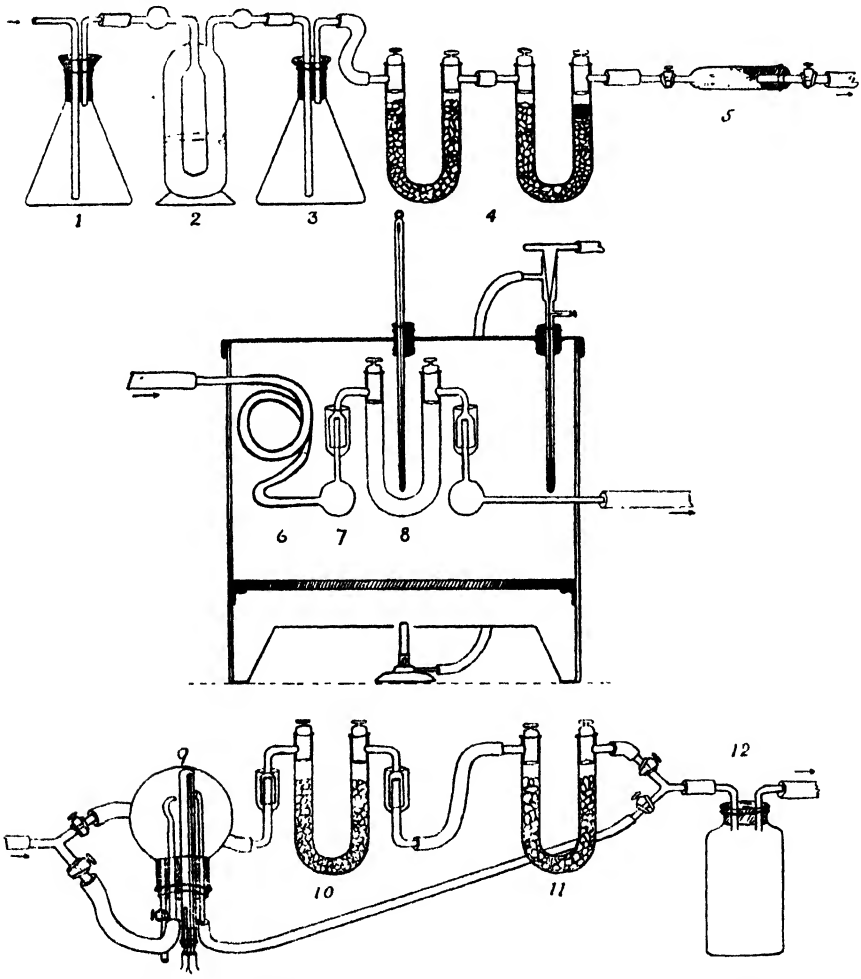


FIG. III (*a*). Diagram of Drying Apparatus: (1), cotton-wool filter; (2), sulphuric acid container; (3), glass-wool filter; (4), $CaCl_2$ drying U-tubes; (5), P_2O_5 tube; (6), lead pipe coil; (7), mercury seal; (8), wool sample container; (9), indicator-condenser; (10), $CaCl_2$ U-tube moisture indicator; (11), $CaCl_2$ tube to prevent diffusion of moisture back from pump; (12), water trap.

DRYING

The principle of the standard drying apparatus described by Barritt and King (1926) and by Roberts (1930), and as used at the Wool Research Association at Torridon has been adopted but modified in some details to allow of numbers of samples being dried simultaneously without sacrificing efficiency. The principle is briefly that a current of hot, dry air is drawn through the samples contained in specially modified U-tubes arranged in succession, until an indicator $CaCl_2$ drying tube ceases to show any gain in weight.

In the accompanying diagram, Fig. III (*a*), air is drawn through a dust filter flask (1), packed with cotton-wool; this also serves to prevent concentrated sulphuric acid from (2) spurting back should a raised pressure be

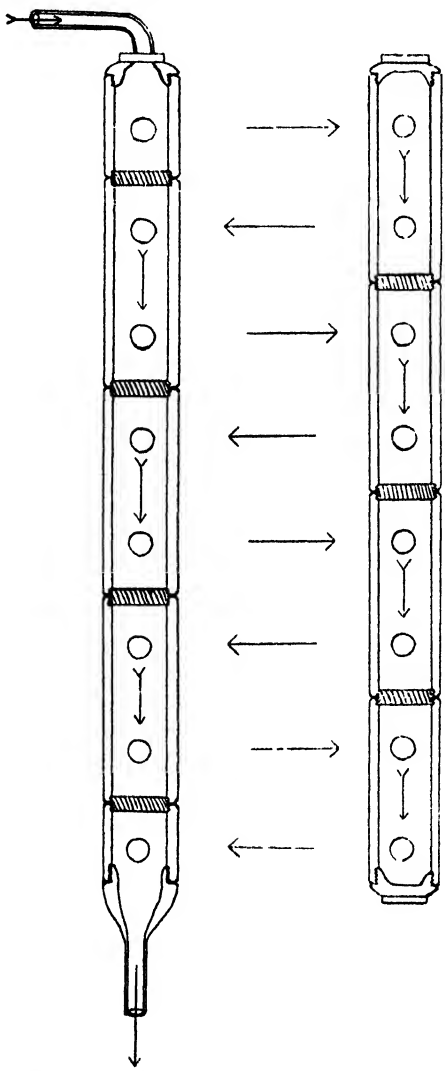


FIG. III (*b*). Diagram of mercury seal units; the sample containers are not shown, but the direction of the air current through them is indicated by arrows.

accidentally induced. After passing through the concentrated sulphuric acid the air stream passes through a glass-wool filter in a flask (3). We found this desirable to trap any droplets of acid which occasionally get carried out by a vigorous current of air. The air stream now passes through two ordinary U-tubes of $CaCl_2$ (4). A pledget of cotton-wool is packed above the $CaCl_2$ at the outlet of the last limb of the second tube to prevent $CaCl_2$ dust getting carried over. A tube containing P_2O_5 follows (5). This also has a pledget of cotton-wool at its outlet to prevent dust being carried into the sample tubes.

The air stream now enters a galvanised iron and asbestos chamber, heated to 103°-105° C. by gas burners regulated by a mercury thermostat. Inside the chamber the air current passes through a coiled lead pipe about 4 ft. long (6), and subsequently enters the first sample tube (8) through a steel-and-glass mercury seal (7). Each sample tube is a light-weight, large sized U-tube with its inlet and outlet bent downwards at right-angles and fused to short lengths of $\frac{3}{8}$ in. glass tubing. This forms part of the mercury seal. The mercury cups are carried on a piece of heavy $\frac{3}{4}$ in. steel tubing. This is cut and plugged between every two seal stems so that the whole air current must pass through each of the eight sample tubes in succession. (See Fig. III (*b*)). The hot, moisture laden air now passes outside the chamber and is condensed against a test tube, containing circulating cold water, contained in a wide-mouthed inverted flask (9). This is utilised to indicate gross moisture only. When it has ceased to show condensation, the air current is diverted by a Y-tube with stop-cocks, into a $CaCl_2$ drying tube (10) which is fitted with mercury seals for easy and rapid removal and weighing. The samples are continuously dried until this U-tube ceases to show any gain in weight from absorption of moisture, i.e., when the air current is passing through the samples and emerging quite dry. By adopting this method much time is saved which otherwise would require to be spent in determining the individual weights of the eight sample tubes. So soon as the indicator U-tube ceases to show any gain in weight the air current is shut off and the two sample tubes, through which the dry air current first passed, are removed and replaced by clean, dry, empty U-tubes. Before removal, the stop-cocks are closed. They are put aside for half an hour in a desiccator to cool to room temperature. One stop-cock is then momentarily opened and shut in each. An indication that there has been no leak is shown by the slight hiss of air entering. The weights of the tubes are then determined and they are replaced on the apparatus. In half an hour the process is repeated, and so on successively until constant weights are obtained. While these weights are being determined the apparatus is kept running with the remaining sample tubes in position. Thereafter the next two sample tubes are removed and treated similarly, being replaced as before with clean, dry, empty tubes, and so on until the whole eight tubes have arrived at constant weights. It is usually found that two weighings only are necessary to determine the constant weights of each tube. The weights of the empty sample tubes are determined subsequently.

The remainder of the apparatus merely consists of a $CaCl_2$ U-tube (11), to prevent diffusion of moisture back from the water pump an empty water-trap bottle (12), and a large-sized, continuous flow filter pump fixed to a pressure main tap by high pressure rubber tubing. It should be noted that although ordinary bunsen rubber tubing may be satisfactory when new,

there is a tendency for cracks to appear under constant use ; we have found high pressure rubber tubing more satisfactory and employ it for all connections of the dry air stream in the apparatus.

DISCUSSION

It is perhaps advisable to include here some observations which, to avoid undue complication, have been omitted from the foregoing description. The use of mercury seals has been found, after exhaustive tests in this and in a previous apparatus, to be a satisfactory method of making connections between the rest of the apparatus and U-tubes which must be removed for frequent weighings. The air current does not pass over the surface of the mercury and it is unlikely that any evaporation of mercury, which might interfere with the weighings, takes place. Had this been otherwise, we would have expected that the determination of a constant weight would have been impossible, which is not so. Provided the sleeves of the U-tubes which dip below the mercury in the seals are kept clean and free from contact with grease, no mercury globules adhere to them when they are removed. When globules were seen, it was found desirable to wipe the sleeves outside and inside with a small piece of clean silk dipped in xylol or ether, having first removed any globules with a dry camel-hair brush. The appearance of these globules on the glass after constant use serves to indicate that dust may have been deposited in the mercury and that it requires cleansing. This is readily effected by passing the dirty mercury in small drops through nitric acid (5 per cent. by weight), in a burette from a micro-funnel. The U-tubes are occasionally cleaned with ether, followed by sulphuric acid and are well rinsed in distilled water and dried (empty) on the apparatus. In some cases, minute fragments of wool, scales or cells may remain behind, but though it is better to remove these it is doubtful whether they would ever be capable of influencing the determination of dry weights.

We have found that a trace of " Everett's No. 1 (stiff) Tap-lubricant " forms an efficient and air-tight tap-lubricant at high temperatures, and we are confident that leakage of atmospheric air into the sample tubes does not occur since each tube can be heard to hiss when it is momentarily opened after cooling and before weighing. In addition, when the air current is passing, each column of mercury in the mercury seals can be seen oscillating slightly. Should an experimental leak be made by loosening or removing a stop-cock, the mercury columns in the seals beyond become stationary at once, and the bubbling of the acid bottle changes speed or ceases entirely.

It should be pointed out that care is necessary in introducing samples into the drying tubes and in removing them, to ensure that the sample does not rub against the lubricated surface of the stop-cock seating. We have found a method of inserting the samples in small fractions to be most satisfactory, since, by the exercise of due care, each fraction can be placed in the sample tube without a single fibre touching the lubricated surface of the stop-cock seating.

While it is not suggested that the principle involved in the method of drying is new, we feel that for dealing with numbers of small samples of wool (up to 2 grammes in weight) it has advantages over the method described by Barritt and King in 1926, and used by other authors, Barker and Hedges (1926) and Roberts (1930), *inter alia*. The chief of these is greater rapidity, in that eight samples are dried without interruption ; the use of mercury

seals forms an efficient and satisfactory connection between the sample tube and apparatus, while the use of a $CaCl_2$ U-tube as a moisture indicator avoids the necessity for a large number of preliminary weighings, which are necessary when sample tubes are dealt with individually.

SUMMARY

1. Apparatuses for scouring and for drying small laboratory samples of wool for general purposes are described.

2. The scouring apparatus devised has advantages in that a number of samples may be treated by standard scouring methods simultaneously and under constant conditions of temperature and agitation. Loss of fibres is avoided by using wire gauze containers of fine mesh.

3. The drying apparatus, which employs a current of hot air dried by a method essentially the same as that used by other workers, possesses the following improvements :—

(*a*) Eight samples can be brought to constant weight without interruption.

(*b*) Connections between the sample-containers (modified U-tubes) and the drying apparatus are made by mercury seals, which render removal for weighing and replacement rapid and easy.

(*c*) The detection of the gross moisture content of the issuing air current, firstly by a condensing indicator and subsequently by the changes in weight shown by a $CaCl_2$ drying tube, avoids the necessity for many preliminary weighings.

ACKNOWLEDGMENTS

We desire to express our appreciation of help and encouragement offered by Professor F. A. E. Crew, Director of the Institute of Animal Genetics, and also to record our thanks to those who by helpful suggestion and kind assistance have aided in the construction of these apparatuses. Among them are Mr. J. A. Fraser Roberts, late of the Wool Industries Research Association, and now of this Institute ; Mr. P. G. Marshall, of this Institute, and Dr. P. Eggleton of the Physiology Department of the University of Edinburgh. Mr. J. Dunn, Technician, has carried out most of the constructional work of the two pieces of apparatus with great skill and accuracy, and for his help we are especially indebted.

The writers desire also gratefully to acknowledge financial assistance rendered by the Empire Marketing Board which made possible the work in progress, and by the Carnegie Trustees whose grant has provided funds to cover costs of construction.

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21—A DESCRIPTION OF A CONTROLLED TEMPERATURE AND HUMIDITY ROOM FOR TEXTILE TESTING AT THE UNIVERSITY COLLEGE, NOTTINGHAM

By C. H. EDWARDS, M.A., A.T.I.
(Department of Textiles, University College, Nottingham.)

INTRODUCTION

The plant to be described in this article has been installed in the Textile Testing Bureau at University College, Nottingham. The need for such control has become increasingly evident for some time and the necessity for accurate control of atmospheric conditions during all textile testing operations cannot be too strongly emphasised. Strength tests in particular are affected by the humidity of the air: cotton yarns gain in strength while wool and artificial silk lose in strength on becoming damp. Figs. 1 and 2 illustrate this fact in the case of cotton and artificial silk respectively. The results are from experiments directed by J. Lomax, F.I.C., at the Bureau. These tests were continued from day to day on the same hanks of yarn, each figure being a mean from a number of individual tests. The curve for the cotton yarn strength closely follows that of the humidity, while the viscose curve is in direct opposition. In the case of wool yarns, a drop of 30 per cent. in strength may ensue from an increase of humidity from 50 per cent. to 90 per cent. Greater variations in humidity are quite normal under ordinary climatic conditions.

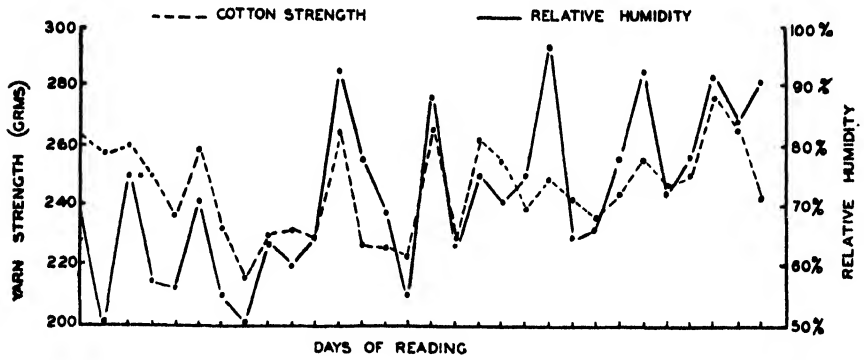

FIG. 1.

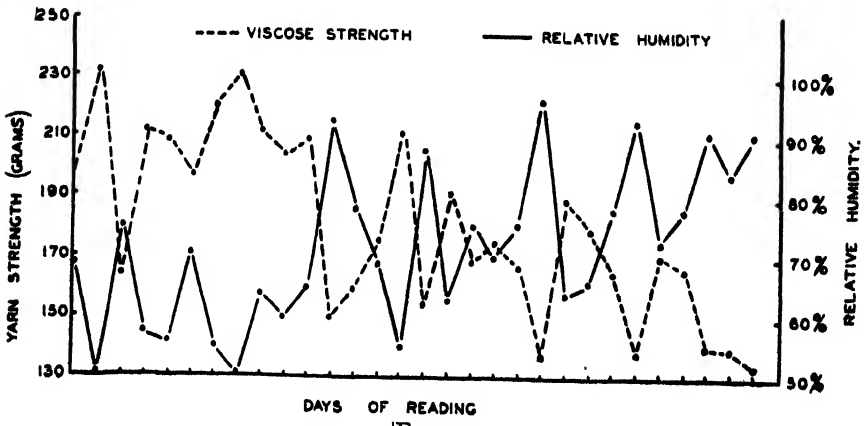

FIG. 2.

When testing yarn for counts, the yarn may be exposed to a controlled atmosphere such that the absorbed moisture in the yarn becomes the exact standard regain for this particular yarn. In this way the count at correct condition may be determined directly and accurately ; this obviates measurement of count as received, with subsequent correction by means of a condition test. The advantages for research work include all the foregoing points, and also the fact that samples of textile fabrics may be accurately weighed out at correct condition. This is frequently far more useful and convenient than working from dry weights.

The details of the scheme were prepared in co-operation with Mr. Marsh of the Wool Industries Research Association and incorporate some features of a commercial control apparatus designed and tested there.

DETAILS OF ROOM

The most suitable room for the purpose was a portion of the Bureau ; this has been divided off from the main room by a double wall and serves the purpose excellently. Some details of the room and a plan are included here. The room has a minimum of outside wall—this wall has a large window which gives ample light in the room. The two long walls are both double, with a 3 inch air space between the surfaces ; this gives excellent heat insulation. Dimensions of the room are : length, 18 feet ; breadth, 8 feet ; height, 17 feet. This room is unusually high, a height of 8 or 10 feet being generally recommended for this purpose, but in this case it has not proved detrimental. The volume is 2,448 cubic feet. Direct access of air to the room has been avoided so far as possible. For this reason, two doors are fitted to form an air-lock, the space between the two being totally enclosed.

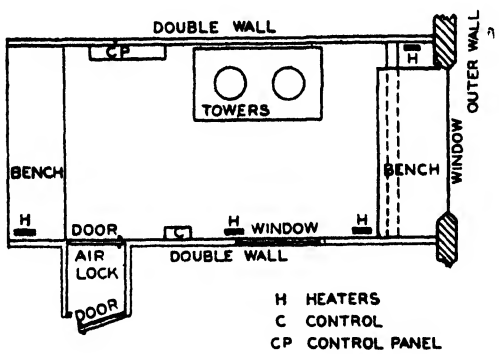

FIG. 3.

The room has a steam pipe below the outside window. This has been left in action since it serves as a partial compensation against the cooling effect of the wall and window. The benches accommodate balances and wrap-reels and a Baer single thread tester has been fixed to the wall. Pegs have been fitted to the wall to hold samples for conditioning. These project into the room and the samples are placed on their extreme ends, so keeping them 2 feet away from the wall and allowing free circulation of the air round them. Above these is fitted a narrow shelf to hold the control instruments. The control panels, which hold the relays, switches and plugs, are fixed permanently to the opposite wall and wired to the electric mains. The control instruments are connected to the panels by flexible leads and may be moved about.

HEAT CONTROL

Since the relative humidity depends on the temperature, some form of temperature control is necessary. A system of electrical heaters has been installed, consisting of four 250 watt radiator lamps placed against doors and windows as shown. These are automatically operated by a "Satchwell" type "k" air thermostat controlling a 15 ampere direct current relay. This system has given satisfactory results, keeping the temperature within one degree of the value set. The heaters are connected to switch plugs on the wall by flexible leads and so may be moved about to the best position.

HUMIDITY CONTROL[1]

The humidity of the air is kept constant by adding or withdrawing moisture as necessary. This is accomplished by drawing the air in the room through wetting or drying towers by means of fans which are operated automatically. The design of these towers is shown in Fig. 4.

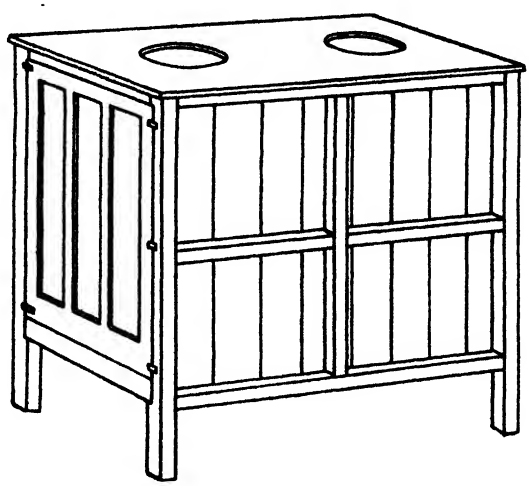

FIG. 4.

They are built in one frame for convenience. The wetting tower has a 12 inch layer of coke, supported on wire mesh at the base and kept moist by a steady water drip. The fan, placed over the hole in the top, draws a stream of air through the wet coke and so moistens the air in the room. The drying tower is of similar construction but, instead of coke, carries three oak trays on which is placed fused lump calcium chloride. This quickly dries the air when the fan above draws the stream of air past the trays. The trays are slatted; the slats of the top one are 3 inches apart, those of the middle one 2 inches apart, with 1 inch spaces for the bottom one. In this way the lumps of calcium chloride fall from one tray to the next as the outer layers are dissolved and only the top tray needs recharging with fresh lumps. The towers are raised 1 foot above the floor to allow free access for the air stream to circulate. A lead tray stands under the towers to catch the drip and is directly connected to the drain. The tray is tilted so that the water drip washes away any calcium chloride which may collect under this tower. The towers have been designed to have a large cross-section with short height, to decrease air resistance. The fans are of the box-blade

type with a power input of 40 watts and diameter 12 inches. They are sufficiently powerful to carry an air stream up to the ceiling, from which it is reflected down by the walls. This circulation is found to be quite satisfactory.

The operation of these fans is automatically controlled by the change in length of a bunch of human hairs. Details of construction of the hair control which has been used are given in Marsh's paper. It depends on the increase in length of animal hairs with a rise of humidity and a decrease in length with fall of humidity. The hairs are fixed at the ends and kept taut by a side pull at their centre due to a short stirrup attached to a light spring blade. One end of this blade is attached to a pillar. The other end is free to move and carries two contacts which operate between two insulated contacts attached to the base board of the instrument. According as the hairs shorten or lengthen, the beam contacts touch one or other of the fixed contacts, but not both at once. These pairs of contacts are connected in a low tension circuit, and when closed, operate relays which switch on the respective fans. Fig. 5 is a diagram of the circuit used.

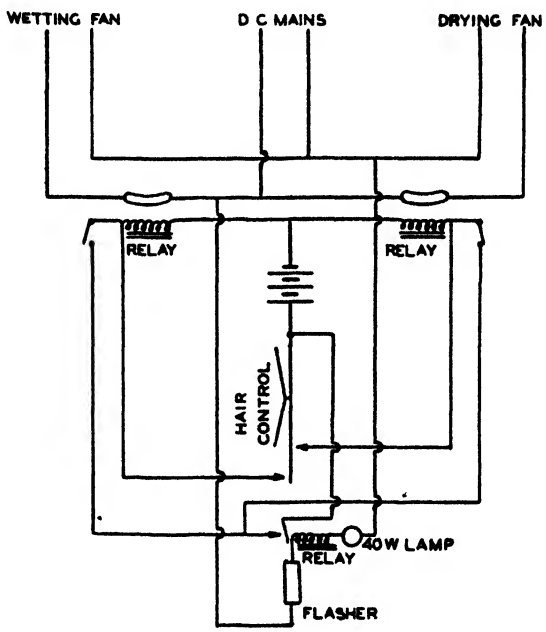

FIG. 5.

The circuit has been designed for direct current since this was the only available supply. The low tension circuit is operated by a 6 volt accumulator. A form of the flasher device, introduced by Stevenson,[8] is incorporated to prevent chattering of the relays. The two relays carry, in addition to the high tension mercury switch, a pair of low tension contacts which are connected in parallel with the hair control contacts. When the hair control causes a relay to operate, its low tension contacts keep it in action independently of the subsequent movement of the hair. This second circuit is interrupted automatically, at a definite interval, by a break relay, whose coil is in circuit with a thermic flasher and lamp and is operated on the mains

circuit. The flasher is set to flash every 30 seconds. Thus the fan relays are switched off every 30 seconds, provided that the hair control has switched them on and moved away again in this interval. By this separate control of switching on and off, all chattering of the relays is eliminated. The relays and plugs are permanently mounted on the control panel. The fans on the tower and the hair control are connected through three-pin plugs. This has the advantage that the movement of the relays does not jar the hair control.

INSTRUMENTS

For the purpose of checking the humidity, a wet and dry bulb hygrometer with standard thermometers is used. A sling hygrometer has also been provided. For taking continuous readings of the temperature and humidity, the " Edney " thermo-hygrograph has been found very useful, since its charts give a continuous record of the conditions maintained during each week.

OBSERVATIONS

Plants similar to the one described here have given excellent service over periods of many months and, although this one has been in operation for a matter of weeks only, the results are satisfactory. The setting of the controls is a matter of experiment and takes some time, the hair control in particular must be allowed a few days to settle down to a steady state, although further adjustments may then be made in a few hours. It has been found possible to keep temperature variation to 1° F. and humidity variation within 2 per cent., the latter being chiefly governed by the closeness of setting of the hair control contacts.

When starting from extreme conditions, it was found that the plant brought the relative humidity from 78 per cent. to 65 per cent. in 70 minutes.

The consumption of calcium chloride varies with the prevailing atmospheric conditions, being greater in summer than in winter, but is about 15 cwt. per annum.

The relays are of standard telephone construction, but are specially wound. Those operating the fans are of 2,000 ohms resistance and take 3 milliamperes. The flasher relay is of low resistance, about 5 ohms, and will carry 0·2 ampere. The low tension contacts can be fitted for commercial use if requested.

Our thanks are due to the Wool Industries Research Association, who have originated this type of plant, and who have given every assistance in the details of construction and maintenance.

REFERENCES

[1] Marsh. *J. Sci. Inst.*, 1932, May.
[2] Stevenson. *J. Sci. Inst.*, 1930, 7, 293.

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PROCEEDINGS

Lancashire Section

Meeting at the Institute, Manchester, Wednesday, 7th December, 1932; Mr. T. E. Mitchell presiding.

RING AND TRAVELLER DESIGNS AND SPEEDS

By DONALD EADIE

(Director of Messrs. Eadie Bros. & Co., Ltd.)

In order to confine the scope of this paper to those aspects of the Ring and Traveller about which, as a maker, I am most competent to speak, I chose the title :—

Ring and Traveller Designs and Speeds

I particularly wanted to make it clear that this would not be a technical talk on spinning and doubling. It is a talk on types of Ring and Traveller at present in use, with some reference to the improvements which are taking place. I also hope to interest you with a few comparative speeds from different countries.

A user of Rings and Travellers naturally thinks about them primarily as a spinning or doubling device, but we, the makers, look upon them as the two parts of a high-speed bearing. Seeing that there are nearly two thousand sizes and kinds of traveller on this market, and perhaps double this number in the U.S.A., there can be little doubt that a suitable combination of ring and traveller already exists for any kind of work that is now accomplished on the Ring Frame, and so the tendency of research is to seek higher performance in the existing fields of usefulness and we are being spurred on by a small but insistent demand for travellers capable of higher speeds, much of which comes from abroad.

We have the impression, rightly or wrongly, that the foreigner is more interested in speed than the Englishman. This may be because there must be many more mills with new machinery in Europe than there are in England and much of the latest machinery is capable of running at speeds which test the travellers to their uttermost. In fact, the wearing-out or flying-off of the traveller may be the limiting factor. Old machinery is not so often run at these high speeds. It has been suggested also that some of the foreign spinners who use or demand these high speeds are manufacturers as well as spinners so that they do not need to be so particular about the quality of their yarn as the Lancashire man must be, who usually spins for the open market. In some cases this is no doubt correct. Whatever the reason may be, really high speeds are not so often met with here as in other countries. The examples which come at the end of this paper support this view. The aim of all ring and traveller makers to-day is therefore to make these high speeds possible and the users can then decide for themselves whether it pays to avail themselves of them or not.

Much of the information which follows has been gathered by machinists and ring makers in other countries with whom we come into very close contact in order to secure the necessary working of certain patents. The information

which they send us is usually very detailed, and we are left with the impression that tests of all kinds are more willingly undertaken and more thoroughly made there than here—at any rate so far as our trade is concerned.

It is a remarkable thing how many of the technical articles on Ring Spinning agree that the traveller is the most important part of the machine and it is, therefore, disappointing to find how little interest is taken in any new style that we want to try out.

Spinning Rings and Travellers

In Plate II (*a*) you will find illustrations of the common types of spinning rings together with their appropriate travellers. The No. 2 flange ring with a flange width of 0·163 in. and the 1½ flange and 2 flange travellers take care of practically all European medium and fine count spinning. There are a few installations of rings with a flange width round about 0·157 in. but practically none of No. 1 flange (0·125).

In the United States it is quite otherwise, and I am indebted to The Whitinsville Spinning Ring Company of Massachussets for the following information.

> A generation ago No. 1 flange-rings were commonly used on counts 40's and finer; ten-years ago on 30's and finer with a tendency to day on 20's and finer. Americans have little question as to the wisdom of this division of flanges.

This means that in spinning rings 1½ ins. and less in diameter there are far more 1 flange rings than 2 flange in use. This means that the range of counts which, in England, is covered with one type of ring and two types of traveller, in America is covered with two types of ring and three types of traveller. I believe that these 1 flange rings do not last quite as long as the heavier 2 flange type and this is probably due principally to the smaller bearing surfaces and possibly in part to the lighter ring not hardening so well.

This increasing tendency to use narrower flanges which is noticeable in America has come about because of the increased spindle speeds of the last few years. The object is to get more stock into the body of the traveller so as to withstand the harder usage. This is on the same principle as the substitution here of 1½ flange travellers for 2 flange but it can be carried a step further because the ring flanges are smaller. The limiting factors in this direction are the dirt and fly which collect on too small a traveller and break down the end and the possibility that too stiff and heavy a traveller will break off the ring flanges. For instance, until Indian mills started using better mixings of cotton the 1½ flange traveller could not be used there at all.

Possibly the greatest difference between British and American practice, however, is to be found in the temper of the travellers. To some extent this applies also to some Continental countries. Different countries show a marked preference for hard, medium or mild tempered travellers. This country favours the medium or mild, while U.S.A. insists on the hardest possible. We have to bear this in mind when executing our orders. I shall have a little more to say on the subject of traveller temper below.

Now let us turn our attention to the rings and consider the factors which permit of the highest speeds. These are: (1) the use of the best possible material, homogeneous and free from spots and which hardens well; (2) correct design in relation to the traveller used; (3) workmanship, in which is included hardness and finish. The essentials of good design are freedom for the traveller and a well-shaped bearing.

Plate II (*b*) shows a Ring Traveller in its normal running position on the flange of a Spinning Ring. You will notice that the inner toe of the traveller runs just clear of the web of the ring and that the bearing of the traveller on the ring has been kept as large as possible, so as to minimise wear. If the bearing

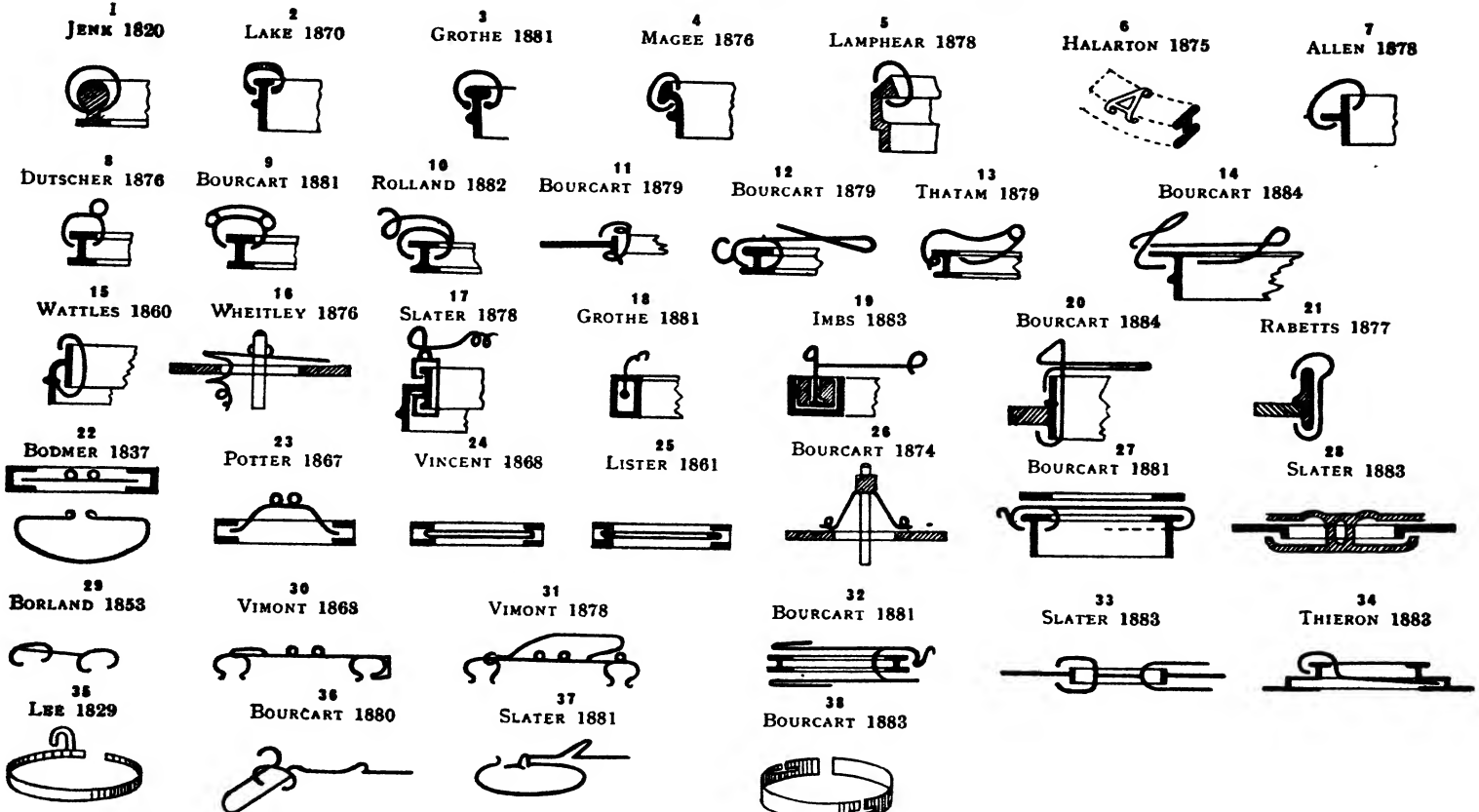
were allowed to be at the toe it would be very small indeed and would soon wear into the ring web. We have several times come across rings where the web has been left too thick so that the travellers clipped and held it—naturally they would not work at all. Spinning ring design seems to have resolved itself into the present style all over the world and, although we have put out many experimental lots embodying slight variations, we have never received a report about them that justified any important change.

It is when we come to workmanship that we find what great strides have been made in recent years. You will quite understand that a good bearing surface is of the utmost importance to travellers running at speeds of 60 ft. per second and upwards. You may not have realised it, but it is none the less an every-day job for a traveller to run as far and as fast as " The Royal Scot." Four hundred miles in 8½ hours is what this famous train does, but this only works out at 68 ft. per second and, as I shall show you presently, travellers are running at almost twice this speed. The ring must therefore be polished and burnished to the highest possible extent so as to help the traveller to give a useful life. In the old days it used to be essential with new rings to reduce speed and fit travellers two or three sizes lighter. Speed was then worked up gradually and heavier travellers used till the old maximum was reached again. This was a slow and expensive process and many mills now buy super-finished rings at a small extra charge because the period of running-in is thereby greatly shortened. This first came to my notice some years ago when a Continental millowner told me that by paying 10 per cent. extra for super-finished rings he had been able to work up to his maximum of 11,500 r.p.m. in nine days. I do not know what size the rings were, but if they were 1½ ins., the traveller velocity was over 80 ft. per second. No other such outstanding performance with new, unlubricated rings has ever come to my notice. The effect on the traveller of a poor bearing surface is to generate heat and the effect of heat is to soften (or temper) the metal by drawing out the hardness. The common complaint is " My travellers are burning away." Now travellers are made hard and brittle to start with and then tempered down so as to give them sufficient spring to withstand the strains of going on to the ring and of running at high speed over indifferent surfaces, such as old rings. Not only do different sizes require different tempers but also different markets have their individual fancies. Tempering or softening induces changes of colour in the steel, so when a traveller changes colour in use it is being softened and worked beyond its useful limit. The cause is excessive friction which may be due to new rings, high speeds, excessive weight or dirt. When conditions are perfect and a lighter traveller will not give the results required and discolouration still continues, then you may know that you have gone beyond the useful limit. This limit for unlubricated spinning rings has been put at 70 to 75 ft. per second by three different competent authorities, a Continental ring-maker, a Continental machinist, and an American ring-maker. Reduced to an easily appreciated form, this is roughly equivalent to 10,700 r.p.m. with a 1⅝ ins. ring.

Until a few days ago I was quite satisfied that this speed of 70-75 ft. per second did in fact represent something near the maximum, but my ideas have just been upset by some figures received from America. These all apply to big package spinning installations and they run up to just over 100 ft. per second. I shall have more to say about these later in this paper.

To return to the subject of the useful maximum for unlubricated steel travellers ; whilst I shall show you one or two examples exceeding this so called limit I have particulars of three separate attempts in different parts of the Continent to spin on dry rings with traveller speeds round about 90 ft. per second. That is to say, about 20 per cent. higher than the useful maximum mentioned just now. One of these was just able to produce results for about four weeks,

PLATE I. Curseurs avec Bagues pour Metiers Continus



J J. Bourcart, Ring Mule Office, Zurich

starting with freshly-burnished rings, but at the end of that time deterioration of the ring set in and spinning became impossible. The other two attempts were both abandoned.

There are various factors which are easily overlooked in connection with extremely high traveller speeds. For example, centrifugal force or the pressure of the traveller against the ring increases according to the square of the velocity, so that if you raise the speed with a 2¼ ins. ring by about 10 per cent. you get something like 24 per cent. increase in the centrifugal force. A traveller weighing one grain and running on a 2 ins. ring with a spindle speed of 10,000 would be thrown against the flange of the ring with a force of approximately 6½ ounces were it not for some offsetting pull of the yarn.

I have seen it stated that higher speeds are possible on larger rings because the traveller is not called upon to change direction so sharply and certainly our highest recorded speeds are on fairly big rings. For instance, the three unsuccessful attempts on the Continent to spin at 90 feet per second were all on smallish rings, certainly under two inch. Whereas the successful American attempts are mostly on 2½ and 3 in. rings.

At high speeds there is a tendency for the travellers to be thrown outwards to such an extent that they may rub heavily on the outside of the ring. This is curable by the use of travellers with a smaller bow if other considerations allow of it. A special ring has also been introduced in America called the curved web ring, of which you will see an illustration in Plate II*b*. No matter how far over the traveller may tilt on this ring it will not rub the outside. In the same Plate you will also see a new variation of the old elliptical traveller which has been recently introduced to achieve the same object. The illustration does not quite do justice to the old elliptical traveller but it will serve our purpose. It is considerably lower in overall height and, being better balanced, is said to take up a better position at speed. I have too little information about its performance in the hands of the public as yet to say much about it. Elliptical travellers are not new, but an old idea may have a new application and we cannot afford to scoff.

A point which sometimes arises between the ring user and the ring maker is the question of unroundness. Now although the amount of unroundness has been greatly reduced in recent years owing to better control of the heat treatment, there is still a certain amount of distortion, and in this connection you may be interested to hear of the following test carried out in 1923 at the Whitinsville Cotton Mills, at Whitinsville, Massachusetts. The test was carried out on a frame of 176 spindles and one side, of 88 rings, was selected for roundness and the other side held rings from ·002 in. to ·027 in. out of round. The spindles were most carefully set at top, bottom and middle positions of the rail, the rail being raised and lowered as many as six times in certain cases to get the spindles accurate. The rings were 1 flange reversible of 1$\frac{11}{16}$ in. diameter, the counts were 32's twist, and the spindle revs. were 9,400. Average room temperatures and wet bulb readings were taken throughout. The test ran three weeks and travellers were changed every third day. The results were as follows in ends down :

	Round.	Out of Round.
1st week	183	161
2nd ,, ...	151	113
3rd ,, ...	190	177
	524	451

An average of four against five in favour of the unround rings. The number of ends down were counted separately for every one of the 176 rings and five of the round rings exceeded ten breaks in the three weeks and seven of the unround ones did the same thing. The yarn from all spindles is reported to have been

equally good by appearance and test. The manager's remark at the end is illuminating. He said :—" How much out of round do my rings have to be to give me perfect spinning ? "

Doubling Rings and Travellers

In Plate II (*c*) you will see sections of the types in common use. As in the case of spinning rings, they vary in size of bearing according to the work they have to do, but by far the greatest proportion are like the second type. This type actually handles work from heavy tyre cords down to 120's two-fold. In this country nearly all doubling is done on this type of ring, as it is the only type that can be adequately lubricated. Abroad, particularly in France, there is a lot of dry doubling carried out on spinning section rings with the travellers running unlubricated, but this work is fairly severe on the rings.

The alleged advantages of using a spinning ring for dry doubling were once explained to me by a French machinery agent as follows :—" If frames are to be fitted with a ' cop building motion ' I never recommend grease-lubricated doubling rings as the dirty traveller is constantly running close to the yarn. With a taper build the traveller only gets close to the yarn as the bobbin fills up all over." He went on to say that spinning-shape travellers are also more satisfactory and cheaper than fine ear-shaped doubling travellers and this far more than compensates for the 50 per cent. reduction in the life of the rings.

Several different metals are in common use for the travellers such as steel, various analyses of brass, phosphor bronze, etc., stainless steel, monel metal and German silver have also been tried. These metals have different characteristics which appeal to certain users. For instance, phosphor bronze has better wearing qualities than most of the copper alloys whilst its coefficient of friction is not much different. Steel is liable to rust, has a higher coefficient of friction but is harder. German silver does not rust and is fairly rigid, which is an advantage in certain cases. The travellers are made from wire of flat, round, or " D " section, and the users have very definite ideas as to which type suits them best. Sometimes demands run a bit wild and we *have* had as many as a hundred special sizes on hand for one customer at the same time. Three types of material and two sections of wire mean six different travellers and all the same weight, so that a request for twenty-four each of five sizes " free for trial purposes " is the kind of thing which nearly causes a riot at the manufacturing end.

It is interesting to note in connection with doubling travellers that the high speeds in parts of the Continent have resulted in a considerable change over from brass wire to steel wire, as the brass was not stiff enough. This applies, for instance, in a country like Switzerland, where 105/2 yarns were being doubled a few years ago on $1\frac{1}{2}$ in. rings at such high speeds as 12,000 r.p.m. and in some cases even 13,000. And now even the steel traveller does not seem to be stiff enough according to one customer who is running at 11,000 with $2\frac{3}{8}$ in. rings.

Lubricants and Lubricated Rings

Lubrication of doubling rings has been the subject of a great many patents ; some inventors set about trying to make more effective use of grease, others tried to use oil. Before we consider any of these in detail let us look into this question of oil or grease. In the common doubling ring grease is applied by hand to the inside of the ring. The first revolution of the spindle whips the traveller through the grease and I have seen an estimation that only about one-fifth of what is applied ever lubricates the traveller—the rest flies off on to the floor, etc. I do not think this figure is quite right, but anyhow a great deal is wasted. The grease has the consistency of clotted cream, and the traveller is shaped so as to leave a reserve at the top. As the ring warms up, the grease slowly runs down and lubricates the traveller bearing and is finally thrown off under the plates by

the little end of the traveller. The advantages of grease are that it " stays put " long enough to do its job (or nearly so) ; it can be obtained practically stainless and it is a good lubricant when the quality is right. This matter of quality must not be overlooked. In grease you only get what you pay for and there is no difficulty in making up a grease which contains from 20 per cent. to 30 per cent. of water.

Now what are the disadvantages of grease ? Firstly it has to be applied by hand to each individual ring and the frame must be stopped. If the work is either so heavy or so fine that greasing has to take place more than once per doff there is a considerable loss of time. Grease is, of course, affected by the temperature of the ring and by the atmospheric temperature. In a hot room it thins and runs off quickly whereas in a cold room it may be in a crumbling condition and get knocked off the rings without doing much good. Lastly the grease thrown off by the travellers collects in a nasty black mass under the rails from whence it is a tedious process to remove it.

It has always been realised that oil would be as good a lubricant as grease but the difficulty until recently has been in getting it to stay on the bearing surfaces. A few doublers have applied it with a brush to the ordinary doubling ring but it tended to run off much too quickly.

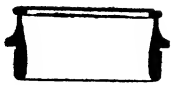
The various systems of wick-feeding not only overcame this difficulty but they enabled the doubler to cut out all stoppages for lubrication. Oil, of course, is practically unaffected by the changes of temperature experienced in a mill, so that unless the supply is interrupted, lubrication should remain almost constant, at all hours of the day and at all stages of the build. Again the surplus lubricant thrown off on to the under side of the rails is easily removable with a cloth and this represents some saving of time.

Let us consider first of all a few of the special types of grease-lubricated rings. In nearly all cases the variations from the plain ring took the form of grooves which were intended to increase the reserve of grease so as to avoid the necessity of stopping the frames in the middle of the run for lubrication—a difficult and dangerous job when the bobbins are getting full. The simplest of these types is the ring with one groove like the first figure in Plate III*a*. When the grease is applied to this ring by hand the traveller presses a considerable portion of it into the groove, from which it subsequently runs down and lubricates the bearing. Then there is the double groove—Fig. 2 on the same Plate. This works on the same principle except that the reserve is doubled. We have also made rings to order with a spiral groove cut from top to bottom of the inside of the ring. Presumably the idea here was that the operative put the pat of grease mostly at the top of the ring and the traveller was expected to work it round the groove so that an adequate supply was assured for the lower half of the ring. History does not relate what happened when the frame went on to reverse twist. I have no reason to think that there are many of any of these three types of ring in existence, and although I have been trying to obtain information regarding their performance for the last four or five months, I have not succeeded.

Next we come to a Patent ring, which was developed principally for cord doubling. This embodies the double groove system plus a certain number of holes connecting the lower groove with the outside of the ring (see the fourth figure in Plate III*a*) so that the toe of the traveller might be adequately lubricated. This ring enjoyed a much greater measure of success than any of those previously mentioned. It was also made in extra deep sizes—$\frac{7}{8}$ in. or 1 in., as against the common $\frac{3}{4}$ in. It was thus very suited to the heavy work it had to perform, such as cord doubling.

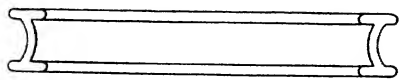
We now come to a sort of intermediate group between the grease-lubricated and the oil-lubricated rings, for which special lubricants were used. One of these was made by my firm over twenty-five years ago. It is illustrated in

PLATE II. Spinning Rings.

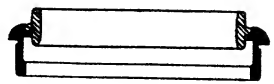


1 FLANGE RING.

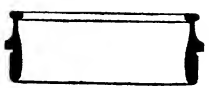
1 FLANGE



CURVED WEB RING.

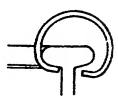


SMALL SECTION RING AND HOLDER.

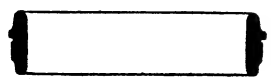


1½ FLANGE RING

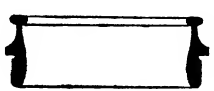
1½ FLANGE
SMALL SECTION
OR
SMALL BOW.



SECTION OF MODERN
SPINNING RING.

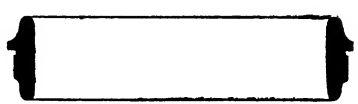


STANDARD RING.

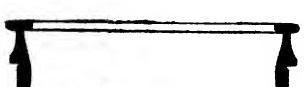


2 FLANGE RING.

1½ FLANGE
B.P.
2 FLANGE.
3 FLANGE.



7/8 DEEP RING.



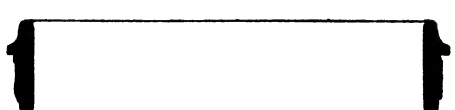
5 FLANGE RING.
(a)

5 FLANGE.

A B C

A NORMAL SPINNING TRAVELLER.
B OLD ELLIPTICAL TRAVELLER.
C NEW ELLIPTICAL TRAVELLER.

(b)



1" DEEP RING.

(c)

the first figure of Plate III (*b*). The special lubricant was put in the well round the ring top and flowed down the holes to the traveller-bearing surface. This idea has been revived in two different forms by others in the last four or five years, but it has not been widely adopted so far as my information goes. In one of these a ring is pressed into an aluminium plate holder, the ring having holes through which the lubricant comes from special wells in the holder. (See figure 3 of Plate III (*b*).)

Holes in rings have two disadvantages—they are inclined to get clogged with dirt, and they are also inclined to make the travellers jump, if they are actually on the traveller bearing surfaces. We have seen this on worn samples and there is nearly always a mark or hole just where the traveller lands after its jump. Incidentally, if the traveller does jump or get a bump it is surprising how quickly it wears a spot on the hardest ring. I remember once investigating a ring complaint where the contention was that we had made our rings from steel tube containing a longitudinal flaw, as nearly all the rings were worn at one spot after a few months' use. Well, first of all, we don't use tubing, so that disposed of the longitudinal flaw theory. Secondly, our tests of the worn spots showed them to be as hard as the rest of the ring. To cut a long story short, we found in the end that the spinner had set his traveller clearers so close that they were making the traveller jump—the alleged flaw was where they landed.

Next consider the wick-lubricated rings, which are of several kinds. The simplest of these was really a standard type of doubling ring with the addition of a hole bored through the wall in which a wick was inserted giving point lubrication. This wick connected with a reserve somewhere on the rail or in the holder. (See the first figure in Plate III (*c*).)

Another wick-lubricated ring had two holes close together with the wick laced between them in a shallow slop; second figure in Plate III (*c*).

A third type has one or two grooves completely encircling the inside of the ring. In the grooves are a number of holes through the wall of the ring and a wick or wicks are laced in and out as many times as are necessary to ensure sufficient lubrication for the work to be done. The arrangement is shown in the third figure on Plate III (*c*).

Wherever wicks are employed, the reserve of oil is held either in each individual holder or in a common reservoir filled with felt provided in the rail. This type of ring has not found much favour yet outside of the United States, but over there some surprisingly fine performances have been put up, not only with cotton, but with worsted and silk as well, but particularly with silk. The highest traveller speed that we know of has been achieved on this ring, namely, 11,400 r.p.m. spindle speed with $2\frac{3}{4}$ in. rings on a Fletcher silk twister. This was not done on one or two spindles as an experiment, but in bulk, and on the strength of it a further 5,000 rings have been installed. The traveller speed in this case works out at about 136 ft. per second—roughly the equivalent of 18,000 revs. with a $1\frac{5}{8}$ in. ring.

Finally, I illustrate another type of wick oiling ring of which nearly a million are in use: the fourth figure on Plate III (*c*). Sufficient oil for several days' running is applied to a felt pad sunk into the existing ring rail. This reserve connects with a spring wick clipped into a helical groove on the inside bearing surface of the ring. The object of a helical as opposed to a horizontal groove is to secure even distribution of the oil over the whole bearing surface of the traveller. The traveller draws off the oil by suction, the flow starting and stopping automatically.

Control of the rate of feed is obtainable through the heavy felt pad in the rail which can be made to feed the wicks just sufficient oil to maintain a constant film between ring and traveller. Experiments with wick lubrication show

that the wicks cannot be allowed to dip into free oil unless some control is introduced to check the flow.

Now, if you will excuse me, I should like to give you a little information as to how these rings have performed in the hands of the public. This patent ring is made by my firm and for that reason I have much more information about it than I have about any other wick oiling type. The system is in operation on all sizes of ring from 1¼ in. to 5½ in. and appears to be equally satisfactory for any size. The increase in production due to freedom from any stoppages for lubrication is considerable and easily calculated. The increase in spindle speeds varies to an enormous extent, but has been greatest in this country where speeds have been low. Twenty-five per cent. increases have been quite common here.

The even lubrication afforded by wick oiling has resulted in more regular twist, which has appealed to many doublers. It has also given such a smooth and even run to the traveller that the reduction in drag had to be made up by using half a size or a size heavier traveller.

The following are three examples of the benefits of wick lubrication :—

Firm A was doing 100/2 voile yarn with 70 turns on 1⅛ in.-rings at 8,000. They stated that this was their maximum with greased rings but since they have adopted oil lubrication they can run successfully at 10,000—25 per cent. rise in speed ; from 18 metres to 22½ metres per second.

Firm B was putting 50 turns of twist into real silk on grease lubricated doubling rings, 1⅞ in diameter, at only 5,500 revs. They found it necessary to stop the frame some time before the bobbins were quite full in order to re-grease the rings. This was a slow process as it had to be done with a thin-bladed knife owing to lack of room. They went over to wick lubricated rings and are now running at 7,500 revs. with no stoppages between doffs. This increase in speed is 36 per cent.

In the United States, silk twisters have been limited to speeds of 3,500 to 4,500 with their special rings and bar travellers. With the aid of the laced type of wick-oiling ring they are now advertising that their frames can be run up to 10,000 revolutions.

There is one difficulty which may arise in the case of rings with controlled oil lubrication. When a great deal of water is used, as in the Scotch system of doubling, the natural gum tends to get washed out of the cotton and accumulates on the outside of the ring top. In this position it causes trouble in starting up as the head of the traveller is pulled on to the stickiness and the end comes down. With greased rings this does not happen to nearly the same extent, as the grease is applied to the ring top and some finds its way over on to the outside where it prevents the stickiness from taking hold. This difficulty caused us a good deal of trouble, but after we found that it had nothing whatever to do with the lubricating oil, and everything to do with the amount of water used, we began to see daylight. I think we may claim to have got over the difficulty now by brushing the travellers once or more per doffing with a brush dipped in a special oil which keeps the gum from getting tacky.

" Brassing."

No talk on doubling rings and travellers would be complete without some reference to that bugbear of the wet doubler—brassed rings. Rings are said to be " brassed " when the brass of the traveller has been deposited on the bearing surfaces and it is comparable to " running a bearing." A brass traveller careering round a steel ring at some 45 m.p.h. must be adequately lubricated. There must be a film of oil between the traveller and the ring, and so long as this oil film is maintained no trouble need be expected, but should the oil film break down, the rubbing surfaces rapidly become dry and trouble is the inevitable result. Minute particles of the traveller are rubbed off, and become deposited on the ring surface, increased friction is set up, speed is reduced, and the results are thus very similar to a " run " or " seized " bearing.

This can happen very quickly ; in fact, a few minutes of oil shortage and the damage is done. It *can* also happen owing to the use of a poor quality of lubricant

or to overloading. There is only one cure. The rings must go back to a maker to be cleaned up. When you think of the monotony of hand-greasing hundreds of rings several times a day, it is not to be wondered at that the work is sometimes " scamped " or that a few rings get missed. There is yet another way in which it can happen. Grease is sometimes kept in a very cold store so that it is brought to the operative in a crumbling condition more like cheese than cream. Naturally it does no good in this state and gets knocked off by the first revolution of the traveller. The moral is: keep your grease in a moderate temperature.

Traveller Speeds

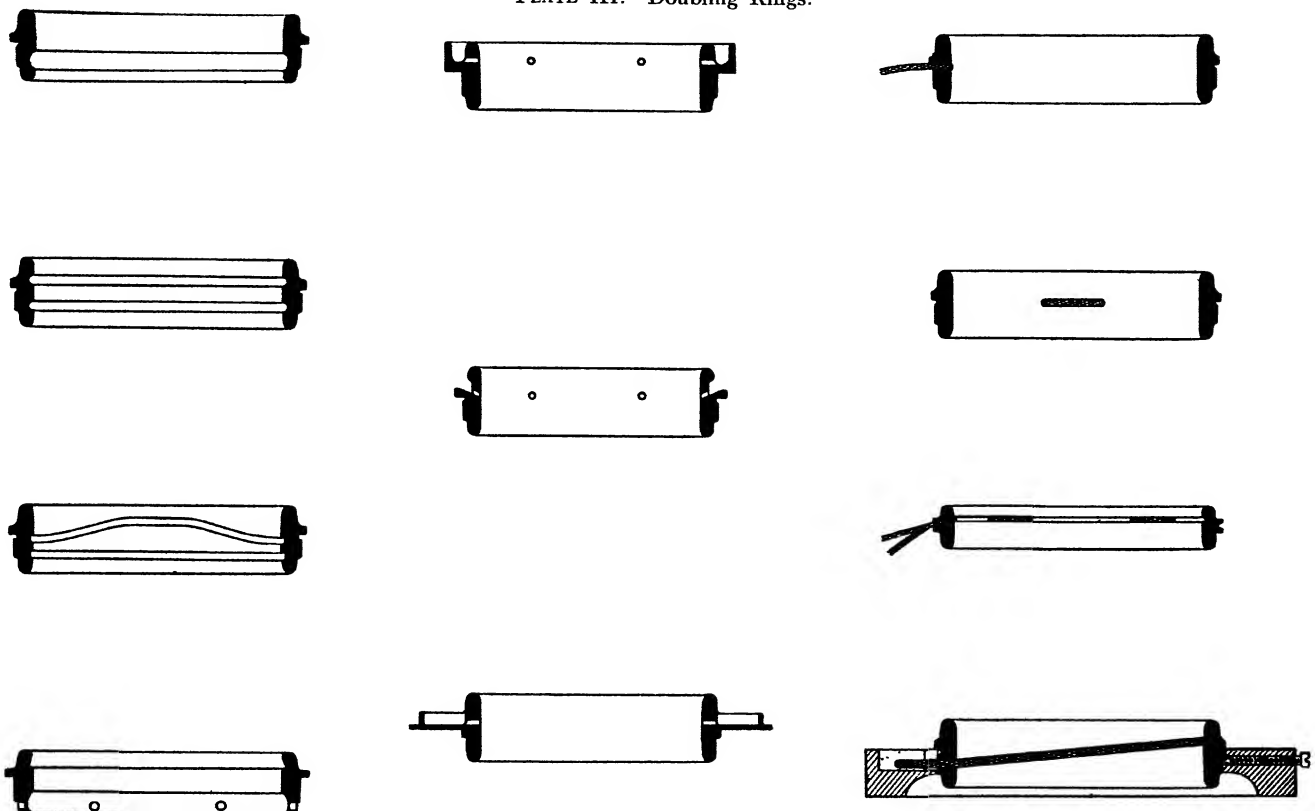
We now come to the last part of this talk—the part on speeds. It consists principally of examples of high speeds reported to us or to our friends in different countries, and it is therefore rather disjointed. I am afraid also that it will at once become apparent that information collected by a ring and traveller maker for his own use is of extremely limited value to the spinner or doubler. Most of this information consists of a bald statement to the effect that in such and such a country certain counts are being spun or doubled at certain speeds. We do not know the quality of the cotton nor that of the finished product. We do, however, very often know the maker of the frame, and of the rings and the travellers, which are the points which interest us, though these, unfortunately, cannot be given here for obvious reasons: As far as possible I shall distinguish between purely experimental speeds which are only of passing interest and speeds which seem to be regular practice. We must assume that the firm which regularly uses high speeds has weighed all the *pros* and *cons* and finds that these speeds are an economical proposition. At one end of the scale we have a few mad speed merchants asking for travellers to run at 16,000 revolutions and at the other we have people like the man to whom we offered some extra speed the other day and who replied that it would mean more frequent doffing, and that, as this was a slow process, he saw no advantage. Somewhere between these we have the happy mean.

As, in most of the examples which I shall give you, the front roller speed is not known, the calculations all ignore this factor, which after all only accounts for a slight reduction in most cases. For instance, at 11,000 spindle revs. with 1⅝ in. rings, ⅞ in. front rollers, and 242 revolutions, the difference between allowing for traveller lag and not allowing for it is less than one foot per second.

Before we take isolated examples of speed, here are one or two remarks of a general nature. In order to protect our patents we had to find firms abroad to make and sell our wick lubricating doubling ring. When we approached the best makers in Germany and America giving them chapter and verse of what the ring had done here, they both replied at once to the effect that while the idea seemed good, the " before " part of our " before and after " propaganda was all wrong. Their doublers were already running at much higher speeds than ours. Our German licensee estimated the difference in doubling speeds in the two countries at from 10 per cent. to 15 per cent. This was early in 1931. We ourselves had known of the very high spindle speeds in Switzerland for some years but I don't think we were generally believed when we spoke of 12,000 and 13,000 revs. We had also been given to understand that the Americans were cabling on 3½ in. rings at 6,000 revs. If there was anything in England to match these speeds at that time (1929) we did not know of it. To day my own impression is that the best speeds here probably compare favourably with average of other countries. On the other hand I don't think that some of *their* best speeds can be matched here at all.

I have previously mentioned that three competent authorities had roughly fixed the maximum speed for spinning travellers running on unlubricated rings at about 70 to 75 ft. per second. This speed represents about 10,700 revs. with 1⅝ in. rings. Let us see what we can produce round about this mark with

PLATE III. Doubling Rings.



(*a*)
Grease Lubricated Rings.

(*b*)
Oil Lubricated Rings.

(*c*)
Oil Lubricated Rings using Wick Feed.

spinning rings and travellers. I recently asked several friends in the machinery business to give me a rough idea of what new frames have been expected to do at various times during the last twenty years. The gist of one reply dealing only with India is as follows:—From 1912 to 1921 no great change, with the average slightly below 9,000 revs. with $1\frac{5}{8}$ in. rings. The average in the period 1929-1932 however is just over 10,000, with a few examples only slightly below 11,000. The rise here then is from about 66 ft. per second to 73 ft., and we are approaching the so-called limit.

Another example from the same market shows a maximum of 12,500 revs. and a minimum of 9,000 with variable speed motors. This is not strictly comparable since the highest speed is not sustained speed but the travellers apparently stand up quite well. Presumably the time spent running at 9,000 revs. is sufficient to cool off the traveller after its spurt up to 12,500. An average of 10,700 is slightly above the limit and giving a mean traveller speed of 76 feet per second would be just on the so-called limit.

A good deal of the increase in speeds has been made possible owing to the much better mixings of cotton now used. I understand Surat and American are much more used. We used to reckon that, count for count, it was necessary to use a traveller five sizes lighter in India than in Lancashire.

The figures given me by another friend agree substantially with these but he adds that Japan has jumped up in the same twenty years to 11,000 revs. and over. He mentions a speed of 14,000 in some cases, but I have no information to confirm this at all. In Switzerland, the other day, we came across a mill where they claim to be running at 10,000 r.p.m. on $1\frac{7}{8}$ in. rings and this speed is substantially above the so-called limit at 82 ft. I do not know what the class of work was.

From the November issue of the American journal *Cotton* I have obtained the only unlubricated traveller speeds higher than these, but they are with much larger rings—they are the ones mentioned earlier in the talk and refer to big package installations in America. They upset the theory of a 70 to 75 ft. maximum. At 88 ft. per second is recorded 7's counts being spun on 3 in. rings at 6,900 revs. and, in the same mill, 13's counts on $2\frac{1}{2}$ in. rings at 8,300 revs.

This is an installation of 25,000 spindles. Previously they used $2\frac{1}{8}$ in. rings and had a total labour cost of 1·70 cents per lb. in the spinning and spooler rooms. This total cost was reduced to ·875 cents per lb. by the above installation. The figures are stated to be " comparative and pre-depression ".

At 94 feet are recorded 10's to 16's being spun on $2\frac{1}{2}$ in. rings at 8,774 revs. At 103 feet we have word of 8's counts being spun on 3 in. rings at 7,816 revs. In this case there is the additional information that when spinning finer than 8's the speed has to be reduced. Spinners attend to eight sides each of 114 spindles and the normal ends down per hour are 30/35 per 1,000 spindles. The installation consists of 2,736 spindles. All these speeds are for unlubricated rings and travellers of spinning shape. Turning to travellers of the doubling shape, here are some examples in the fine range from 80/2 to 105/2 for comparison. In England we have examples of 100/2 being done on two different types of patent ring at 71 ft., apparently without trouble. Also in England, we have 80/2, 75 turns, being done at 80 ft. per second, 10,500 revs. on $1\frac{3}{4}$ in. rings with wick lubrication. Again we have examples from Switzerland at 82, 84, and 88 ft., the latter being done at 13,000 on 40 m/m rings with ordinary grease lubrication.

Swiss speeds seem to be very high indeed since, as recently as last month, our representative obtained doubling speeds from four mills all of which were over 82 ft. per second, viz., one case of 10,000 and one of 11,000 revs. in conjunction with $1\frac{7}{8}$ in. rings, one case of 10,000 with 2 in. rings and one of 6,000 with $3\frac{1}{2}$ in. rings. I don't know where we should go to find such high figures in this country. In all

probability they exist somewhere but I assure you that we do not hear of them. These figures certainly seem to confirm what our American and German friends said when we told them of the increases in speed that were possible with wick lubrication.

Our information is rather poor in the next range of counts below the fine ones just given, but the only example is none the less startling in the extreme. We sold a set of wick-lubricated rings of $2\frac{3}{8}$ in. diameter to a French firm and they wrote us last month saying that some trouble (unspecified) was being experienced with the travellers at speeds between 10,000 and 11,000 on 78/2 metric counts. We figured this out and found that the lower figure gave 103 ft. per second and the higher 113—either figure a record so far as we were concerned for rings and travellers of standard depth. Below this range most of my information applies to cable yarns for motor tyres, a lot of which is 15 fold 23's. Speeds here seem to vary tremendously and we have records from different mills of 59, 61, 78 and 89 ft. per second on rings from $4\frac{1}{8}$ in. up to $5\frac{1}{2}$ in.

We understand that there is at least one frame running at about 96 ft. per second—4,000 revs., with $5\frac{1}{2}$ in. rings, but this is rather exceptional and seems to be high water mark for the moment. On the whole these compare favourably with what we hear from abroad.

Worsted 62/2's yarn is being doubled successfully in one country on a self-lubricating *spinning ring* of very ingenious design. With the unlubricated spinning ring in the same mill, the speed is low, viz., 6,000 revs. with 2 in. rings, whereas when lubrication was successfully applied the speed was raised to 6,000 at the start and then 8,800. With the same type of ring too, 20's counts with 21 turns is being spun on $2\frac{3}{8}$ in. rings at 9,700 revs.—or 101 ft. per second traveller speed.

Finally, although we may be a bit behind with the spinning ring there can be no doubt that for twisting silk and artificial silk we are several jumps ahead. In America one firm alone has over 5,000 rings of the laced wick pattern bought on the basis of their trials during which they ran up to 11,400 revs. with $2\frac{3}{4}$ in. rings putting about 10 turns in real silk. This gives a traveller speed of 136 ft. per second, but this might be substantially reduced if we knew the delivery rate. For instance, similar work is being done in this country on rayon by one firm and the delivery is at the extraordinary rate of 650 feet a minute.

The immediate result of this speed in America is amusing since the frame maker is on the horns of a dilemma. He cannot make up his mind whether to tell his customers of the almost unlimited capacity for speed possessed by these rings and travellers and so risk cracking up his frames, or whether to claim only reasonable speeds and run the risk of having his competitors step in and claim something better. The situation is rather like that of the motor manufacturer who " hots up " his engine to such an extent that he has to redesign the whole of the chassis in order to withstand the increased strains and stresses. When you come to think of it there is a good deal of similarity between cars and rings and travellers. Both want careful running in. Only the best of both are capable of sustained high speeds. Finally it is the high speed merchant in both fields who enables us to progress and improve the breed. Differences in quality which pass quite undetected at touring speeds are instantly revealed by the punishing work of Brooklands track or by the highest spindle speeds.

DISCUSSION

The Chairman (Mr. T. E. Mitchell) said those present had listened to an admirable lecture. Personally, he had had little experience of the self lubricating ring referred to by Mr. Eadie. He considered that travellers wanted oiling at the top as well as at the bottom, and he thought that if a heavier metal were employed much better running of the traveller round the ring could be obtained.

Mr. Mitchell said he considered that rings and travellers were worthy of careful research; there was room, especially, on the doubling side for development in this direction.

A speaker said he could quite understand the attitude of the spinner referred to by the lecturer who did not want to speed up his frames because it resulted in a more frequent doffing. He considered that the high speeds obtained by foreigners was due to using much better cotton. He wished to know which the lecturer preferred—using a ring polisher or boiling the ring.

Mr. Eadie, in reply, said that the only work done by a ring polisher that he had ever seen could not be described as satisfactory. Actually he would like to see more polishers used as he would then sell more travellers.

Another speaker referred to the length of time taken in running in. He mentioned the occurrence of waves and asked how these occurred and if they had any special significance. He also enquired as to how wear could arise on the outer surface of the ring.

The Lecturer said that in striving for a high finish one had to avoid heating up the rings which induced surface softness. He would not like to make any kind of guess as to how long it required to run in a ring; it varied with every factor involved. Where there was a choice of count, he suggested commencing with the heavier as this would do the work of running in quicker than the lighter counts. Regarding the waves on the inside flange, his experience was that fine counts produced more waving than medium counts and he held the theory that the traveller was inclined to flutter. Americans said that the build had something to do with this. He thought that the theory of "traveller fluttering" was sounder.

A further questioner asked if the lecturer could state the average life of a ring.

Mr. Eadie said a lot of rings came into his office which had run up to 20 years. He used to supply a Swiss firm of silk spinners, who on one occasion showed him rings of four different makes, his own being one; they were all worn out. None had been run for longer than six months. In silk spinning the life of a ring was very short. In any case the length of life varied with the amount of work done. Mills were in a better position to answer this question for themselves. He thought twelve years or so was a very common life for doubling rings.

The Lecturer was next questioned upon his statement as to the use of grease of a cream like consistency, and was asked if this was not a question of room temperature.

Mr. Eadie said that it would not do for the grease to flow so quickly that one greasing would not be sufficient for a whole doubling. On the other hand if it were put on too cold or dry, it would drop or be knocked off. He always considered that a consistency similar to clotted cream was the best.

Mr. Fletcher Chadwick, referring to the question of grease, said that it was his experience that the consistency depended entirely on the temperature and humidity. He did not know of a grease which would be of the right consistency at all times. Taking the two extremes of Summer and Winter, a heavier and more solid grease was required in Summer than when the temperature was lower.

Mr. Sutcliffe referred to the greater speeds obtained in the United States and suggested that this might be due to the tendency of working with bigger distances between spindle and spindle. He would like to obtain information on this point.

Mr. Eadie replied that he would endeavour to obtain the information.

The Chairman then called upon Mr. Fletcher Chadwick to propose a vote of thanks to the lecturer.

Mr. Chadwick said he had listened with great interest to the lecture. On entering the room he was an optimist in regard to his knowledge of rings but he now felt a pessimist and that he knew nothing. He thought that the lecturer had taken a lenient view of the uses of rings and travellers. We should emphasise the effect of bad setting of machinery on the wearing of the traveller. Spindles badly set, and rings out of roundness, etc., were found to be the cause of excessive wear and this was all due to bad setting. Another point was the question of ballooning. If a traveller toe wore away quickly, the fault might be due to the setting of the running part or to the fact that the traveller was of the wrong count. Mr. Chadwick said he had been particularly interested in the remarks referring to the self lubricating ring. The lecture had opened a great field for thought and experiment.

Mr. W. Kershaw, in seconding the motion, said that although his knowledge of the subject under discussion was somewhat elementary, yet he had been extremely interested and found it of benefit. From the research point of view the lubricating problem was of special interest. In the examination of a faulty cloth, traces were often found of minute particles of metal. It was equally certain that faults might occur from the lubricants employed. He had very great pleasure in seconding the vote of thanks to the Lecturer for his excellent paper.

The vote was heartily accorded and Mr. Eadie briefly responded. After the lecture many examples of rings and travellers on view were inspected.

TEXTILE INSTITUTE COMPETITIONS

DISTRIBUTION OF PRIZES

The prizes awarded in connection with the Fabrics and Yarns Competitions for 1932 were distributed at the Institute on Saturday, December 3rd, by Professor Aldred F. Barker, of the Department of Textiles, University of Leeds. Mr. John Crompton, Chairman of the Competitions Committee and founder of the scheme, was in the chair.

Mr. Crompton said that the quality of the work submitted year after year was increasing and he felt justified in claiming that the Competitions Scheme was something which was of very material benefit to the trade. The members of the Adjudicating Committee* represented many different interests ; they were representative not only of the technical side and of the manufacturing side but also of the distributive side of the industry. Thus the work of competitors was given very careful consideration and from every angle the work was judged according to its merits. They were privileged on this occasion to have with them Professor Barker to speak to them and to present the prizes.

Professor Barker said :

" It is our privilege to welcome here this afternoon the winners of the Crompton Prizes, but before we do this I wish to say a word about our Chairman—Mr. Crompton. At the last banquet of the Worshipful Company of Weavers—the oldest of the London Trade Guilds—the Chaplain, Canon Gale, gave a beautiful old ' Grace,' finishing with the words—

' let us think of the Giver.'

And in opening our proceedings this afternoon I would say, ' let us think of the giver,' Mr. Crompton, the founder of the Crompton Prize Scheme. As I turn over the pages of my memories of the Textile Institute, his genial presence is always in evidence, ever cheerful, ever helpful. The Textile Institute owes much to him. And we may well think also of Mrs. Crompton, and ask Mr. Crompton to convey to her our heartfelt wishes for a speedy restoration to health.

" Now in welcoming the Crompton Prize Winners this afternoon, I must try and think of a method of presentation of what I wish to say ; a presentation which in the short time allotted to me will enable me to make my impress on you. And I think the method which will best suit my purpose will be that coming to us from America—but no worse on that account. If we think of the designing section of our work we shall realise that it has a threefold aspect—there is I, the designer ; there is you, the prospective purchaser ; and there is the design, which I am hoping will take your fancy. Let us deal first with the designer.

" Now the first thing we must look for in the designer is ' pride in his vocation.' Unless he has a true pride and a genuine interest in his work and in the industry which claims his activities, he will never make headway. And what a wonderful industry ours is ! Think for a moment of the similes and metaphors in Ancient, and indeed in all literature—

' The King's daughter is all glorious within,
Her clothing is of wrought gold,
She shall be brought unto the King
In a raiment of needle-work.'

Then again think of ' the golden thread of life ' ; and as it is the ' Scott Centenary,' some of you may think of the verses out of ' Guy Mannering ' :

' Twist ye, twine ye ! even so
Mingle shades of Joy and Woe,
Hope and Fear, and Peace and Strife,
In the thread of human life.

* The report of this Committee will be found on page P286.

' While the mystic twist is spinning,
And the infant's life beginning,
Dimly seen through twilight bending,
Lo ! what varied shapes attending !

' Now they wax and now they dwindle,
Whirling with the whirling spindle.
Twist ye, twine ye !—even so
Mingle human bliss and woe.'

" Then, if our Lancashire friends will forgive me, I should like to quote from the Yorkshire ' Song of the Weyver ' :

' I'm nobbut a weyver, me name is Joe Blobb,
A " poverty knocker " and aat of a job ;
I weyved a hand-leum when business wor throng,
And Click-a-clack, thump ! I went all the day long.
Click-a-clack thump, thump !
Click-a-clack, thump, thump !
Click-a-clack, thump ! I went
All the day long.'

" Can we not feel the joy of the hand-loom weaver in his—

' Click-a-clack, thump, thump !
Click-a-clack, thump, thump !
Click-a-clack, thump ! I went
All the day long ? '

" But here I can well imagine some of my audience saying ' What joy can there be in the machine-ridden industry of to-day ? '

" How splendidly my old colleague, Professor Lascelles Abercrombie, has put this :—

' And shall there be no end to life's expense
In mills and yards and factories,
With no more recompense
Than sleep in warrens and low styes,
And undelighted food ?
Shall still our ravenous and unhandsome mood
Make men poor and keep them poor ?—
Either to starve or work in deadly shops
Where the dam'd wisdom of the wheels
Fearfully fascinates men's wit and steals,
With privy embezzlement that never stops,
The worker's conscience into their spinning roar,—
Until men are the dead stuff there,
And the engines are aware ?
Shall we not think of Beauty any more
In our activities ?
Or do no better than to God complain ?—
I would that to the world would come again
That indignation, that anger of the Lord,
Which once was known among us men.'

" But against this I must remind you that Rupert Brook wrote :

' The keen unpassioned beauty of a great machine ' ;

and one of our great thinkers wrote of—

' the marriage of the machine with personality.'

This is what we must aim at attaining, and just in so far as we can attain to this ideal will our designs be ' living ' and ' vital ' rather than ' dead ' and ' mechanical.' Is the machine to dominate us or are we to dominate the machine—to impress our personality upon it and its productions.

" The next equally important condition is that the designer should be ' one of the gifted ones of nature.' We are not all born with a faculty for design and one of the first duties and privileges of our Colleges of Art and of Technology is to discover those who are gifted in this respect. Then should the Colleges and Schools in collaboration see to it that every thus gifted student is drafted into the living stream of design and given every opportunity for self expression along the line of his bent.

" When the gifted designer, however, comes to face the demands of the market, he will be brought up with a shock—for he will often find that the ' buyer ' will have none of his artistic inspirations but demands that which makes one shiver. I remember, for example, visiting a Yorkshire Woollen Mill where I was shown rugs in red, yellow, and green which nearly made me ill. But these were the colourings demanded by a negro tribe in the heart of Africa.

" Now we cannot get away from this condition—to live we must meet the trade demand ; so that if this is bad, the only thing we can do is to change it. And to do this demands the Art training not only of our gifted designers, but also of the purchasing public.

" And here I would give you a rather beautiful simile—the wave with its crest. At the crest of the wave are the skilled designers dancing in the sunshine of inspiration, but only in so far as there is the uplift of the wave from beneath can there be the crest on the height. I do not believe that Carlyle's advocacy of the ' dominating man ' is a presentation of the conditions of life which make for true progress. The wave is the truer simile, and I would commend the idea to you for your most careful consideration ; and if you are in agreement with me then you will become staunch advocates for the better Art training of the whole of our people—not only for those who are destined to come out at the top.

" Here is another way of looking at the same problem which possibly takes us a step farther. A philosopher recently said that original creative work does not reside in the creation of something which has never been in the world before but in the creation by each one of us of something beyond anything which we ourselves have previously experienced and expressed and from which we can gain the inspiration of achievement. Originality should have reference to the individual in the first place, and then this individual originality may ultimately lead to an originality of wider scope but not necessarily of more importance. This again emphasizes the importance of training both the gifted and non-gifted in artistic perception alike. And this in order that first, the truly gifted ones may be given their chance ; and that second, there may be a responsive public demanding artistic things and even stimulating the gifted ones in their productions.

" Then what of Textile Design itself ?

" I recently put the question to one of our accredited Textile designers—Why it is that the radiating lines of a sea-shell are entrancingly beautiful, while similar curves drawn with compasses are anything but beautiful and certainly uninspiring. And his answer was that behind the radiation of the sea-shell is vital force—life ; while in the geometric curves is deadness. The one is dynamic, moving—the other is static, still. And to-day the whole world is demanding living design, and unless we can get our designers into this living stream they will never succeed.

" Some years ago Sir Frank Warner said to me : ' If you represent the world's demand for tapestry design by a column 36 ins. high, we are only supplying about 1 in. of this.' If this be so, then with reference to this type of design we may say that we are not regaining what we have lost but are already making a good fight for a better position in this industry than we have ever yet held. I remember some years ago staying in Switzerland with a German professor of the Fine Arts, who had just visited the International Exhibition of Schools of Art in Paris. He agreed with me that in design the British Schools of Art were at the top ! I really think we may take it that we have at least as good raw material as any of our Continental competitors—but the truth is we have not yet learned how to make the best of it. The Crompton Prize Scheme, however, is helping us all—teachers and taught alike—and if only our Colleges of Art and Technology will collaborate and put their shoulders to the wheel, success is inevitable.

" But we have yet a long way to go. Some of our designers for men's wear are getting their inspiration from our Art Galleries, and in this type of work

Britain is leading the world ; but, in some phases of our Art life, the coming dominance of German inspiration is recognised. In Tapestry Design we have too long lingered in a mechanical deadness and we must all try to evolve those conditions under which our most promising boys and girls are brought into the stream of living design and at the same time develop an educated public which will demand the right thing and not be satisfied unless they get it. Some of the exhibits of the Crompton Prize awards in both Colour and Design are most inspiring and all are good, and I must heartily congratulate the prize-winners on the success which has attended their endeavours."

Professor Barker then distributed the prizes to successful competitors in accordance with the undermentioned list.

(A) COMPETITION (Crompton Memorial)—WOVEN FABRICS

First Prize (£35 and Certificate)—Ernest Hartley (Keighley Technical College).
Second Prize (£25 and Certificate)—Frederick McKay (Manchester College of Technology).
Third Prize (£15 and Certificate)—Gordon Trevor Duckworth (Nelson Municipal Technical School).
Prizes of £5 each—Henry Knight (Salford Royal Technical College) ; Stanley Lee (Bradford Technical College) ; Arthur Mutton (Burnley Municipal College) ; Ronald Williamson (Manchester College of Technology).

(B) COMPETITION—NOVELTY FOLDED YARNS

First Prize (£7)—Cyril Howden (Bradford Technical College).
Second Prize (£5)—Harry Eccles (Blackburn Technical College).
Third Prize (£3)—Joseph Airey (Blackburn Technical College).

(C) COMPETITION—NOVEL WOVEN FABRIC

First Prize (£7)—Frederick Lynn (Dewsbury Technical College).
Second Prize (£5)—Arthur Johnson (Leeds University).
Third Prize (£3)—Richard Maurice Halliday (Leeds University).

(D) COMPETITION—WOVEN FABRIC (Special Students)

First Prize (£5)—Norman Hindle (Keighley Technical College).
Second Prize (£3)—George Pepper (Bradford Technical College).
Third Prize (£2)—John Kenneth Smith (Burnley Municipal College).

(E) COMPETITION—KNITTED FABRIC

First Prize (£7)—Miss Jean Forgham (Leicester Colleges of Art and Technology).
Second Prize (£5)—Miss Phyllis M. Hafford (Leicester Colleges of Art and Technology).
Third Prize (£3)—Miss Margaret K. Watts (Leicester Colleges of Art and Technology).

Mr. F. C. Porter moved a vote of thanks to Professor Barker who, he said, by his teaching and writing had helped in a great many ways the development of the textile industry. For years he had been engaged in this work and his activities included extensive overseas travels. He was also welcome to this particular audience as he was a foundation member of the Textile Institute for which body he had done a great deal of work.

Mr. H. C. Barnes, seconding the proposal, pointed out that in the Textile Institute and Industry Professor Barker had a very special place. He said " The Institute has for its object the encouragement of the whole art of textile production, that is, not merely in science and scientific research, but also in the branches of economics, productive technology, and Art. These competitions are carried on for the encouragement of the design or artistic side. Perhaps this side, in comparison with the achievements of scientific research, is relatively neglected. The economic, technical, and artistic aspects may not have kept up with the

scientific. If that is so, it is not the fault of Professor Barker. The achievements of our scientific friends are so impressive as to be rather depressing. We have to rely upon Professor Barker for protection against them, that is for all-round sanity. He has shown his feelings for textiles in many ways. For example, there is in his Department at Leeds a magnificent collection of fabrics and his books on this subject are most inspiring. He stands for a vigorous use of imaginative treatment. His intense interest in textile materials and textiles has taken him from China to Peru ; quite literally from Kashmir to Peru. I think I shall be right in interpreting his ideas if I say that a woven fabric can be a genuine work of art and in fact a masterpiece. He has mentioned Kashmir shawls. We have, in this country, a great tradition for textiles ; Yorkshire suitings, West of England cloths, Irish and Scotch linens, Scotch tweeds, Macclesfield silks, Nottingham lace, etc., are known all over the world. The finest cotton goods are known everywhere as ' Manchester goods.' It is a reputation of which we may be very proud but it does not do to rest on past achievements. There are other branches in which progress can be made. The design of new textiles is not a branch which is being neglected. Some of the fabrics which are now being produced from rayon in Lancashire can only be described as marvellous in their qualities. Mr. Crompton, who inaugurated this Competitions Scheme, is a far-sighted man and in founding it he was no doubt aiming at results, not only for the whole of Lancashire, but for the textile industries generally. Many prizes have gone to Yorkshire, but if Lancashire or other sections can learn anything from Yorkshire I do not think they will grumble. Every section seems to have something which it can add to the common stock. The Midland section is a newcomer and I think that what it has to show is a really excellent modern note in line and colour. Perhaps that is because almost all the competitors were women. I think in the British textile trade on the question of design we can learn a lot from the womenfolk. It seems to me significant that we get the most desirable fabrics from those places where there is a craft tradition, where there are hand loom weavers as in Scotland, in Macclesfield and Soho, and in Paris. It is not merely because hand looms are used but because these craftsmen have an instinctive feeling for the material, structure, finish and colour of the medium in which they work. In my opinion, the Textile Institute should encourage such real craftsmanship, bringing together all the elements of which it consists. It is only by intense interest in this aspect of textile production that we can hope to achieve the high level of attainment at which British textile industries should aim."

The President, Mr. George Garnett, in supporting, said he and Professor Barker had been associated since they were in the twenties. He was one of Professor Barker's first pupils when he was at Saltaire technical school. He was not in agreement with him when he said that we had much to learn from Germany in the way of design. His experience was that in men's suitings we led the world and quite recently he had had continental testimony to this position. In regard to women's dress goods, perhaps the same statement could not yet be made, but we hoped to attain a similar position ere long. Professor Barker's work was such that when he retired, as he was soon to do, he could feel that he had played his part well and truly and that his record was one of which he might be justifiably proud. He could feel that he had not lived in vain.

" Designers," Mr. Garnett continued, " ought in his opinion to be much more highly remunerated. Their work ran the factory ; they were essential to the industry. Their training should be of the very best obtainable and when in actual employment their workplaces should be adequate and in keeping with their work. A boarded-off corner of the mill for the designer," said Mr. Garnett, " could not be productive of the highest inspiration and work."

The resolution being carried by acclamation, Professor Barker, in thanking the audience, said that in men's wear we absolutely did lead, but in the tapestry

designs he thought there was a field in which we by no means led. We should enter this field and try to gain some of the prizes that were awaiting us.

The proceedings concluded by a vote of thanks, on the motion of Mr. Dumville, to Mr. Crompton for presiding.

The Report of the Adjudicating Committee, to which reference is made above, is given below :—

" In the principal competition for woven fabrics, not only are the competitors more numerous this year, but the level of attainment throughout the ranges of cloths submitted is distinctly high. A better standard in average production was looked for by reason of the reduced number of specimens required from each competitor. This reduction appears to have been justified by the results and it is hoped that on the existing basis the ' A ' Competition may continue to attract an increasing number of candidates. The Committee is not unmindful of the desirability of some re-arrangement whereby special appeal can be made to students engaged in different sections of textile production, and urges the importance of securing adequate funds for the purpose. In this connection, there is room for specialisation in relation to woollen and worsted fabrics and the Committee would heartily welcome financial assistance.

" For the first time, a special class has been provided for knitted fabrics, and lady competitors carried off the whole of the prizes. The specimens sent in produced keen competition, and both in design and colour admirable effects have been secured. In the matter of colour, the specimens suggest quite a challenging spirit in boldness of conception.

" In the competition for special fabrics for specified purposes, an extension of the field of application is particularly welcomed.

" As a whole, the exhibits of the competitors are distinctly encouraging to all interests concerned and, in addition to the display which will be made on the occasion of the distribution of prizes at Manchester, on Saturday, 3rd December, there will be a full day's display on Friday, 2nd December."

NOTES AND NOTICES

Annual General Meeting

The next Annual General Meeting of the Institute has been fixed to take place on the same afternoon as the regular meeting of Council in May—the third Wednesday (17th May). The Council reached this decision at their meeting in November. The matter of nomination for the Presidency was also under consideration but no immediate decision was arrived at. In due course, notices will be issued to Members as to nominations for Council. The Council is composed of thirty elected members, ten of whom retire annually by rotation. The financial position of the Institute will, of course, be reported upon at the Annual Meeting and it is confidently hoped that an improved report may be presented. The Membership strength of the Institute, which is so very important a consideration, may also prove satisfactory. The additions to membership during the current year have been remarkably substantial though, unfortunately, the increases each month during the year have been seriously offset by withdrawals due, mainly, to the depressed state of industry.

Designs and Structure of Fabrics

The annual exhibition of prize-winning fabrics and yarns in connection with this Institute's Competitions for the current year took place on Friday and Saturday, 2nd and 3rd December, at Headquarters. A total sum of £150 was awarded, and the prizes were presented by Professor A. F. Barker, of Leeds. There was an excellent attendance, and it was generally conceded that the exhibits formed a distinctly creditable collection. Each year, the Competitions Committee has given most careful consideration to the conditions attached to the various competitions and, in some respects, almost drastic alterations have been effected by comparison with the details of the early competitions of the Institute. In the " A " Competition (associated with the Crompton Memorial Scheme), for instance, the total number of specimens demanded from each candidate has been greatly reduced. The Committee, however, has effected this reduction in such a manner that the requirement of versatility on the part of competitors is not sacrificed. The evidence now is that the number of specimens required is small enough to be regarded as a minimum for some time to come. Special interest attached to this year's exhibits by reason of the fact that, for the first time, a competition for knitted fabrics was included. Inasmuch as the three prize winners in this section were young ladies of College of Art training, the question has again been raised as to the adequacy of training in Art so far as design in relation to woven fabrics is concerned. The Crompton Competition provides for competitors who " have taken an Art Course, including a course in Textile Design and Structure approved by the Competitions Committee." So far, however, there has been little or no response from this particular class of students and it is felt that some movement in this direction ought to be assisted. The Committee would certainly welcome any suggestions from those concerned with the Art side of training in relation to design for woven fabrics.

Institute Publications

Since 1924, when a full report of the Empire Textile Conference at Wembley was issued, the Institute has published several distinctive documents. These have been consistently kept at a low price—in some instances only just over cost—and in all cases special prices for students have been fixed. As a result of this policy, funds available for publication have been locked up and unless released by steady sales are no longer available for a continuation of the work. Recently, an appeal was issued to the Heads of over fifty Textile Departments of Technical Colleges and Schools giving a list of publications available and quoting special

prices to Students. Response has been made to the appeal by Leeds University, and the Technical Colleges at Batley, Bolton, Bradford, Huddersfield, Oldham, Rochdale, Salford and Shipley. The thanks of the Publications Committee are due to these institutions. Despite the stringency of the times it is hoped that other Colleges will respond to the appeal circulated and it should be noted by members generally that assistance to the work of the Institute can be rendered by securing copies of its special publications. Our advertisement pages this month give full particulars of the literature available.

British Association for the Advancement of Science

York Meeting, September, 1932.

The Hundred-and-first Annual Meeting of the British Association, held appropriately at York, the town of its origin, had an excellent programme, planned to cover all its 13 Sections except that of Physiology. Papers of interest to the textile industries were read to more than one section and the following is a list of those to which attention may be drawn.

Section (A) Mathematical and Physical Sciences

The Psychological Bases of Wool-sorting. By Dr. S. G. Barker and Mr. C. G. Winson.

The Theory of Drying. By Messrs. J. Frith and F. Buckingham.

Controlled Humidity in Woollen and Worsted Mills. By Dr. S. G. Barker and Mr. M. C. Marsh. (See *J. Text. Inst.* 1932, A623).

Section (B) Chemistry

The Constitution of Polysaccharides, with Special Reference to Fibres: Introduction. By Professor W. M. Haworth.

Molecular Weight of Cellulose and its Intermediate Hydrolysis Products. Relation between Cellulose and Chitin. By Professor Max Bergman.

The Nature and Size of the Colloid Particles of Cellulose and Related Substances. By Professor H. Staudinger.

Amylose and Amylopectin. By Dr. E. L. Hirst.

The Space Model of Cellulose. By Professor H. Mark.

Protein Fibres and the Formation of Polysaccharide Chains. By Mr. W. T. Astbury.

Section (D) Zoology

A Sheep-goat Hybrid. By Mr. W. C. Miller.

Section (E) Geography

The Wool-textile Industry of the Pennines in its Physical Setting. By Mr. W. B. Crump.

The Distribution of Occupations in the West Riding with particular reference to Textiles, By Mr. H. C. K. Henderson.

Section (F) Economic Science and Statistics

The Economic Position of Japan. By Professor G. C. Allen.

Colour and Colour Cycles. By Mr. R. F. Wilson.

Section (J) Psychology

Individual Differences in Colour Discrimination. By Mr. W. O'D. Pierce.

Section (M) Agriculture

Sheep Farming: a distinctive feature of British Agriculture. By Professor R. G. White.

Certain Aspects of the Genetics of Sheep and their Potential Economic Significance. By Mr. W. C. Miller.

Some Economic Aspects of the Scottish Sheep Industry. By Dr. A. H. H. Fraser.

Geographical and Historical Aspects of East Riding Agriculture. By Dr. S. J. Best.

Textile Institute Diplomas

Election to Fellowship has been completed as follows since the appearance of the previous list (November issue of this *Journal*) :—

FELLOWSHIP

KING, Willie Edgar (Bradford).

Institute Membership*

At the *July* meeting of the Council, the following were elected to Membership of the Institute :—A. E. Battye, M.Sc. (Leeds), Tootal Broadhurst Lee Co., Ltd., 56, Oxford Street, Manchester (Research Chemist) ; Sir Ness N. Wadia, K.B.E., C.I.E., Strachey House, Pedder Road, Bombay, India (Millowner).

At the *September* meeting of the Council, the following were elected to Membership of the Institute :—W. Von Bergen, 166, Luddington Avenue, Clifton, N.J., U.S.A. (Chief Chemist, Forstmann Woollen Co.) ; A. Roberts, M.Sc., Hetlands, Heaton, Bolton (Director Mather & Platt, Ltd.). The following were elected to Junior Membership :—A. K. Bingham, " Mostyn House," 70, Wingate-Saul Road, Lancaster (Assistant Dyer and Textile Student) ; G. Dinwiddie, " Thorn Cottage," Bromley Cross, Bolton (Trainee, United Thread Mills, Ltd.) ; H. Haigh The Meadows, Haworth Road, Bradford, Yorks. (Wool & Top Traveller) ; C. H. Hampson, The Grove, Westhoughton, Lancs. (Manager and Secretary, Reeling and Winding) ; H. Mulhall, 93, Morris Street, Oldham (Junior Draughtsman, Textile Engineering).

At the *October* meeting of the Council, the following were elected to Membership of the Institute :—T. Baker, 13, Raimond Street, Halliwell, Bolton (Loom Overlooker) ; J. P. Drew, 44, Arundel Road, Lytham St. Annes, Lancs. (Manager and Salesman, Cliff Spinning Co) ; W. Hindle, representative member for Talbot Spinning & Weaving Co., Ltd., Talbot Mills, Chorley (Secretary) ; J. L. Holland, 238, Hornby Street, Bury (Assistant Manager and Assistant Salesman, Bury Ring Mill, Ltd.) ; F. C. Hoyle, 28, Cloisters Avenue, Bickley, Kent (Salesman) ; Miss A. J. Martin, A.R.C.A., Alouette, Mill Hill, Shenfield, Essex (London representative in publicity for Linen Industry Research Association, and part-time teacher) ; I. P. Morris, B.Sc. (Hons.), A.I.C., Chemical Department, Ministry Gardens, Cairo, Egypt (Senior Chemist) ; J. Peacock, 59, Tannahill Terrace, Craigielea, Paisley (Chemist, J. & P. Coats, Ltd.) ; T. Roscoe, 2, Maze Street, Darcy Lever, Bolton (Manager's Assistant, Doubling Dept., Thos. Taylor & Sons, Ltd.) ; J. Guilfoyle Williams, B.Sc. (Lond.), A.I.C., Merchandise Research Laboratory, Selfridge & Co., Ltd., Oxford Street, London, W.1 (Chief Chemist). The following were elected to Junior Membership :—S. Angus, 12, Raphael Street, Bolton (Frame Overlooker) ; M. M. Braga, " Lyndene," Wigan Road, Bolton (Textile Student) ; J. L. Butler, Halliwell House, Church Road, Bolton (Textile Student) ; J. Dyson, 17, Osborne Street, Rochdale (Sectional Chargehand, Ring Spindles, Dunlop Cotton Mills) ; F. W. Fogg, 14, Devonshire Road, Sherwood, Nottingham (Under-Manager, Ladies' Underwear Dept.) ; F. J. Mathias, 25, Albert Road, Whalley Range, Manchester (Student) ; R. H. Robinson, 18, Chadwick Street, Bolton (Textile Student).

At the *November* meeting of the Council, the following were elected to Membership of the Institute :—A. Baker, F.I.C., M.I.Chem.E., Yews, New Barn, Longfield, Kent (Joint Managing Director, Bowaters Paper Mill, and Mersey Paper Mill) ; A. Bibby, Wyndy Ridge, Nottingham Road, Chaddesden, Derby (Supervisor, Staple Fibre Yarn Spg. and Preparatory Mill of British Celanese, Ltd.) ; W. E. Billinghame, Durlston, Burnt Ash Lane, Bromley, Kent (Chairman and Managing Director, Amoa Chemical Co., Ltd.) ; F. E. Ellis, A.R.C.A., 8, Hirstwood Road, Nab Wood, Saltaire, Yorks. (Lecturer, Technical College, Bradford) ; T. E. Ellison, D.Sc., A.I.C., William Ewart & Son, Ltd., Glenbank

* Previously omitted by reason of space considerations.— *Editor*

Bleach Works, Belfast (Chief Chemist); J. R. Horsham, 24, Linton Street, Exley Head, Keighley (Control of sample Dept., Robert Clough's (Keighley), Ltd.); W. Knight, "Formosa," The Spa, Melksham, Wiltshire (Fabric technologist, Avon India Rubber Co., Ltd.); Y. M. Marathe, University College, Shakespeare Street, Nottingham (Student); C. F. Sunderland, Empire House, St. Martin's-le-Grand, London, E.C.1 (Sales Manager, Weaving Section, John Holdsworth & Co., Ltd.); H. N. Whalley, "Knarrside," Tintwistle, Hadfield, near Manchester (Manager of Spinning Section, Gartside & Co. (of Manchester), Ltd.); H. Wilson, 2, Moss Bank, Queen Street, Shaw, Lancs. (Cotton Carder and Winding Overlooker). The following were elected to Junior Membership:— W. Dixon, 3, Glen Cottages, Montserrat, Bolton (Cotton Weaver, Barlow and Jones, Ltd.); J. R. Dunkerley, 50, Durham Street, Werneth, Oldham (Textile Draughtsman); A. A. Hayes, "Elsinore," Regent Road, Lostock, Bolton (Assistant Comber and Frame Overlooker, Wm. Heaton & Sons, Ltd.); J. C. Mills, "Greystoke," Whitefield, Manchester (Probationer, John Hall, Ltd.); K. C. Sarangapani, B.A. (Madras), 50, The Crescent, Anson Estate, Manchester (Student); R. Schweiger, Dalton Hall, Victoria Park, Manchester (Student); W. H. Thom, "Edenholme," Clayton-le-Dale, near Blackburn (Salesman, John Dugdale & Sons); A. H. Werner, 15, York Road, Chorlton-cum-Hardy, Manchester (Student).

At the *December* meeting of Council, the following were elected to Membership of the Institute:— T. Ross, Rock Bank, Bollington, Nr. Macclesfield (Head of Experimental Mill, Fine Cotton Spinners' and Doublers, Assoc.); R. D. Banaji, B.Sc. (Bombay), Moorhaven, 17 Grosvenor Mount, Headingley, Leeds (Student); R. A. J. Berry, 5 Allerton Road, Southport (Managing Director of Brook Mill (Leyland) Ltd.); A. S. Sanders, 9 Elm Grove, Ribbleton, Preston (Asst. Shed Manager, Burrows Ltd., Preston); T. R. Hartley, Firestone Tyre and Rubber Co. Ltd., Great West Road, Brentford, Middlesex (Fabric Inspector); G. G. Leadbetter, Oswald McCardell & Co. Ltd., Stretford, Manchester (Textile Chemist); H. A. Mason-Jones, 195 Stand Lane, Radcliffe, Manchester (Sales Organiser and Manager); W. W. Platt, 1054 Middleton Road, Chadderton, Oldham (Textile Fitter, Platt Bros. & Co., Ltd.). The following were elected to Junior Membership:—T. H. Brierley, 30 Lansdowne Road, Chadderton, Oldham (Stripper and Grinder, Sun Mill Co., Ltd.); G. S. Spring, Linden Lea, Bromley Cross, near Bolton (Cotton Spinning Apprentice); A. Warburton, 154 Crompton Way, Bolton (Ring Jobber); P. E. Adcock, 101 Carr Road, Nelson, Lancs. (Chemical Engineer for Rayon Sizing); N. A. Tsitsis, 3 Clifton Road, Chorlton-cum-Hardy, Manchester (Student).

REVIEWS

Weltwirtschaft der Wolle (Technologie der Textilfasern, Vol. VIII, No. 4), by Dr. Jur. H. Behnsen and Dr. Rer. Pol. W. Genzmer. Published by Julius Springer, Berlin. (195 pp. Price, 32 R.M.).

The book under review is a survey of the international organisation, economics, and statistics of the wool textile trade. Part 1 is devoted to an analysis of sheep and wool production in the various countries of the world, the years 1922 to 1927 being compared with the average for the pre-war period 1909-13. Following a discussion of wool classing in Part 2, the marketing of the raw materials of the several sections of the industry—greasy wool, washed wool, tops, yarn, noils, waste, etc.—receives detailed attention in Part 3, the organisation of wool sales being particularly well described. Factors affecting the price of wool and its variations from 1891 to 1931 are discussed in Part 4, followed in Part 5 by an interesting study of the various forms of duty, German and foreign, as they affect the German wool textile trade. The latter is made the subject of detailed statistical analysis in all its branches in Part 6, 1913 being taken as the standard year for assessing progress or otherwise in more recent years. The statistics relating to imports and exports in each section of the industry, together with the analysis of overseas markets, will prove extremely valuable to the industrialist. Similar, but less detailed, studies of the most important wool textile industries in other parts of the world, including Great Britain, are made in Part 7. Of great value to all who read German is the list of references to original literature which concludes the book. The authors are to be congratulated on having remedied a serious deficiency in the literature of the economics of the wool textile trade, but it is difficult to believe that the price will not minimise its more general use. J.B.S.

Die Ausrüstung (Apprêtur.) By E. Ristenpart. Published by M. Krayn, Berlin, 1932. (141 pp. Price, 10 R.M.).

This book forms the fifth part of the "Chemische Technologie der Gespinstfasern." The author states in the preface that it has been written for the use of the practical finisher, and as a text-book for technical students. He has attempted to deal in 141 by no means closely written pages with the finishing of cotton, rayon, linen, wool, and silk, in the form of yarn and woven and knitted goods. As might be expected, therefore, the result is not entirely satisfactory and one cannot find much that would be helpful to the practical finisher. As a text book for students it may be useful, as this is a subject in which text books are not plentiful. The excellent pictures and diagrams of plant form a redeeming feature of the book but deserve fuller treatment and more informative matter in the text as a background. R.G.

The Yorkshire Textile Industry, 1932-1933. Published by John Worrall, Ltd., Oldham. (Price, 15/- net. Post free).

This Directory announces two new features in the form of articles, one on the market developments, etc., in the woollen and worsted trade since the publication of the last edition and the other dealing with new machinery accessories and improvements recently introduced by advertisers. These are interesting enough but one wonders how many searching the literature will think of looking in a Directory for matter of this kind. Irrespective of the ideas of advertisers and others, the function of a directory is to direct or lead the inquirer to the information needed. Extraneous matter which confuses this issue is a hindrance and therefore detracts from the value of the work. An addition which would enhance the value of these well-known and indispensable directories would be to include under each town-heading a section for machinists and suppliers of accessories, thus forming for each town and village a complete picture of its textile and allied resources. Typographically these volumes have much improved. T.

Yarn Number Calculator.

The Henry L. Scott Co., Providence, R.I., has recently issued a circular calculator consisting of two discs. The outer disc, which is free to revolve, bears fixed points from which calculations can be initiated upon the inner disc which bears two graduated circles. It is a useful device as it enables quick

checking from one count of yarn to another and also the finding of the size of any yarn. Provision is made for calculations relating to Silk, Rayon, Worsted, Woollen, Jute, Linen, Ramie, Hemp, Cotton, and Asbestos yarns. It is issued in a leatherette case at $2.50. T.

Report of the Imperial Economic Committee on the Preparing for Market and Marketing of Hemp Fibres. Printed and published by H.M. Stationery Office. (Price 6d. net.)

This report deals not only with "true" hemp (*Cannabis sativa*) but with commercial hemps such as manila, sisal, henequen, Indian (Sunn) hemp, New Zealand hemp, and Mauritius hemp. At the outset the historical uses of true hemp are described and also an account is given of its decline and substitution by other fibres. Amid a wide number of sources of fibre supply the user, other properties being adequate to his purpose, aims at cheapness, and the fibre producer is, therefore, concerned not only with the volume of production and the fluctuations in the price of his own particular fibre but also with the development and prices of competing fibres. This report therefore covers the chief sources of rope, twine, and net fibres, dealing with their volume, production, and preparation so as to reveal their relative positions.

First consideration is given to the position now occupied by Manila Hemp (*Musa textilis*) grown mainly in the Philippine Islands over a slowly-increasing area. Reference is made to improvements made on large plantations taken over by United States and Japanese interests and the interesting comment is added that "if other Philippine producers are slow to take advantage of the improved technique they may be gradually eliminated." It is recorded that though there is a very small production of Manila hemp in certain parts of the British Empire there is "no prospect of the Empire becoming self-sufficient."

Two main outlets for Manila hemp exist:—for marine cordage; and for ropes, twines, and nets other than marine cordage. Trials of the suitability for marine cordage of other Empire fibres—sisal, New Zealand, Indian Sunn, and Mauritius hemps—are being made under the auspices of the Imperial Institute, in collaboration with the Admiralty. As a result of the tests carried out and elsewhere reported upon* the general conclusion was reached that "while sisal may surpass Manila in strength and appearance, and compares favourably in durability, it is inferior in retaining its buoyancy, size and shape, after immersion. Whether sisal or any other Empire hemps is widely adopted is likely to depend, therefore, on the importance attached to these latter qualities." The Standards demanded by the Board of Trade's regulations are necessarily high. Users will naturally be reluctant to change.

Outside the market for marine cordage, manila has been losing ground. It has been unable to compete with increasing supplies of well-cleaned sisal. This sisal competition has provoked improvement in henequen production as well and manila hemp has now both competitors to meet. The rest of the report gives consideration to the use of Empire fibres for the manufacture of twines, cords and small ropes other than marine cordage and should prove of very real value to those interested as it presents a broad picture of all the "Richmonds in the field," thus enabling their relative value of competitive power to be estimated. T.

Yarn Diameters and Cloth Structures: Theory and Practice. By T. Woodhouse and A. Brand. Published by Macmillan & Co., Ltd., 1932. (158 pages and Index. Price 10/6).

This work is a record of a series of investigations carried out by the joint authors with respect to maximum cloth structures attainable with given counts and diameters of yarn. There are twelve chapters and the work is kept within the limits and objects of the original investigation.

In chapter two, 16 illustrations are used to show possible differences in plain cloth structures, ranging from a piece of fine cotton calico to a heavy jute fabric. Having shown the common differences the authors proceed in subsequent chapters to discuss the problem of making fabrics with the greatest possible number of ends and picks per inch for stated kinds of yarn.

A good deal of experimental work has been recorded in the book dealing with a four-fold jute yarn counting 16 lb. per spindle (cotton count = 1·07). Comparisons

*"Empire Fibres for Marine Cordage." Published by the Imperial Institute, 1931.

are made between the Specific Gravities of the textile fibres and their known working densities in the form of cops, beams, and rolls of cloth and these observations are used to formulate working diameters of the yarns, first the jute yarn, and from that basis, other types of yarn such as cotton, worsted, etc. The calculated working yarn diameters are tested out by actual weaving in the case of the jute yarn and the authors' assumptions are proved to be substantially correct. Further tests were also made with 3/24s cotton varying the ratio of ends and picks per inch from maximum warp settings down to maximum weft settings, i.e., from " poplin " via " calico," to " limbric," if one might use such terms.

The diagrams of cloth structures which the authors use are well up to their usual standard of excellence. There are 72 illustrations of the text in addition to numerous tables of results.

The work can be recommended to all students of cloth structure because it provides a new field of observations upon a branch of textile science about which there is much difference of opinion. J.R.

"A Study of Empire Wool Production." By J. E. Nichols. Published by the Wool Industries Research Association, Leeds. (148 pages and 15 pages of illustrations. Price, 5/- nett.)

In his introduction the author explains that " From 1928 to 1931 a survey was undertaken of most of the principal wool-producing areas of the Empire outside Great Britain to study the numerous factors which influence the rationale of production," and apparently this work is in the nature of an abridged general report of his trip to these various parts.

The book is divided into three parts.

Part 1 contains 32 pages and includes sections and sub-headings :—1. Sheep Products, 2. The Stratification of the Industry, 3. Wool and the Nature of the Fleece, and 4. Wool Classing.

Part 2 has 101 pages and embraces eleven sections, nine of which deal with the following countries, New Zealand, Australia, South Africa, Southern Rhodesia, Kenya, Canada, Irish Free State, Palestine, Other Empire Countries ; Section ten treats briefly of Producers' Organisations, and eleven touches on Education and Research.

Part 3 deals with " The Problem of Wool Improvement " and occupies five pages.

Part 1. In this part, " Wool and the Nature of the Fleece " is perhaps the more interesting to the wool user and briefly describes under sub-headings, Fibre Characters, Density, Group Characteristics, Regional Characteristics, Quality, Grease in the Fleece, and Colour. Another section deals with wool Classing and sets out the considerations involved. Incidentally the feature " trueness to type " is introduced which at once raises the question of standards and reminds one how, for example, at present the term Merino is loosely used to cover a variety of materials including even fine crossbred and, we think the author might have used a more typical example than the figure shown on Plate 1 which we cannot accept as showing real Merino wool, independent of the variation in growth.

Part 2. The author here deals more or less briefly with different wool-producing countries within the Empire, discussing important features and submitting tables—such as are published by the various States concerned, the firm of Dalgety, and the Bulletin of the National Wool Manufacturers' Association, on the statistical side.

Part 3. sets out phases of " The Problem of Wool Improvement " as follows :— " Both producer and manufacturer are concerned with the question of improving wool and its processing in relation to its subsequent performance and use, and two methods of attaining this objective are suggested. The first consists in the elaboration and adoption of more efficient techniques in converting the raw material into finished products, including the methods of preparation and classing. The second consists in raising the standards of the raw material in relation to manufacturing demands, though it is recognised that the latter may change with the introduction of new methods of manufacture, new uses and fashions. The second is chiefly a biological problem."

The first of these suggestions is the constant aim of the wool user, in his own interest; but he cannot " make a silken purse from a sow's ear," nor spin fine yarns from coarse irregular wools only in the relative sense, nor can he obtain in the resultant fabric the characteristics of fine wool spun to thick counts when using coarse wool, therefore it is not easy to see how efficient technique can materially alter this aspect of the subject.

Regarding the second method, this in many cases is the constant endeavour of the wool grower within the limits of his conditions—climate, pasture, etc.—and his sheep are bred and culled to suit these and market conditions.

The possibility of the " introduction of new methods of manufacture, new uses and fashions," we do not consider as likely seriously to upset the producer of fine wool, and we cannot imagine the really fine and better types of wool will ever go out of fashion; this trouble can only arise in the case of coarse and inferior materials. It might be argued that in recent times cotton gowns have ousted silk at important social functions but on the other hand it requires a stretch of imagination to visualise a gentleman of taste wearing clothes made from Herdwick or Blackface wool at important society functions or for evening wear, so long as fine fabrics from Merino wool are available.

Again the author states " any means of wool improvement which serves only to remove a particular type of wool from one specific manufacturing class to another is of little real benefit, if any," surely as a general case, if the material is really improved it is available for a greater variety of uses and is intrinsically more valuable.

Continuing, " For instance, wools of the carpet type such as the Scotch Blackface may be displaced from their particular class by cross breeding, e.g. with Merino, and be called upon to enter into competition with others much more suitable for other purposes while at the same time the value of the sheep for slaughter may be lessened."

It is granted that the Scotch Blackface wool is extensively used in carpet manufacture, this is on account of its cheapness but it is also very evident that wool will always make a better carpet than kemp.

Regarding the comment on carcase, Dr. Nichols could have told us of the difference in Cheviots of the North and of the Border, how it came about and in what way the carcase has suffered. However, later the author states " breeding and selection are the only means which can lead to real improvement within individual flocks and strains."

As the term pure breed can now only be considered relative, and from the fact that such crosses as the Leicester Merino which produces a decent carcase and a wool more useful than the Leicester, we can endorse what Dr. Nichols has stated above; it is the price that matters, given remumerative prices the required type of wool will be forthcoming. As a survey, the work is well done and we would very much like a real book by Dr. Nichols, giving in detail, particulars of experiments on crossing to show how " The Problem of Wool Improvement " is being really tackled. - Ho.

Woollen Spinning. By O. Bernhardt and J. Marcher. Vol. VIII/2A. *Technologie der Textilfasern.* Edited by Dr. R. O. Herzog. Published by Julius Springer, 1932. (Price, 37.5 R.M.).

The authors introduce their subject by a brief study of the physical properties of the fibre and yarn construction; they compare different yarn structures and attempt to disclose the basic principles of woollen spinning. Woollen spinning is reviewed from the raw wool to the production of the finished yarn—beating, washing, drying, willowing, carding, spinning and their allied processes being dealt with comprehensively. Two chapters are devoted to the study of the preparation and production of re-manufactured wool and cotton.

A good feature is the quality of the illustrations and line diagrams. The authors accompany each description of a process with a photograph or line diagram of the respective machine, or of the part concerned. The variety of machines and arrangement of parts, especially with reference to carding, should

be of interest to both the student and practical man. The Gilljam Card is described in which the strippers are run in the reverse direction to normal practice and the slope of the pins altered accordingly.

After a brief description of the principles underlying mule spinning, the mechanisms and motions are described and illustrated. The Schubert and Salzer mule with its fixed spindles and traversing delivery rollers is included.

In their description of several new designs of false twist tube in woollen ring spinning, it is a little startling to find the authors merely making a passing reference to the new Gessner tube, and showing only the old type of tube made by Messrs. Platt Bros., with the two pegs and governor clip, without reference to the Wool Industries Research Association's improvements.

The book is distinctly German in character and most of the subject matter is derived from German machines. An English edition on similar lines would be a welcome addition to the literature. S.T.

"The Viscosity of Cellulose Solutions." Report of the Viscosity Sub-Committee of the Fabrics Co-ordinating Research Committee, Department of Scientific and Industrial Research, 1932. Published by H.M.S.O., London. (46 pages. Price, 1/–.)

There are described in the published literature a rather confusing variety of methods for the determination of the viscosity of cellulose in solution. This quantity is, of course, a very sensitive and unambiguous index of chemical degradation of cellulose, and is therefore the basis of a valuable test. The various published methods all agree in the use of cuprammonium hydroxide as a solvent but differ in the standard concentration of cellulose and in the type of viscometer used. The capillary and the falling steel ball viscometers seem almost equally popular in the literature.

After a useful review of the methods which have from time to time been put forward, the Viscosity Sub-Committee proceeds to recommend a standard technique and expression of results, designed to meet the expressed wishes and needs of industry. Thanks largely to the work of Clibbens and Geake, the suggested method is so simple that, given the necessary solution, it might be included in a school chemistry course. The capillary viscometer has been chosen, apparently to make possible the inclusion of a wide range of variously degraded celluloses at the same solution concentration of 0·5 per cent. This certainly avoids the complication of a not altogether exact conversion from one concentration to another, but at the same time advantages of the falling sphere method as improved by Tankard and Graham (*J.T.I.*, 1930, **21**, p. 260), are such that one feels that the balance of advantage is almost even.

In spite of the use of a capillary viscometer it is found that for highly degraded celluloses such as rayons the much higher concentration of 2 per cent. has still to be used. The result is that the values for cotton and rayon samples lie on entirely separate and distinct scales. This is, of course, adequate for the limited requirements of either industry, but does not facilitate a perspective view of the question of degradation of cellulose. It is a matter for regret that sufficient evidence is not yet available to enable the Committee to make a successful or indeed very helpful attempt to solve the really unavoidable conversion from one concentration to another, and that this difficulty still awaits solution. As regards the dissolution of the cellulose, the technique of Clibbens and Geake, whereby solution is effected in the viscometer itself, is of course, adopted. At the same time one is disappointed to observe that the rather ineffective stoppering of the viscometer tube by means of a rubber stopper carrying a glass tube and screw clip is recommended in preference to the very neat, reliable and precise spring loaded stopper of Tankard and Graham. The point is a small one, but the use of the spring stopper avoids the most unpleasant and doubtful part of the whole operation. Indeed the whole contribution which these latter authors have made to the technique of the measurement, and the forceful arguments they put forward, do not seem to have received the attention they merit. A case could still be made out for the opinion that their method is superior for industrial use to the method which the Report recommends. The arguments on both sides seem almost equally balanced, and for the sake of uniformity industry should therefore adhere to the method chosen by the Com-

mittee, particularly because it seems that the capillary method is at present the more widely used in industry.

The greatest difficulty in the use of the viscosity technique lies in the cuprammonium solution itself. The preparation analysis and adjustment of this solution is a rather laborious and exacting operation, and a special apparatus is required. The report does not lay sufficient stress on the imperative need for a simpler preparative technique. This point would, of course, be met if the solvent should become a commercial article at a reasonable price. The measurement is so important that the demand should justify this.

Once the solvent is available, the recommended measurement of cellulose viscosity is simple and the capillary viscometers are fairly easily made and calibrated—though by no means so easily as the plain glass tubes and commercial steel balls of Tankard and Graham, which need no calibration at all.

There are two further points of detail which call for comment. The Report does not appear to mention the fact that in the measurement of viscosity of linen the solution must be filtered to remove suspended matter. It is suggested that the viscometers be wrapped in black cloth and wired to the spokes of a bicycle wheel. Where the method is to be in regular use time would surely be saved if they were neatly clipped into a slowly revolving light tight box.

Whilst the Report of the Sub-Committee is valuable in that it makes an authoritative recommendation for the general industrial use of the method employed at the Shirley Institute, the research worker will feel that the last word has not yet been said, and that there is much room for progress. Such matters as the preparation of the solvent and the expression on a uniform basis of results obtained at different concentrations, are in urgent need of attention. The preface to the Report itself emphasises the fact that its recommendations "refer specifically to the use of viscosity measurements in industrial control in the specifications of materials, and in laboratory investigations of immediate industrial bearing.

Read in the light of this statement it constitutes a plea for uniformity in the use of this most valuable method which industry cannot afford to ignore.

S.M.N.

Education for Trades and Industries. By C. T. Millis. Published by Edward Arnold & Co., London. (157 pages and Index. 6/- net.)

This volume is intended as a supplement to the author's larger book on "Technical Education—Its Development and Aims," and gives some account of the earlier history of the educational provision made for certain trades and industries. The author played an important part in this history and, as he says, much of the information given in the book is drawn from his own personal experience and knowledge. Probably for this reason, the attention devoted to the growth of technical education in London is disproportionately great, as is also that relating to the various branches of the building trades. The account of the rapid developments in other parts of the country is comparatively slight, although it was in the provinces—and especially in the North of England—that the system of grouped courses of instruction was first adopted and put into effective operation. There is, for example, no mention in the Section dealing with the Textile Industries of the valuable work done by the Union of Lancashire and Cheshire Institutes, which is certainly noteworthy; and there is no reference to the establishment of courses of instruction for persons concerned with Mining, Metallurgy or the Chemical Industries.

The quotation from Professor E. Midgley on page 140, isolated from its context, gives a higher estimate of the value of the training in textile technology than is probably justifiable, since it takes no account of the training given in this branch at the Verviers Textile School, which is certainly not less effective than that of even the best of our English Technical Colleges.

The author very rightly stresses the importance of the technical school of the future devoting great attention to the training of skilled craftsmen, whose educational needs sometimes tend to be forgotten.

In spite of its omissions, the book provides a record in a convenient form of the work of a number of the pioneers of technical education in England.

A. A.

THE
Journal of the Textile Institute

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PROCEEDINGS—NAME INDEX

In this Index (C) indicates that the matter is the subject of a Communication, and (R) that the matter is a Review.

PROCEEDINGS—SUBJECT INDEX

THE JOURNAL

of the

TEXTILE INSTITUTE

VOL. XXIII—1932

TRANSACTIONS AND INDEX

THE JOURNAL OF THE
TEXTILE INSTITUTE
TRANSACTIONS

A METHOD FOR STUDYING THE SCALE STRUCTURE OF MEDULLATED AND PIGMENTED ANIMAL FIBRES

By J. I. HARDY, Ph.D.
(National Research Fellow in Biological Sciences, (U S A))

INTRODUCTION AND SUMMARY

The difficulties encountered in the study of the surface structure of animal fibres have been largely overcome, in the case of white, unmedullated fibres, by correct mounting and illumination. Where pigmented or medullated fibres occur they interfere seriously with these methods. Accurate examination of the scale structure of such heavily pigmented or medullated fibres has presented difficulties, and the photography of the surface structure has not been successfully accomplished. Saxinger[1] and Herzog[2] pressed fibres partially into plastic materials, using the negative impression thus secured for examination and study. These methods furnish an inverted image of only a portion of the circumference of the fibres, and are inadequate for biological studies upon the structure of entire fibres.

The purpose of this article is to present a method in which a plastic material is used, but which is applicable in the accurate examination of the scale structure of all animal fibres, with ordinary laboratory equipment. This method is similar in principle to the impression methods already cited, but furnishes a positive impression of the fibres and presents the entire circumference for examination. Its novelty lies in the fact that it gives a complete cast of the fibres, as shown by photo-micrographs published with this paper.

EXPERIMENTAL METHOD OF MAKING CELLULOID IMPRESSIONS

The fibres are first cleaned with water, alcohol and ether, and thoroughly dried. They are then mounted on a microscope slide, with the fibres all pointing in the same direction. The mounting consists of securing the ends of the fibres to the slide by means of wax or adhesive plaster. The fibres should be so spaced that they do not touch or overlap each other. Adhesive tape about ½ cm. wide is stuck on the slide, two layers thick, and arranged so as to leave the fibres to be examined exposed in an open space about 1 cm. × 2 cm. in size. Into this open frame sufficient celluloid solution is poured to fill the opening to a little above the level of the plaster. This solution consists of about 20 gms. of celluloid in 100 gms. of acetone, and should be about the consistency of syrup. With certain kinds of celluloid

[1] Saxinger, G.: Eine neue Methode zur Untersuchung des Haarepithels (Oberhautchens) Zeitschrift für Tierzuchtung und Zuchtungsbiologie, Band 5. Berlin, 1926
[2] Herzog, A.: Abdrucke tierischer Wollen und Haare in Harz Melliands Textilberichte, 1927.

a 30% solution may be necessary to give the required consistency. In damp climates where impressions from this solution tend to become milky while drying, a less volatile clear drying solvent may be substituted for the acetone. Oil Red BN may be added to advantage when the impressions are to be used primarily for microscopical examination, although it is not an advantage in their photography. After the solution is poured into the plaster frame, it is scraped level with the surface of the plaster by means of a second microscope slide. When a frame is not used for the celluloid it dries too rapidly around the edges, making the removal of some kinds of fibres more difficult. This action also serves to press the celluloid closely about the fibres, leaving them completely enveloped. The mount is then permitted to dry sufficiently to allow the plaster to be peeled off the slide, bringing with it the celluloid cast of the entire circumference of each fibre, but leaving the fibres themselves attached to the slide. In doing this, a fissure is produced by each fibre on the lower side of the film. See Plate I*e*. (Cross sections may now be made from these fibres, at the same points at which the impressions were made.) The thin sheet of cellluoid containing the impressions is cut from the plaster frame and placed on a thin microscope slide, under a cover glass which is held in place by means of a frame of gummed paper. With fibres of small diameter, it is difficult to remove the celluloid from all at the same time without breaking some of them. In this case, it is best to detach the fibres from the slide and remove them with the celluloid. Each fibre may then be withdrawn individually from the film. The ends of the fibre held under the plaster have been protected from the celluloid and may be easily grasped with tweezers and removed. Very short fibres may be handled by fastening their ends directly upon the adhesive surface of the frame, which is in turn placed upon the slide. Fibres having low tensile strength should be drawn from the celluloid before it hardens completely. Two or three trial tests will readily establish the best time for withdrawal.

When mounting the celluloid impression, the surface having the fissures through which the fibres were withdrawn should be next to the slide. Some may prefer to mount these impressions between two cover-slips cemented together, and it is then immaterial which side up the impressions are mounted. In either case the impressions of the fibres may be examined through either side, making it possible to study the entire surface. For some fibre studies, the fissure produced in removing the fibres may be a disadvantage. In such cases, they may be drawn out of their celluloid cases, in the direction of their root ends, for varying distances, depending on their strength and elasticity. Strong fibres like horse mane or tail hair, or human hair, may be completely removed for a distance of at least 2 cm. Delicate wool fibres may be pulled for a distance of at least 2 mm. This is ample for microscopical examination or for photography. Before withdrawal, the desired length of fibre should be cut off in the celluloid.

In addition to showing the pattern of the scales upon the fibres, all these methods of making impressions reveal the saw-tooth projections of the scales from the fibre.

APPLICATION OF THE METHOD

This method has been used in the author's studies on the felting quality of wool, carried out in the Textile Department of the University of Leeds,

PLATE I

FIGS. *a* *b* *c* *d* *e*

Photographed by J. Manby.

PLATE II

FIGS *a* *b* *c* *d*

Photographed by J Manby

England, and in the Institut für Tierzucht und Molkereiwesen, University of Halle, Germany. Varying degrees of damage to the surface structure of wool may readily be seen by this method, and their visibility is in no way interfered with by the presence of medulla, pigment or dyes. The method serves equally well with flat-lying or projecting scales, impressions of fibres taken in this way are readily examined under an ordinary microscope or projected through a projection microscope, and they are easily photographed.

The Author wishes to express his appreciation to Dr. J. B. Speakman and Mr. J. Manby for their helpful co-operation during the preparation of this article.

DESCRIPTION OF PLATES

Animal Fibres. Photomicrographs.
Magnification × 500.

PLATE I.

(*a*) Unmedullated crossbred wool fibre. Photographed by method of J. Manby. *Journal of Textile Institute*, 1932, Vol. 23, pages T5-113.
(*b*) Impression of similar crossbred wool fibre after its removal from impression medium.
(*c*) Mink fibre—the medulla interferes with the outline of its surface scales. This Photograph was made from a position slightly farther from root end of fibre than (*d*) or (*e*) by the same method as in (*a*).
(*d*) Impression of mink fibre after its removal from impression medium.
(*e*) Impression of mink fibre showing fissure in impression medium through which fibre was removed

PLATE II.

(*a*) Heavily medullated fibre from Scotch Black face sheep, showing pattern of surface scales greatly obscured by medulla. Photographed by same method as in (*a*), Plate I.
(*b*) Impression of the same fibre shown in (*a*) after its removal from impression medium
(*c*) Black fibre from Karakul sheep, showing only the outline of the fibre. Photographed by same method as in (*a*), Plate I.
(*d*) Impression of the same black fibre shown in (*c*) after its removal from impression medium.

U.S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
WASHINGTON, D.C.
September 25th, 1931.

AN IMPROVED METHOD FOR REVEALING THE SCALE STRUCTURE OF WOOL AND HAIR

By J. MANBY, F.R.P.S.
(Photographic Department, University, Leeds)

During further work in the microscopic study of scaliness in wool fibres and hairs, the author has found a new method of mounting which is, perhaps, of real use. The chief advantage in this method is that, for visual work, daylight or other diffused light, and a microscope fitted with an Abbé condenser may be used, as in ordinary laboratory practice, with greater satisfaction than hitherto. Photomicrographs may be made with this apparatus, but a point source of light and an achromatic sub-stage condenser are essential for the best results in photography.

The following is a record of this new method of using the mounting medium in mounting the fibre, and a number of photomicrographs showing comparative results by this and the previous method* are reproduced in

* *J. Text. Inst.*, 1930, **21**, T231.

the plates given at the end of the paper. The previous method is useless for the visual examination, and for the photography of scaliness when using diffused light and the ordinary microscope.

EXPERIMENTAL METHODS

Attaching the Fibre to the Microscope Slide

Wool fibres are attached to the microscope slide in the usual way, care being taken to place them in contact with the slide for a reason to be given below. The customary wax or resin may be used to fix the fibre at each end ; sealing-wax being preferable when Xylol Balsam is used as a mounting medium (see below) as otherwise the Xylol would dissolve the wax or resin and loosen the fibre.

Method of using the Mounting Medium

Mounting the fibre in any medium, under a cover-glass, rules out at once the most satisfactory use of diffused light and the ordinary microscope, fitted with an Abbé condenser. It is required by this method, that the mounting medium shall cover approximately the lower half of the fibre only, as it lies upon the slide, and that optical contact shall be produced between

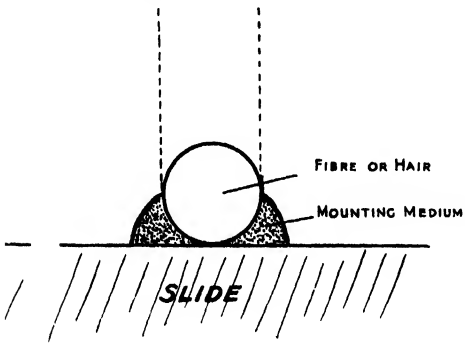


Diagram A.

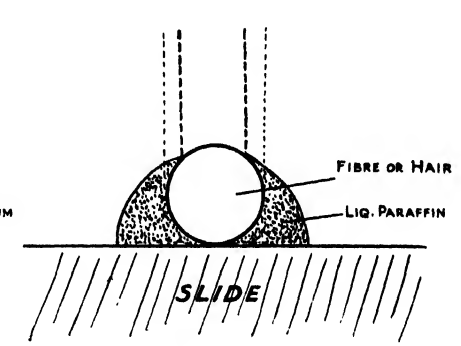


Diagram B.

the two ; hence the importance, when mounting the fibre, of allowing it to be in contact with the slide. A small drop of the selected mounting medium is placed at either end of the fibre and allowed to drain to the other. The medium will temporarily cover the upper surface of the fibre, but it will very soon dry off, leaving only a thin film on that surface. Hairs may simply be laid upon the slide and the medium allowed to drain along them. The condition then produced is illustrated in Diagram A. No cover-glass is used, and the preparation may be studied or photographed at once. The method is very simple, and the mounts are permanent.

Mounting Media

It was recognised that, by this method of mounting, the bottom scales would not be seen if a satisfactory mounting medium, of about the same refractive index as the fibre, could be found.

5 % Xylol Balsam was found to be very suitable for most wool fibres and many hairs having bold or pronounced scales, and when the fibre is mounted in this medium by this method, the back scales are obliterated, and therefore the top and bottom scales cannot be confused. This balsam is not, however, so satisfactory for hairs which have comparatively fine or delicate scales,

such as human hair, pigs' bristle, etc. The balsam, even down to the dilution at which it becomes useless for its purpose, remains as a varnish upon the upper surface of such hairs (frequently at intervals along their length) and thereby hides the surface structure.

Three other mounting media were found which do not give this trouble, and which may be used satisfactorily for all wool fibres and hairs, viz. :—

1 % Celluloid in Amyl Acetate, see Pl. III, Fig. 13. (The Celluloid takes a day or two to dissolve.)

25 % Glycerin in water, see Pl. III, Fig. 14. (Water alone, may be used, but it evaporates too readily, and optical contact between the fibre and slide is broken.)

3 % Glycerin Jelly. (Gelatin 3 grams, Glycerin 3 c.c. Water 94 c.c. together with 1 gram Carbolic Acid or a little Thymol as preservative.) The jelly must be melted each time it is used.

There is little to choose between these three media, but the 3 % Glycerin Jelly is now commonly preferred. See Pl. I, Figs. 3, 4, and 5. Pl. III, Figs. 11 and 12, and Pl. IV, Figs. 16 and 18.

When using any one of these three media by this method, the bottom scales may be seen only if focussed upon (the refractive index is lower than that of the fibre) and therefore, are not confused with the top scales when they are in focus. It will be recognised that this mount is quite different from an ordinary air mount, which commonly gives very poor visual and photographic results. Covering the fibre, as it lies in the mounting medium, with another medium (of much lower refractive index than the fibre) and a cover-glass, is useless for visual work, and gives no improvement in photography under the best conditions.

As stated above, to mount the fibre under a cover glass prevents the satisfactory use of diffused light and the ordinary microscope. By mounting the fibre, without a cover-glass, in too viscid or dense a mounting medium, it is possible to produce the condition shown in Diagram B. In this case more than half the diameter of the fibre is immersed in the medium. See Pl. II, Figs. 9 and 10. Liquid Paraffin was used to produce this condition. This " untrue impression " may be seen occasionally when using 5 % Xylol Balsam, but only for a minute or so, *i.e.* until the Xylol evaporates.

If, in any case, there is an objection to leaving a thin film of mounting medium on the upper surface of the fibre, it may be overcome by using either the 1 % Celluloid or the 3 % Glycerin Jelly mountant in the following manner. A thin film of either medium should be prepared by flowing the medium over a clean slide, which is then put in an upright position to drain and dry thoroughly. The fibre should then be attached or laid, as necessary, upon the dry medium. If celluloid is being used, Amyl Acetate should now be allowed to flow over the fibre (and medium) and at once drained off. When the Glycerin Jelly is used, cold water should be applied in the same way.*

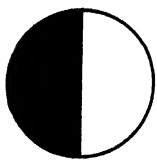
* A " fixed," unexposed lantern plate may be cut to produce three microscope slides, having a suitable gelatin film. Sheet celluloid may be used as the slide when a celluloid mount is desired. The hair is simply laid upon the celluloid and amyl acetate flowed over and drained. When glycerin jelly is used the fibre may be laid on the dry jelly and warm breath applied. After the moisture has evaporated the fibre will be found partly embedded in the jelly. A film of Mayer's albumen fixative, or mucilage of Gum Tragacanth may also be used, but glycerin jelly is preferred.

After again drying, approximately half the depth of the fibre is embedded in the medium, thereby producing optical contact, and the upper surface of the fibre is free from medium.

This method, although possible, has not been found to give a better or more true microscopic picture, than a preparation in which either medium had been allowed to flow over the fibre as it lay upon the slide.

Illumination

Axial illumination is unsuitable, even when the iris diaphragm of the sub-stage condenser is stopped down as necessary, for the satisfactory observation of scales upon fibres. Oblique, transmitted light at right angles to the length of the fibre is satisfactory, and may be produced by using a "stop" thus,



to cut off about half of the light that enters the sub-stage condenser. (As described in the previous paper, *loc. cit.*)

It is most important that the light should be focussed in the plane of the fibre, and the iris diaphragm stopped down only enough to prevent flare and to show the scale edges.

Although the Abbé condenser breaks down when used as an oblique illuminator with its central rays completely stopped out, it is found to be quite satisfactory, when used with the "stop" suggested, and when the specimen is uncovered as in this method, for the ordinary routine of studying scaliness.

Microscope Objectives

It is now found that the best results, visual and photographic, are obtained by using an 8 mm. ($\frac{1}{3}$ inch) apochromatic objective and a compensating ocular, ×10 or above. A 4 mm. ($\frac{1}{6}$ inch) lens, with a ×6 eyepiece, will give better results with very thin hairs only, such as Angora, and the tips of many hairs.

Photography

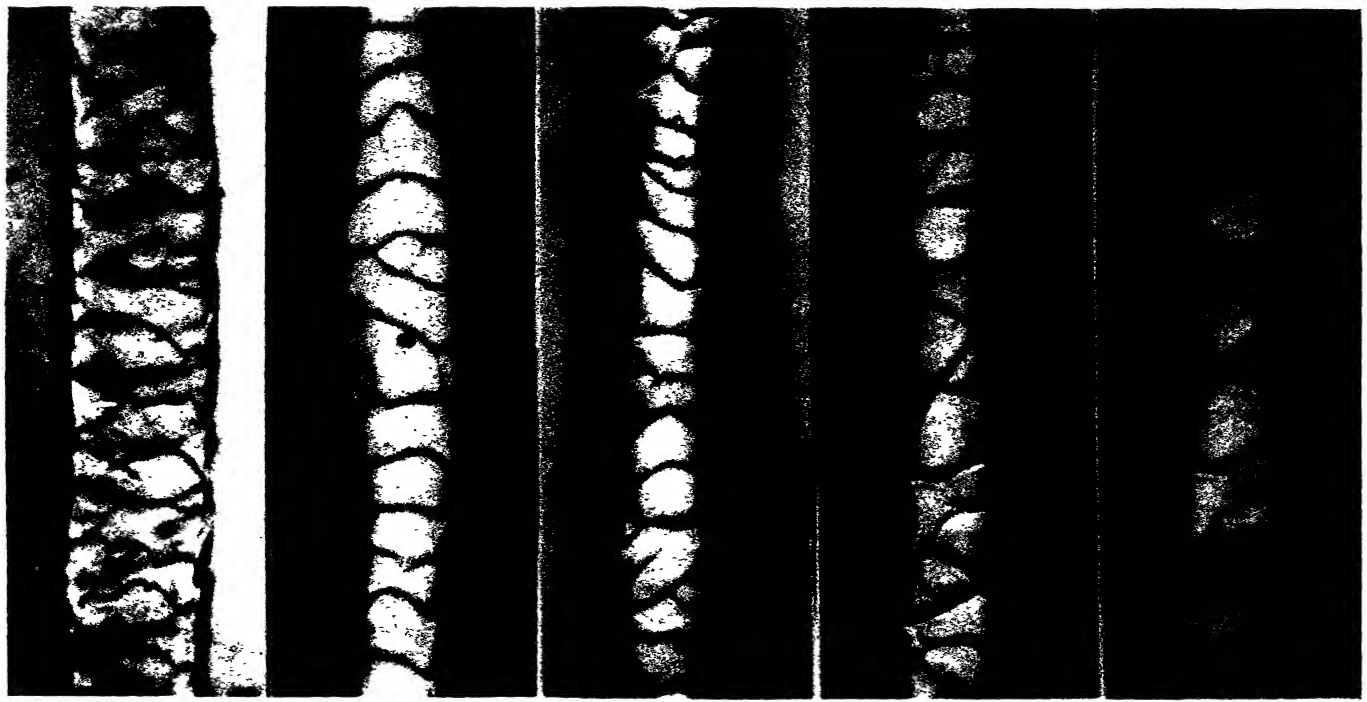
The Abbé condenser and diffused light was used to produce only one photomicrograph, Pl. I, Fig. 5. The advantage of using an achromatic condenser and a point source of light is shown in a photomicrograph of the same field, Pl. I, Fig. 4. Visually, the scale edges may be seen much more clearly than these photographs suggest. By using the fine adjustment an impression of depth is received which is impossible in photography, when the focus must be "fixed." Also, the eye is sensitive to a greater range of light and shade than is likely to be rendered by photography.

For photography the thin, 5 % Xylol Balsam may be preferred by some workers, for certain wool fibres, such as Merino (see Pl. I, Fig. 2 and Pl. II, Figs. 6, 7, and 8), but the author, when using this method, now prefers the 3 % Glycerin Jelly for all fibres and hairs.

When the best apparatus is available for photography, this method is not intended entirely to supersede that described previously (*loc. cit.*), but where thought wise, to be used in conjunction with it. (Comparative results are reproduced in Pls. I and IV.) Process isochromatic or panchromatic plates, and a green or yellow-green light filter may be used to give the most suitable contrast. The prints were made by contact. The magnification of the

PLATE I

MERINO WOOL FIBRES × 800.



FIGS. 1 2 3 4 5

← one field → ← one field →

FIG. 1. 3% Celluloid in amyl acetate, covered with cover-glass.

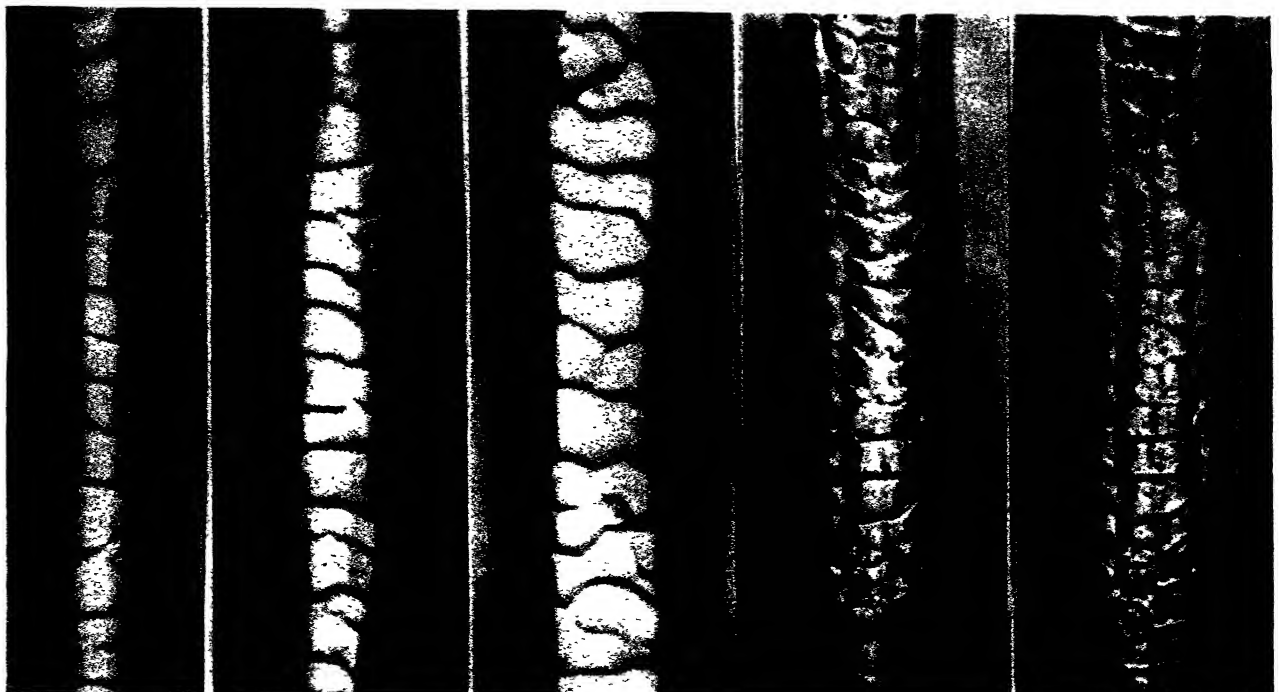
FIG. 2. 5% Xylol Balsam, uncovered.

FIGS. 3, 4 and 5. 3% Glycerin Jelly, uncovered.

(Fig. 5 was photographed by diffused light and the ordinary microscope.)

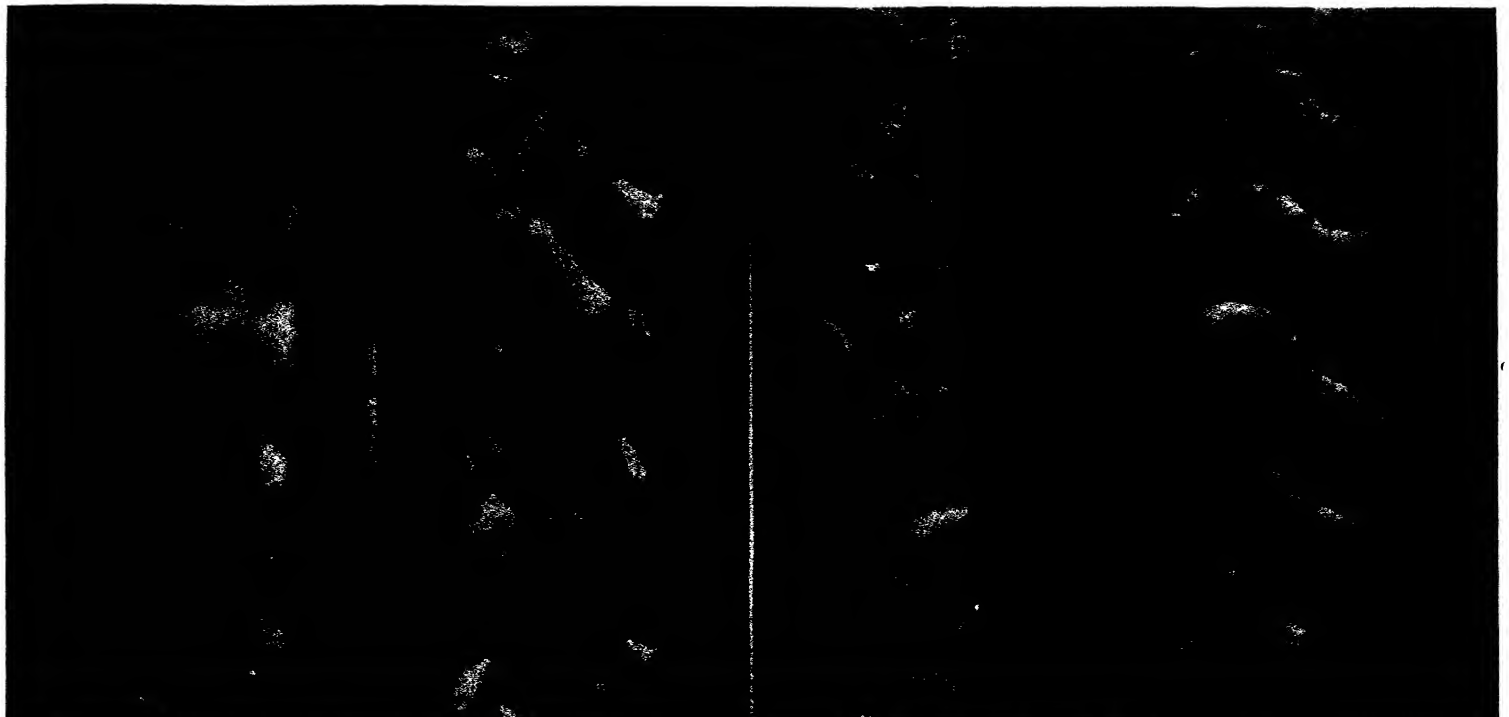
PLATE II

MERINO WOOL FIBRES × 800.



FIGS 6 7 8 9 10

FIGS. 6, 7 and 8. 5% Xylol Balsam, uncovered.
FIG. 9. Liquid Paraffin, uncovered, surface focussed illustrates "untrue impression"
FIG. 10. Liquid Paraffin, uncovered, deeper focus illustrates "untrue impression."



FIGS. 11 12 13 14

one field

FIG. 11. 3% Glycerin Jelly, covered with cover-glass.
FIG. 12. 3% Glycerin Jelly, uncovered.

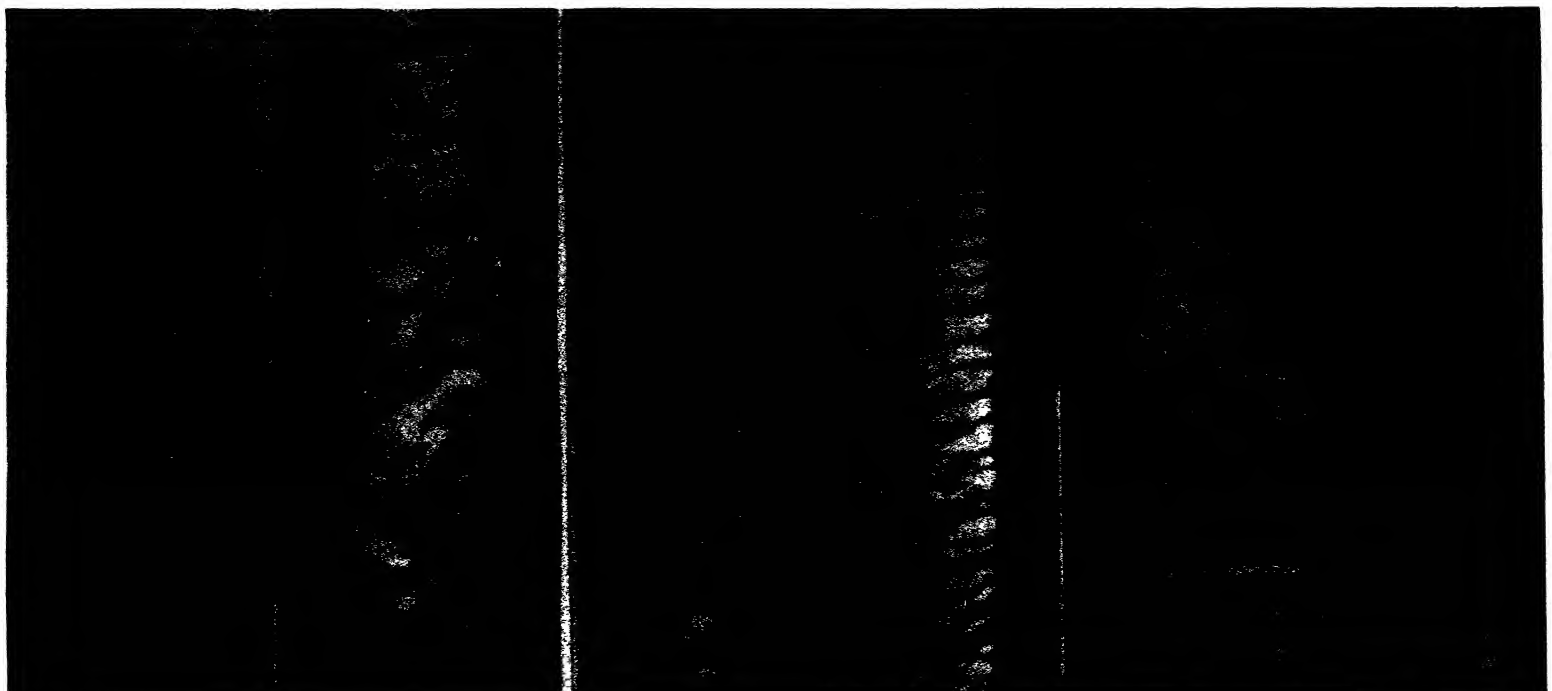
FIG. 13. 1% Celluloid in amyl Acetate, uncovered.
FIG. 14. 25% Glycerin, uncovered.

PLATE IV

HUMAN HAIR × 800 AND × 500.

Eyebrow Hair: near tip.

Hair from Head: near root.



FIGS. 15 ← similar fields × 800 → 16 | 17 ← one field × 500 → 18

FIGS. 15 and 17. 3% Celluloid in amyl Acetate, covered with cover-glass.
FIGS. 16 and 18. 3% Glycerin Jelly, uncovered.

photomicrographs reproduced is 800 diameters throughout, excepting Pl. IV, Figs. 17 and 18, which are ×500. A camera extension of 3 feet was required, when using the 8 mm. objective, and ×10 ocular, to give a magnification of ×800. It is hoped, after selecting from amongst the mounting media given that this method will be of some use to those engaged on this type of work.

THE SULPHUR CONTENT AND REGAIN OF DESCALED HUMAN HAIR

By N. H. CHAMBERLAIN
(Leeds University)

INTRODUCTION

Up to the present time it has been generally assumed, for want of more precise information, that wool and hair fibres are more or less chemically homogeneous, with the exception of medullated fibres, in which it has been shown by Barritt and King[1] that the medulla is characterized by a somewhat lower sulphur content than the rest of the fibre.

Broadly speaking, a hair or wool fibre consists of a bundle of spindle-shaped cortical cells, in the centre of which the medulla, if present, is situated, the whole being enclosed in a thin outer sheath of epithelial scales, whose nature and function have been the subject of considerable speculation. Since Barritt and King have shown that the medulla is deficient in sulphur, it becomes of interest to ascertain whether the outer scales differ materially from the remainder of the fibre. The well-known Pauly test is based on the fact that the scales appear to be free from the amino-acid tyrosine, but so far as the writer is aware this is the only chemical difference that has been observed. The present work consists of an attempt to determine by direct experiment whether the sulphur content of the scale layer is appreciably different from that of the rest of the fibre.

Barritt and King[2] have observed a decrease in sulphur content in wool, upon exposure to ultra-violet light and subsequent washing with very dilute caustic soda solution, accompanied by a considerable loss of the scale layer as observed microscopically, and have suggested in consequence that the scales possess a higher sulphur content than the rest of the fibre ; but since they also state that wool loses part of its sulphur as sulphur dioxide under the action of ultra-violet light, the contribution of the partial loss of the scale layer to the general decrease in sulphur content observed is indeterminate.

In order effectively to deal with the problem it becomes necessary to devise a method for the mechanical removal of the scales from animal fibres, by scraping or friction ; chemical reagents are inadmissible for the purpose, as the criticism may always be raised that the rest of the fibre is chemically altered by the scale-removing reagent. Such a method was proposed by King[3] in 1927. Fibres were drawn, under slight tension, up and down across the edge of a microscope slide placed horizontally, and under properly adjusted conditions, complete descaling of the fibre could be effected. This method, though admirable where only few fibres are concerned, is not well suited to the purpose of descaling the relatively large (0·20-0·25 gm.) quantities of material required for sulphur estimations. It has been found possible, however, by the use of another method, to descale

human hair in quantities sufficient for this purpose, and it may be stated at this point that the results so obtained do not bear out Barritt and King's suggestion regarding the higher sulphur content of the scale layer.

PREPARATION OF DESCALED HAIR

The method consists essentially of removing the scales from hair by friction between folds of emery paper of fine grade. Shortly after the adoption of this method, a paper appeared by Calvert[4] reporting its use for the removal of the outer cuticle of cotton hairs, so that no originality is claimed for it ; nevertheless a few of the details regarding its application to wool and hair may not be considered superfluous.

The paper used was Hubert's metallurgical emery, grade IM. (Finer grades are available, and may be used for finer fibres.) It was cut into pieces approximately one inch square, which were folded in two with the rough surface inwards. The fibre was drawn smoothly through the folded paper held in the finger and thumb of the right hand ; a little practice enables the operator to regulate the pressure on the fibre so that descaling is effective, and the risk of breakage small. Each fibre was drawn through the paper 20 times, 10 times from root to tip first, then 10 times from tip to root to complete the process. Microscopic examination of the fibres so treated showed that the great majority of the scales were removed, a few small patches of scales being discernible here and there on the more rounded sides of fibres with an elliptical cross-section. Microphotographs of descaled fibres are given by King (*loc. cit.*). It has been considered unnecessary to add to these, as no further features of interest were observed.

It was found that with fibres not specially cleaned, the method worked extremely well, but when it was tried on fibres which had been thoroughly extracted with ether and alcohol, there was a great tendency for the fibre to slip through the paper in a series of short jerks, which usually culminated in its breakage. This difficulty was overcome by dipping the paper in a dilute solution of pure olive oil in ether, and allowing the ether to evaporate, so as to leave a thin film of oil on the friction surface.

PROPERTIES OF DESCALED HAIR

The sample of human hair used in the present instance was light brown in colour, 40-50 cms. in length, remarkably free from medulla, with a well-marked scale structure and a fairly uniform elliptical cross-section, the average eccentricity being about 4/3. The descaling process affects the fibre remarkably in several ways. King (*loc. cit.*) mentions the fact that descaled fibres lose the power to " creep " in one direction when rubbed between finger and thumb. Not less remarkable is the decrease in flexural rigidity which occurs. As descaling proceeds the hair loses all its " springiness " and becomes extremely limp. After a little experience this phenomenon, coupled with the sound produced by the friction of the fibre on the paper, affords a reliable guide to the progress of the descaling process. Further, brown fibres become much lighter in colour upon descaling. The effect is in all probability an optical one, and is not due to any preferential removal of brown pigment.

THE SULPHUR CONTENT OF DESCALED HAIR

In order to determine whether there is any appreciable change in sulphur content consequent upon removal of the scales, two determinations were

made in which the actual loss in weight caused by the descaling process was measured as accurately as possible. For this purpose a lock of hair was tied with thread at several points along its length to prevent it from becoming tangled, and thoroughly extracted successively with ether and alcohol in a Soxhlet apparatus. It was finally washed in several changes of distilled water to remove dust and adsorbed alcohol, and dried in vacuo (Hyvac pump) over P_2O_5 for 14 days at room temperature. It was then weighed. Fibres were drawn from this sample and descaled as described above, until approximately 0·25 gm. of descaled material had been accumulated. In the event of a fibre breaking, which generally occurred early in the treatment if at all, the pieces were descaled separately if long enough, and if not, were carefully preserved apart from the rest of the descaled sample. In this way every hair was entirely accounted for, except for the dust removed by the emery from the descaled portion. When a sufficiently large sample had been prepared, all three fractions, namely, the untouched remainder of the original sample, the descaled portion, and the undescaled broken pieces, were again submitted to the extraction and drying processes already described and again weighed. The total loss in weight of the material gave the amount removed from the descaled portion, assuming that none of the broken pieces of fraction 3 were descaled at all. This was not strictly true, but the error involved is a small one, and for the present purpose negligible.

The descaled portion was next analysed for sulphur, using the modification of the Benedict-Denis method described by Rimington.[5] As his technique was followed in its entirety, except for the initial cleansing of the fibres, it will not be described here.

RESULTS OBTAINED

(*a*) *Normal Hair.* Two experiments were performed in order to determine the sulphur content of the normal, undescaled hair.

In the first a sample of hair which had been cut small and well mixed was used. Two determinations of sulphur upon this sample gave identically the same result, namely, 5·02% of the dry weight.

The second experiment was performed with a view to ascertaining the distribution of sulphur along the fibre, as, if this varied greatly from root to tip, the objection might be raised that accidental breakage during descaling (which occurs, in most cases, towards the tip of the fibre) might tend to cause a preferential exclusion of parts of the fibre containing more or less sulphur than the average from the descaled fraction. Accordingly, a lock of hair was divided into three equal lengths, and each portion analysed separately. The results were as follows (sulphur contents calculated on dry weight of material) :—

Tip fraction	4·97%
Middle fraction	5·15%
Root fraction	5·08%

This result agrees with that of Takodoro and Ugami,[6] who found a lower sulphur content at the tip of human hair. In the present case the variation in sulphur content along the fibre is small, and the possibility referred to above may be neglected.

(*b*) *Descaled Hair.* The results of the duplicate determinations on descaled hair were as follows :—

	Experiment I	Experiment II
Weight of initial sample	1·4304 gms.	0·3696 gms.
Weight of unused remainder of initial sample ...	1·1452 gms.	0·0742 gms.
Weight of broken pieces (assumed undescaled)	0·0203 gms.	0·0273 gms.
Weight of descaled sample	0·2243 gms.	0·2123 gms.
Loss in weight of the descaled portion calculated as percentage of its undescaled weight ...	15·32%	20·8%
Sulphur content of descaled portion	5·02%	5·04%

(All figures given are dry weights, or are calculated on dry weights.)

Thus, the mean value for the sulphur content of the normal hair is 5·02%, and of the descaled hair 5·03%. The conclusion is inevitable that the sulphur content of the epithelial scales of human hair does not differ materially from that of the remainder of the fibre.

THE REGAIN OF DESCALED HAIR

Prior to carrying out the sulphur determinations on the descaled hair samples, several determinations of the regain of the samples were made, using the method described by Speakman.[7] The results were as follows :—

Regains at 22·2° C. (65° F.), 63% *relative humidity.*

Normal Hair (mean of 6 determinations) ... 15·00%
Descaled Hair (mean of 4 determinations) ... 15·09%

In other words the regain of the fibre, like its sulphur content, is not affected by removal of the epithelial scales.

SUMMARY.

A method is described for descaling human hair in reasonable quantity.

The results of sulphur determinations on both normal and descaled hair are given, which show that no difference in this respect is to be observed between the two.

It is shown that the regain of human hair is similarly unaffected by removal of the epithelial scales.

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[1] Barritt, J., and King, A. T. *J. Text. Inst.*, 1926, **17**, T386.
[2] *Ibid. J. Text. Inst.*, 1929, **20**, T154.
[3] King, A. T. *Biochem. J.*, 1927, **21**, 434.
[4] Calvert. *J. Text. Inst.*, 1930, **21**, T293.
[5] Rimington. *J. Soc. Chem. Ind.*, 1930, **49**, T139.
[6] Takodoro and Ugami. *J. Biochem. Japan*, 1930, **12**, 187.
[7] Speakman. *J. Soc. Chem. Ind.*, 1930, **49**, T209.

THE JOURNAL OF THE
TEXTILE INSTITUTE
TRANSACTIONS

6—MEASUREMENT OF FIBRE AND YARN DIAMETERS BY DIFFRACTION METHOD

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(Linen Industry Research Association)

INTRODUCTION AND SUMMARY

In most branches of textile work the measurement of fineness of fibre is of considerable importance. Three methods have been in common use: (1) by microscope, (2) by projection, (3) by area of cross section or weight per unit length. With almost all fibres there is very considerable variation between the individuals in any one sample, so that numerous observations have to be made and all these methods are extremely slow and tedious The diffraction method of measuring the visual diameter of fibres possesses many desirable features as regards simplicity of apparatus and rapidity in use. It was first proposed about 1824, by Young,[1] who devised an instrument called an " eriometer " for measuring the diameter of wool fibres based on the phenomenon of diffraction. When a light source such as a slit is viewed through a bundle of fibres arranged approximately parallel to one another and to the slit, a series of alternate dark and bright bands are seen extending symmetrically on both sides of the source in directions perpendicular to the axes of the fibres. From the theory of diffraction a known relation exists between the separation of the bands and the diameter of the fibres. Young's eriometer was not successful as " it was too delicate to be employed by the hard hands of peasants with any advantage," and the method fell into disuse It was again brought to the notice of textile workers by Ewles,[2] in 1928, who described a slightly modified form in the shape of a portable instrument for measuring the diameter of wool fibres. Later, McNicholas and Curtis[3] described a further modification for the same purpose. The present paper describes a form of the eriometer, developed in connection with work on flax fibres. Whilst it is superficially very similar to the form of McNicholas and Curtis, it differs with respect to the method employed for measuring the band separation and actually the details of the design were supplied to an instrument maker before the appearance of their description. When applying this method to flax fibres it has been found convenient to use a narrower slit than is usually recommended in the instruments for wool; by this means definition is considerably increased, but the diffraction system is made more complicated. This effect is discussed and illustrated by results.

One of the main objects has been to make the design as simple as is consistent with a reasonable accuracy, to permit production of an instrument at a low cost. Results are given comparing measurements of visual diameter of flax fibre strands and of flax yarns with estimations of fineness and diameter respectively by other methods. The method can be used for fineness measurement of other textile fibres and several other applications are discussed.

After a little experience, probably special mounting of the fibres is unnecessary for long staple straight fibres; with cotton and wool, mounting may be advantageous to keep the fibres straight. The nearer the sample approaches to a single layer of straight fibres parallel to each other, the better the definition and the ease of measurement.

THEORY OF DIFFRACTION METHOD

When an illuminated narrow slit is viewed past a fibre or narrow opaque obstacle held parallel to the slit, the light passing by the edges is diffracted and diffraction fringes are seen as a series of maxima and minima of illumination extending on both sides of the geometrical shadow.

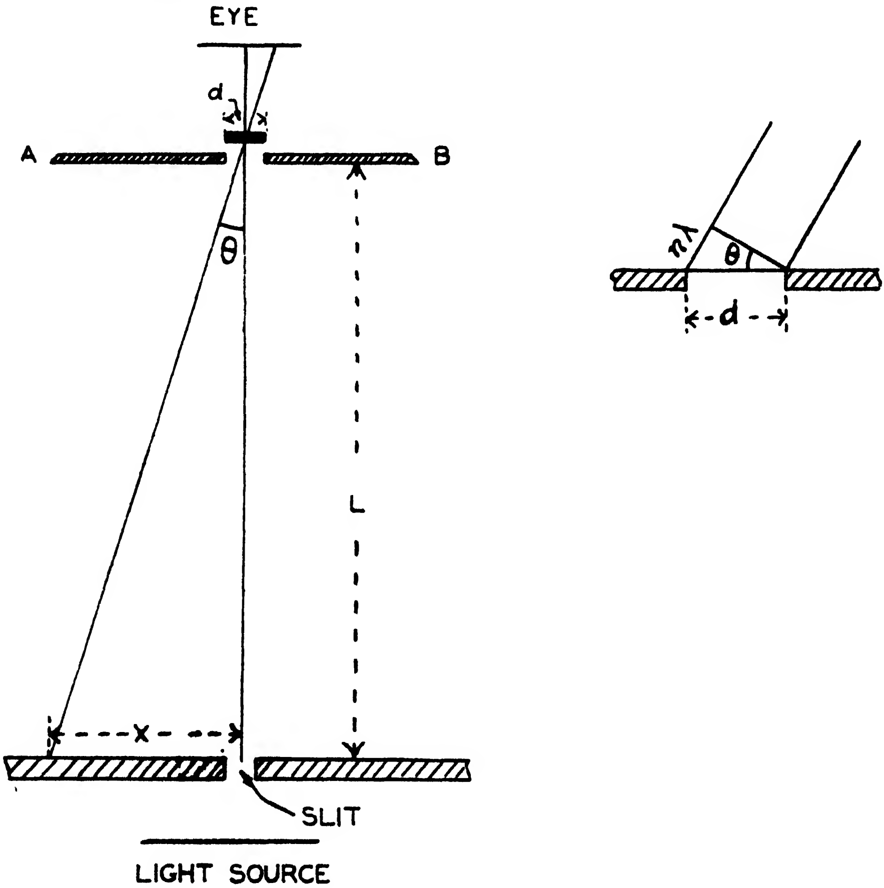


FIG. 1

The diagrammatic sketch in Fig. 1 shows a section in a plane perpendicular to the length of the obstacle of diameter " d," parallel to the slit which is considered narrow compared with its length, so that only diffraction effects parallel to its length need be considered. By Babinet's Principle[4] the effects observed will be exactly the same if the opaque obstacle is replaced by a slit of equal width " d " in a screen AB. For light incident perpendicularly on the screen, the path retardation at an angle θ is

$$d \sin \theta = n \lambda \quad \text{.......} \quad (1)$$

where λ is the wave length of light. From this equation values of θ are

obtained for n = 1, 2, 3, etc., when destructive interference will occur of all secondary waves originating from different points across the slit and there will be minima of intensity. For intermediate values of θ re-inforcement of secondary waves will occur and maxima of intensity or bright bands will be seen.

Consider first of all light of only one wave length. Undeviated light passing the equivalent slit will be brought to a focus on the retina forming a real image of the slit. The diffracted light is also brought to a focus and is seen projected outwards as a series of bright and dark bands in the plane of the slit.

The distance to the centre of the first dark band X is given by $\sin \theta = \lambda/d = \frac{X}{L}$ (since the angle θ is always so small that $\sin \theta = \tan \theta$), where L is the distance between the slit and the opaque obstacle.

$$\therefore d = L\lambda/X \quad \ldots\ldots (2)$$

The value of θ corresponding to the first position of maximum intensity is given[5] by $\sin \theta = \frac{1{\cdot}43\,\lambda}{d}$. If Y is the distance between the slit and the first bright band,

$$d = 1{\cdot}43L\lambda/Y \quad \ldots\ldots (3)$$

From the instrument a scale reading S is obtained which is equal to 2X or 2Y as the case may be. Generally, then,

$$d = \frac{2nL\lambda}{S} = \frac{C}{S} \quad \ldots\ldots (4)$$

where C is a constant for the instrument using a given method of setting, n = 1, 2, 3, etc., for successive dark bands and n = 1·43, 2·46, etc., for successive bright bands, of the principal diffraction system.

When the slit is viewed through a number of opaque obstacles parallel to each other, it can be shown by again applying Babinet's Principle and considering the equivalent case of equal slits arranged parallel to each other but not equidistant,[6] so that the system of diffraction fringes given by a single opaque obstacle will be present with their intensities multiplied by the number of obstacles. Thus each obstacle may be considered as acting independently, so that the resultant diffraction pattern is the result of superimposition of the pattern from each obstacle on those from all the other obstacles. The maximum definition will be obtained when all the obstacles are equal in diameter. In the case of a sample composed of textile fibres there will be some variation in diameters, which will cause a widening of the regions of maximum intensity. The greater the variation in the individual diameters, the poorer the definition, particularly in the bands of higher orders, which tend to fuse into each other.

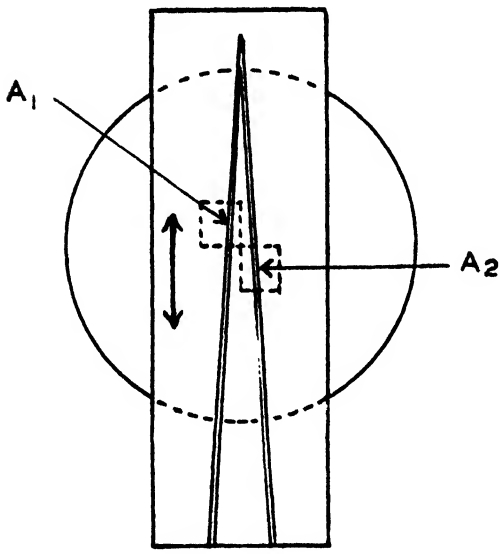
The presence of several obstacles or of their equivalent slits, however, introduces additions to the simple pattern from a single obstacle in the form of secondary maxima,[7] whose positions and intensities depend on the number of obstacles. These secondary maxima are caused by interference of the light from the various apertures; they are only seen when the number of apertures is small and, when the apertures or obstacles are not very close, they are contained within the first two bands of the first system. Interference fringes are also formed, extending outside the geometrical image,

when the obstacle or equivalent slit is very narrow ; they are equally spaced at a distance which is inversely proportional to the diameter of the obstacle.

DESCRIPTION

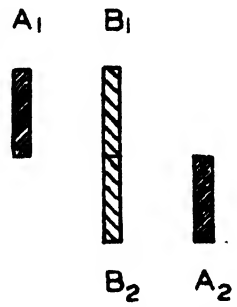
The success of this method depends on being able to obtain diffraction bands easily and with good definition. In the case of flax fibre strands and fine objects of similar dimensions, two conditions were found to be necessary : (1) a fine slit, (2) a very small aperture at the eyepiece. If a wide slit is used with a conveniently short distance between the sample and the slit, the bands are very close together and difficult to distinguish clearly. If the length is increased, then difficulty may be experienced by the consequent reduction in intensity. Clear definition of the bands is obtained even with a short length by using a suitably narrow slit.

Obviously from equation 4, the instrument can be designed to measure the length necessary to produce a fixed separation between the slit and the diffraction band, or to measure this separation when the length is maintained



A

FIG. 2a



B

FIG. 2b

constant. Young and Ewles varied the length till the first band or the first dark band respectively coincided with a bright spot at a fixed distance from the slit. McNicholas and Curtis[3] used a fixed length and measured the traverse of part of the slit required to bring it into coincidence with the first dark band.

An instrument with a fixed and fairly short length has advantages as regards convenience in use. It can be used on a table and a large sample can be arranged on a holder, so that readings can be taken at various places by sliding the holder across the small aperture. If the individuals in the sample are fairly parallel to one another, it is only necessary to make a slight rotation of the head of the instrument to bring the fibres parallel to the slit, so that the best definition after each lateral movement may be obtained.

Having fixed the length, it is necessary to provide means for measuring the separation of the bands. A method somewhat similar to that described by Edser[8] has been used very successfully. In the first form a long V-shaped slit was used, made to slide over two squares slotted out of the base of the tube as shown diagrammatically in Fig. 2a. This appears as two slits, A_1 and A_2,

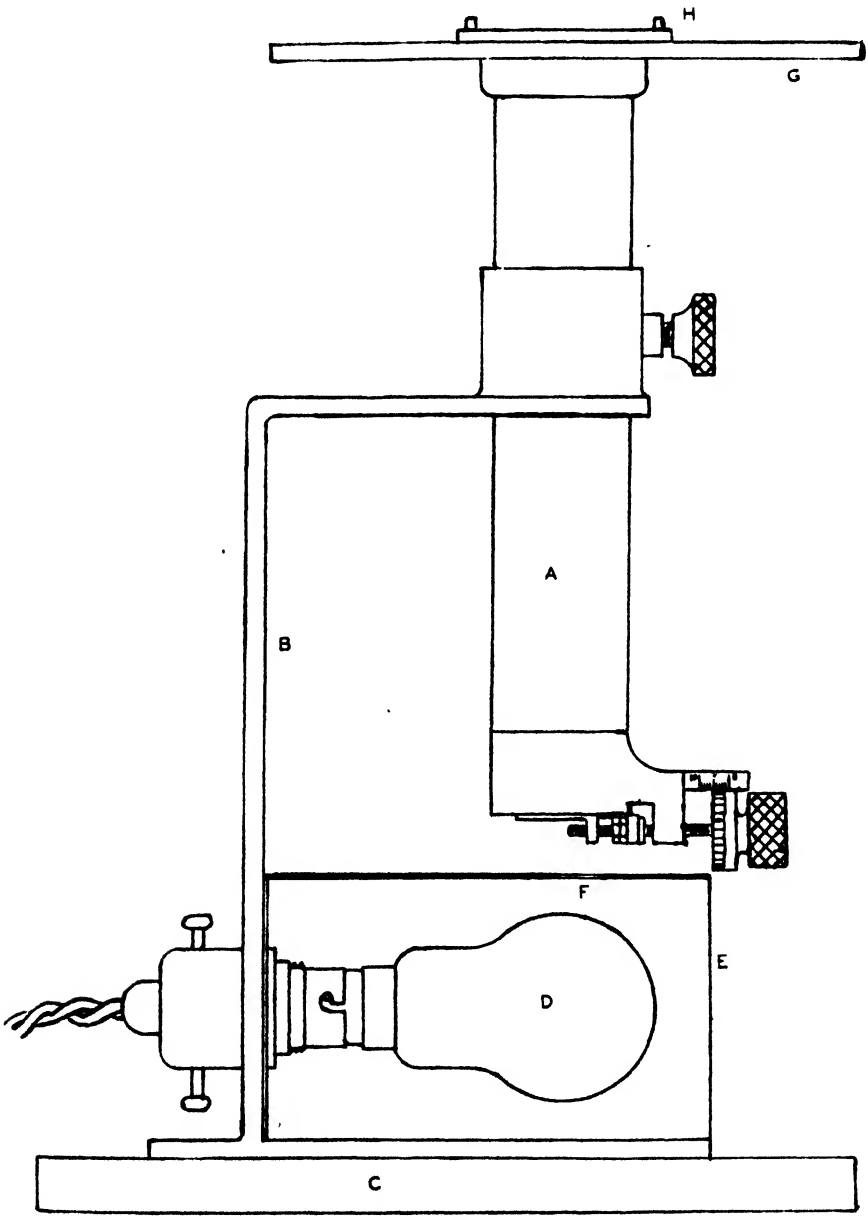


FIG. 4

which can be made to approach or recede from each other on sliding the holder containing the V in the direction of the arrows. If the slits are viewed through parallel fibres, each one forms its own set of diffraction bands and the manipulation consists in adjusting the position of the holder till,

as shown in Fig. 2b, the first band, B_1, to the right of slit A_1, coincides with the first band, B_2, to the left of the slit A_2. The distance between the slit and the first bright band is equal to half the distance between the slits A_1A_2, which is known from the dimensions of the V slit and the position of its holder. Owing to the slight inclination of the two slits to each other, the sample fibres are set at a slight inclination to both, but in practice the effect is negligible, since the fibres in the sample are not accurately parallel. Since this arrangement necessitates a micrometer screw attachment in order to read accurately the separation of the slits, it was later replaced by two slides each containing a slit and made traversible in opposite directions by a micrometer screw, as shown in Fig. 4b. The mechanical construction is no more complicated and it has the advantage that the slits remain parallel.

Using a fine slit the first band is narrow with only a trace of colour visible at each edge, so the setting of top and bottom bands in one line can be made quite accurately. When white light is used as source and the objects are fine, the bands are wider apart and more dispersed and the colours are more clearly seen ; in such cases the brighter parts of each should be brought into alignment.

The method of setting may be varied in several ways, e.g., by aligning the first bright bands or the first dark bands. By this means the range of the instrument can be varied, using an appropriate instrument constant for each. This variation in method of setting has also been employed as a method of checking the performance of the instrument, as will be discussed later.

A general view of the instrument is shown in the photograph in Fig. 3, and in detail in the line drawing in Fig. 4. The tube A, $1\frac{1}{2}$ inches internal diameter, is blackened inside and can be raised and lowered in the stand B, which is fixed to a wood base C, and supports a 60 watt pearl lamp D, shaded by the guard E, except for the aperture F left below the vertical tube. The distance between the sample and the slits is 22·8 cms. The top consists of a rectangular plate G, fixed to a ring which fits over the outside of the tube A, and is perforated in the centre by a hole of 1 mm. diameter. The sample carrier H consists of a plate with grooved sides to fit on the plate G, with a central slot " x," above which is supported a small slotted plate kept in position by four dowel pins, which holds the sample in position by its own weight. The plan view of the top is shown in Fig. 4a.

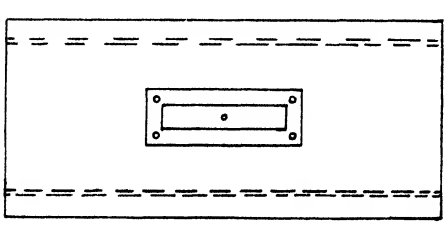


FIG. 4a

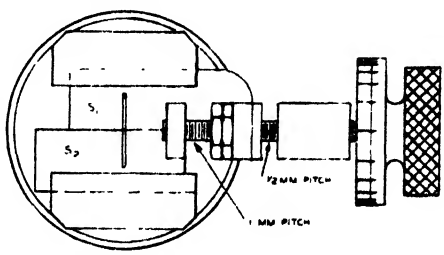


FIG. 4b

The bottom of the tube A is closed by two slides fitting together with a slightly chamfered edge and running in grooves at the sides. These plates each contain a slit 0·3 mm. wide and can be moved sideways by rotation of the knurled head on the end of the screw, which is also provided with a vernier knob divided into 100 parts and registering against a scale fixed to a lug projecting from the tube. The arrangement is shown enlarged in Fig. 4b.

The screw is made with two pitches of thread separated by a collar. The screw passing through the tapped bush has a pitch of $\frac{1}{2}$ mm. The top slide S_1 is fixed to a bracket which is clamped up to the collar by lock nuts, so that one revolution of the screw moves the slit S_1 $\frac{1}{2}$ mm. to the left. The slide S_2 carries a bracket tapped to fit the thread of 1 mm. pitch, so one revolution of the screw moves the slit S_2 1 mm. to the right minus the $\frac{1}{2}$ mm. through which the micrometer head has moved to the left, or a total movement of slit S_2 of $\frac{1}{2}$ mm. to the right of the zero position. Thus on one revolution of the head, the slits become separated to a distance of 1 mm. and the head advanced by $\frac{1}{2}$ mm., so that the linear scale is graduated in $\frac{1}{2}$ mms. to show mms. of actual separation of the slits.

CALIBRATION AND PERFORMANCE

If monochromatic light of known wave length is used for the illumination of the slit, the constant for the instrument could be calculated, but when white light is used as in the present case, the value to be adopted for the effective average wave length is somewhat uncertain. The difficulty is overcome by determining the instrument constant directly by measurements made on obstacles of known diameters. This is most conveniently done by using fine wire, and by using a series of wires of varying diameters the performance of the instrument can be tested.

Fine copper wires of 36-47 S.W.G. were wound closely and as nearly parallel as possible on to a card containing a central rectangular slot. The windings were cemented to the card and one layer cut away. This card was then placed on the sample holder and held down by the slotted metal plate. With such a sample excellent bands are easily obtained, with the higher orders clearly defined.

The direct image of the slit is seen fringed on each side by a series of bands which appear as one or more narrow and intense lines of a yellowish colour, referred to later as the bright (uncoloured) bands, and then a series of rainbow coloured bands with dark spaces between. So long as the coloured bands are well defined no difficulty is experienced in aligning the top and bottom bands at their brightest region. The definition is very much improved by using a small eyepiece aperture and also by using a fairly fine slit. As the slit width is increased, the general illumination masks the brightness of the fringes and the first bright bands become merged into the direct image of the slit. By trial it was found that a slit width of 0·3 mms. and an eyepiece aperture of 1 mm. diameter gave good definition and the almost uncoloured bands are quite distinct. These bands are almost ideal for the method of setting adopted, being bright and sharp. The appearance of the bands is shown in Fig. 5b with the slits in the zero position ; only the first bright uncoloured band is shown owing to the great intensity of the light from the slit compared with the higher order bands, which, however, are clearly visible in the actual instrument. Fig. 5a shows the appearance with the slits separated when the wires are not quite parallel to the slit ; Fig. 5c shows the appearance with the wires parallel to the slit and the slits separated and almost correctly set for the alignment of the first bands in the top and bottom patterns.

A series of observations was made in this way with each of the prepared wire specimens and the average taken of twenty readings on each at different places. The diameters of the wires were carefully measured with a

microscope fitted with a micrometer eyepiece. These values were plotted against the reciprocal scale reading and as shown by the top line in Fig. 6, the points lie very closely on a straight line passing through the zero. The equation to this mean straight line is $D = \frac{0{\cdot}165}{S}$ where D is the diameter

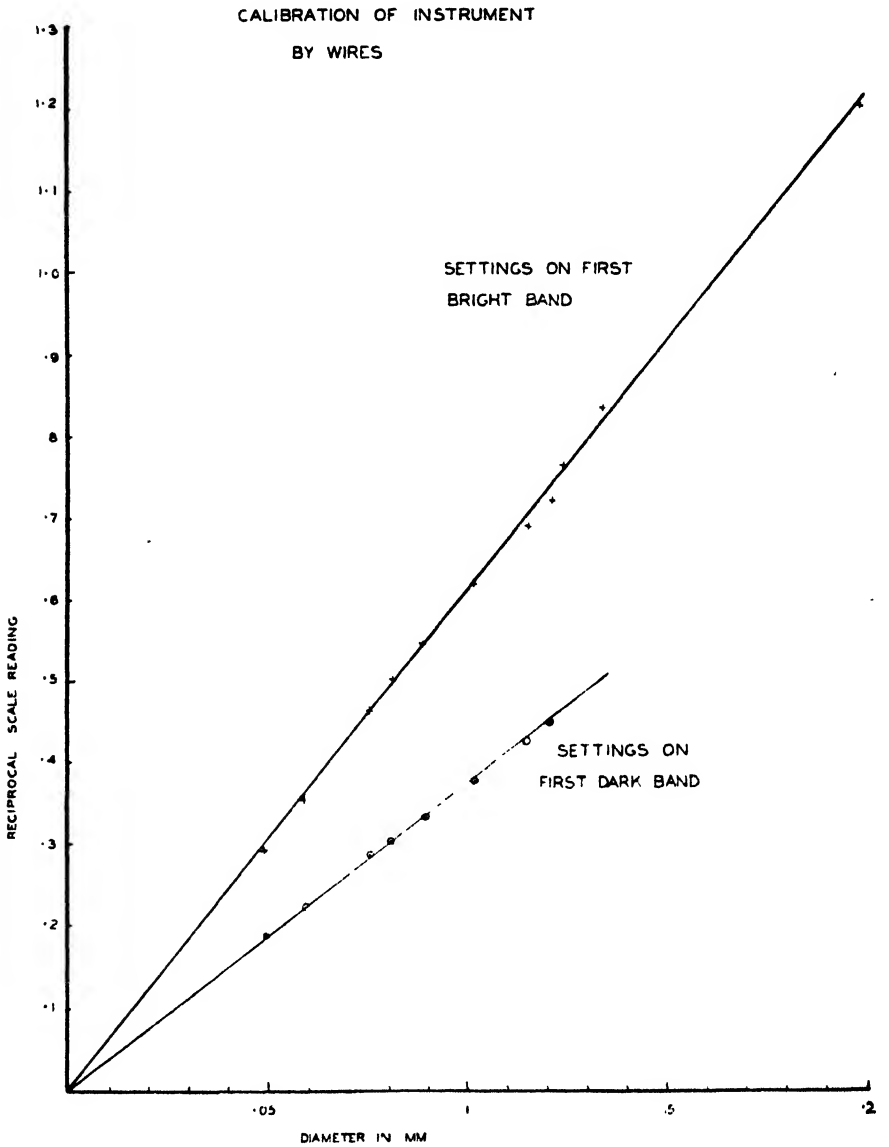


FIG. 6

of the wire in mms. and S is the scale reading. This indicates that the bright (uncoloured) band can be used in the manner indicated by theory to measure the diameter.

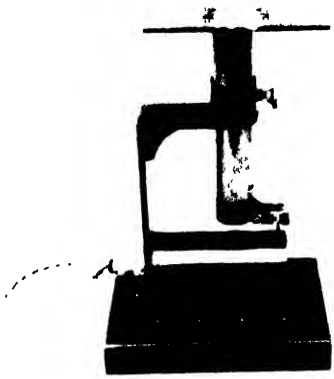


FIG. 3

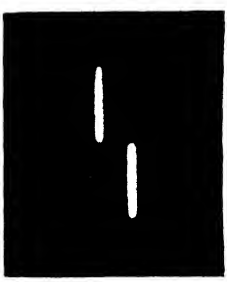


FIG. 5a

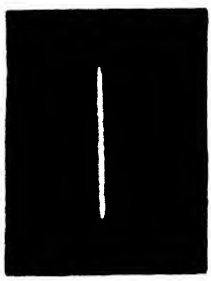


FIG. 5b

FIG. 5c

From equation 4, the instrument constant

$$C = 2nL\lambda$$

If in this the values n = 1·43, L = 228 mms. are substituted, a value for λ = 2530 is obtained. This is far below the average effective wave length of white light, so it may be concluded that n is not equal to 1·43 and that the first bright uncoloured band is not the first maximum of intensity in the principal diffraction system.

The observations of the change in the pattern on varying the slit width indicates that the real diffraction pattern commences beyond this first bright but uncoloured band. A series of observations were made with samples made up from 44 S.W.G. wire containing 1, 2, 3, ... 6 wires and obtaining the scale readings for the alignment of the first uncoloured bright band, the next (first) dark band, the second bright band (first coloured band), the second dark band and the third bright band. These mean scale readings are tabulated in Table I. The readings with any one method of setting do not show any consistent variation with varying number of wires in the sample. It is assumed that the value of n (equation 4) should be 1 for the first dark band, 1·43 for the first bright coloured band and so on. The mean scale reading for each method of setting is then expressed in proportion to the setting on the first dark band as unity. The values obtained show a close agreement with the corresponding theoretical value and give a value of n = 0·6 for the first bright (uncoloured) band.

A similar test was carried out with eleven samples of flax fibres of very different kinds, so that the number of fibres forming the pattern and the closeness of packing of the fibres in the sample would vary considerably. The results are tabulated in Table II and on comparing the average readings with that on the first dark band as unity, values of n are obtained which again agree well with the theoretical values for the primary diffraction bands and with those obtained from the measurements on wires.

Since the first bright (uncoloured) band is seen with one wire only and also seen independently of the number and spacing of the obstacles, it would appear to be an interference band extending beyond the geometrical image as indicated by theory and not a secondary diffraction band due to interference of the light from adjacent apertures.

As a further check on the method, a series of observations were made, using settings on the first dark band, with the wires of different diameters. The plot of reciprocal scale reading against diameter is shown by the lower curve in Fig. 6 and again they are seen to lie closely on a straight line passing through the zero. The equation to this mean straight line is

$$D = {}^{0\cdot269}/_{S}.$$

This gives the instrument constant with this method of setting as C = 0·269. Substitution of the appropriate values n = 1, L = 228 mms. in equation 4 then gives λ = 5899 as the average effective wave length of white light, which is of the right order for the brightest part of the visible spectrum. The ratio of the two instrument constants for settings on the first bright (uncoloured) band and on the first dark band, or ${}^{0\cdot165}/_{0\cdot269}$ = 0·61 gives the average value of n for the first bright band (uncoloured) as obtained from the wires of different diameters and agrees with the values obtained from Tables I and II.

Table I
Further Check on Method. Observations with Varying Settings past Varying Numbers of Wires (Wire 44 S.W.G.)

Number of Wires in Sample	Instrument Reading for Setting on Band				
	1st Bright Uncoloured	1st Dark	2nd Bright Coloured	2nd Dark	3rd Bright
1	1·98	3·23	4·97	6·50	8·18
2	1·94	3·57	5·06	6·94	8·26
3	2·08	3·22	4·92	6·50	8·12
4	2·09	3·45	5·05	6·82	8·20
5	1·96	3·48	4·97	6·68	8·34
6	2·00	3·28	4·98	6·48	8·30
Mean	2·01	3·37	4·99	6·65	8·23
VALUE OF n—					
Theoretical	—	1.0 0	1·43	2·00	2·46
Mean Experimental ...	0·6	1.00	1·48	1·97	2·44

Table II
Investigation of Effect of Spacing of Individuals in Sample.

Flax Fibres Sample	Instrument Reading for Setting on Band			
	1st Bright	1st Dark	2nd Bright	2nd Dark
A	3·28	5·22	7·90	10·40
B	2·48	4·02	5·82	7·95
C	2·40	3·88	5·58	7·75
D	2·25	3·60	5·42	7·30
E	2·86	4·40	6·20	8·60
F	3·10	5·10	7·60	10·22
G	1·80	3·22	4·64	6·40
H	1·95	3·60	5·10	7·30
I	3·00	5·40	7·80	10·70
J	2·25	3·90	5·86	7·60
K	2·20	3·75	4·95	7·10
Mean	2·51	4·19	6·08	8·30
VALUE OF n—				
Theoretical ...	—	1·00	1·43	2·00
Mean Experimental	0·6	1·00	1·45	1·98

Table III
Accuracy of Method.

Diameter of Wire D	Diameter by Diffraction Method		Per cent. error.	
	1st Bright Band $D = \frac{0{\cdot}165}{S}$	1st Dark Band $D = \frac{0{\cdot}269}{S}$	1st Brigh Band	1st Dark Band
mms.				
0·1980	0·198	—	0·0	—
·1340	·1375	—	+2·61	—
·1240	·126	—	+1·61	—
·1212	·119	0·120	−1·81	−0·99
·1155	·1138	·114	−1·47	−1·30
·1020	·1021	·1011	+0·10	−0·88
·0893	·0898	·0896	+0·56	+0·34
·0809	·0825	·0815	+1·98	+0·74
·0753	·0763	·077	+1·33	+2·26
·0591	·0585	·060	+1·01	+1·52
·0492	·0479	·0506	−2·64	+2·85
		Mean ...	1·37	1·36

The accuracy of the instrument is illustrated by the figures in Table III, using both methods of setting, comparing actual diameters with those calculated from the instrument constants determined. The average percentage errors are 1·37 and 1·36 for the two methods, so that either method of setting may be used. The method of setting on the bright band is considered easier and as the separation of the slits in this case is less, it enables

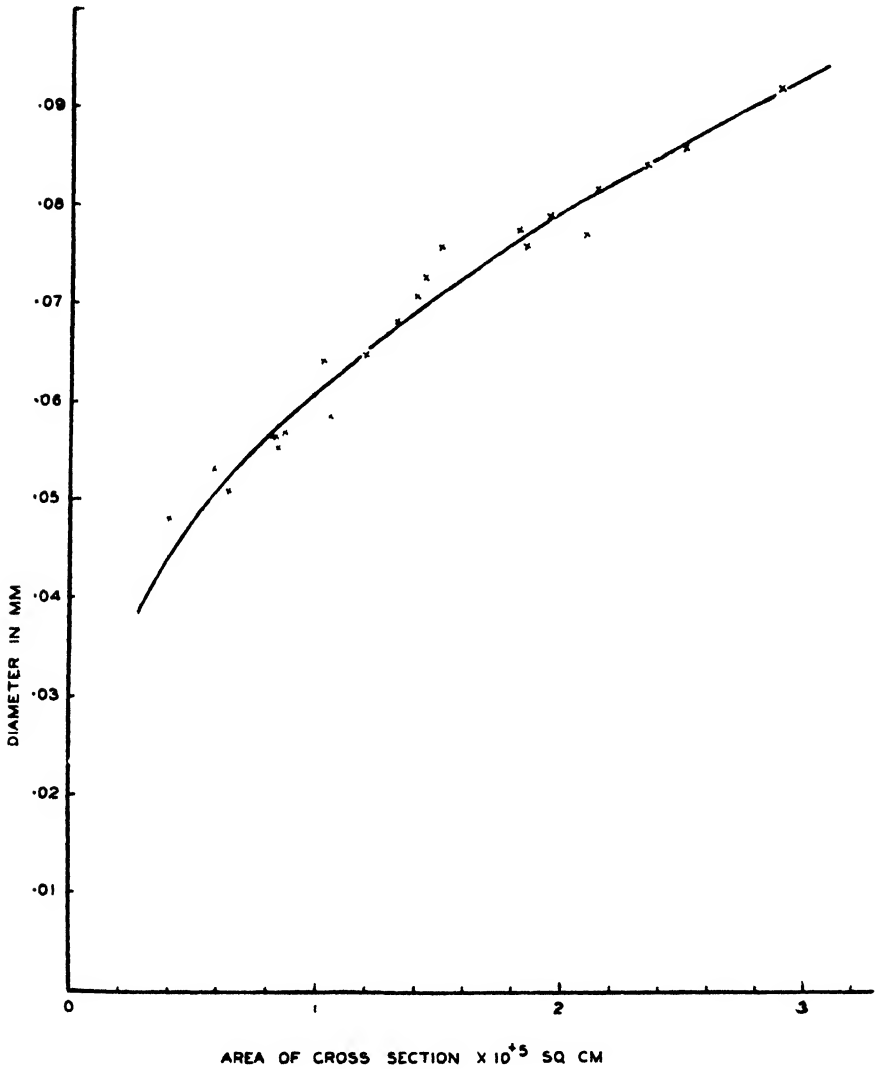


FIG. 7

measurement of a wider range of samples with the one instrument. With specimens of larger diameter the bands may become too close for accurate settings and in such cases an extension tube may be used to increase the band separation.

Comparison of Visual Diameter and Area of Cross Section

Measurements were made of the visual diameter of flax fibre strands with this diffraction instrument and compared with the average area of cross-section as usually obtained from the sorting test by weighing and counting.[9]

A very varied selection of fibre strands was used, from the very fine strands obtained from wet spun yarns up to the relatively coarse strands in hackled fibre. The results of these measurements on 22 samples are shown graphically in Fig. 7, and it will be seen that they can be closely represented by the smooth curve shown. This shows, therefore, that flax fibre strands graded in fineness by either of these measurements would lie in the same relative order.

The measurement of fineness in terms of area of cross-section involves separation of the strands into groups of known length, or cutting into known lengths ; in both cases it is necessary to destroy the existing formation in a sliver or other sample. This is not necessary in the diffraction method with straight long staple fibres such as flax, which can be laid on the sample holder plate without special mounting. With a little manipulation, measurements can be made on slivers of such fibres without breaking up the formation.

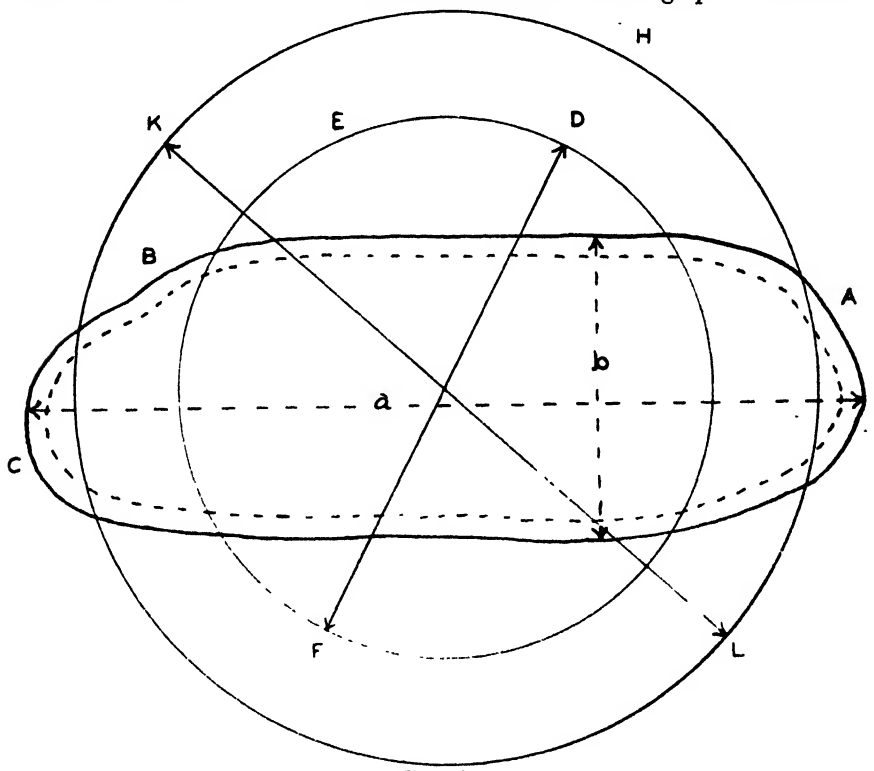


FIG. 8

Since a great deal of investigation involving fibre strand dimensions has already been carried out and the results published in terms of area of cross-section, the determination of the exact relation between area and visual diameter is of some interest in order that the results of new work may be correlated with the old. If A_s = area of cross-section in sq. cms., D = diameter in mms., the smooth curve shown in Fig. 7 is found to be closely expressed by the empirical relation

$$A_s = 0{\cdot}0155\, D^{2{\cdot}63} \qquad \text{(5)}$$

The fibre strands are therefore not of circular cross-section ; it is in fact known that they are not of any regular shape and are very variable. The term diameter when applied to flax fibre strands is therefore very indefinite and may vary considerably according to which way the fibre is viewed.

If a circular section *is* assumed, then the area of cross-section computed from the average visual diameter is considerably greater than the actual area. It is, in fact, found from the results used for Fig. 7, that if A is the computed area $\left(\frac{\pi D^2}{4}\right)$, then over the range used the simple empirical formula

$$A_s = \frac{A-1}{2} \quad \ldots\ldots (6)$$

represents the results very closely.

There are two reasons why the computed area A is greater than the actual area A_s. In the first place, the latter is the actual area of the solid material in the cross-section, since a density of 1·5 is used in the calculation. Actually, the fibre strand is not solid, but contains interspaces between the individual ultimate fibres, so that even if the fibre strands were circular in cross-section, the computed area A would be greater than the actual area of material. Secondly, the fibre strands are not circular but generally of an irregular shape. In Fig. 8 let ABC represent the outline of the section of a fibre strand; if this was compressed solid to eliminate the interspaces, it would be represented by the dotted line and enclose an area A_s. The circle DEF has the same area as that enclosed by the contour ABC, so if the strand was circular it would have a diameter FD. The circle HKL is drawn to enclose an area A which is related to that of the circle DEF, in accordance with equation 6, so that KL represents the visual diameter as measured. Now the visual diameter of the strand shown may vary from a to b, according to the direction of viewing and it is clear from Fig. 8, which simply depicts the average results of measurements, that the visual diameter measured (KL) is much nearer to the greater diameter b than to the small diameter a. This means therefore that when fibres are laid loosely on a flat surface, the majority lie on their flat or broader side. This is in accordance with mechanical principles, as the stable position of a body at rest is that in which it possesses minimum potential energy and this is the case when its centre of gravity is in its lowest position. The point is, perhaps, one of minor importance, but it is an addition to our knowledge of the lie of fibre strands in slivers and may prove to be a factor to be considered.

OTHER APPLICATIONS

Measurement of Yarn Diameter

The diffraction method may also be used for the measurement of average yarn diameters. For medium or coarse yarn, it is necessary to use an extension piece on the tube to double the distance between the sample and the slit as the diffraction bands would be too close together to be readily distinguished. The eyepiece aperture is also enlarged in order to view the slit through a number of pieces of the yarn side by side.

A number of measurements have been carried out on a selection of flax yarns, grey boiled and bleached varying from 25's tow to 120's line. The yarns were wound by hand on to a slotted card in the same way as the wires and one layer cut away after cementing the ends to the card. The average diameter of each yarn was also determined by measurement of the yarn count and apparent density[10], which method was originally proved to agree well with microscopic measurement. Fig. 9 shows the results from the two methods plotted against each other; the points lie close to a straight line,

which, however, does not pass through the origin, because usually the diameter by the density method is very slightly greater than that by the diffraction method. This slight difference may be due to the small tension

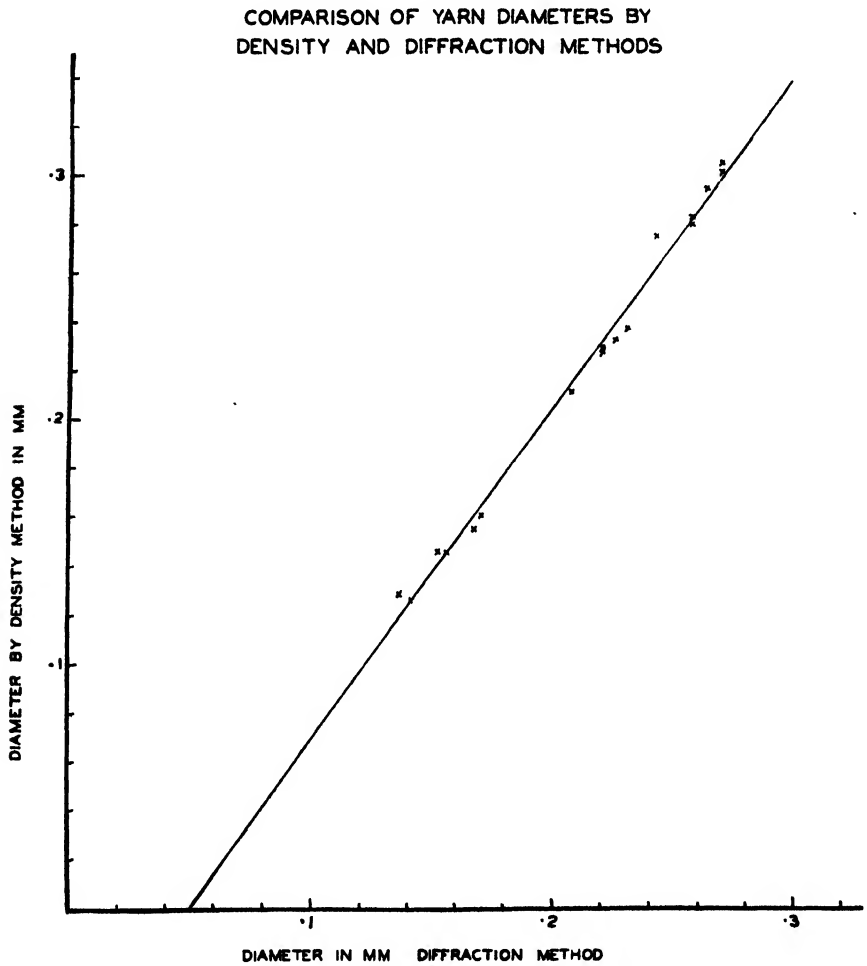


FIG. 9

which has to be applied to the yarn in order to wind it on to the slotted card, no tension being used in the density method. The straight line shown is represented by the equation

$$D_L = 1{\cdot}35\, D_o - 0{\cdot}00675 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

where D_L = diameter in cms. by density method,

D_o = diameter in cms. by diffraction method.

Of course, if the above explanation of the differences is correct, then the values of the constants in this equation would depend on the tension applied and the yarn should be wound on to the card under a fixed tension.

Although somewhat tedious, the instrument could be used for determining the regularity of diameter of a yarn. The yarn would be wound on to a bobbin or spool and arrangement made for pulling it off under a constant tension while passing over the small hole in the top of the instrument. The yarn

would be kept stationary while a measurement of diameter is made, pulled through a certain distance and another measurement made and so on until sufficient observations are obtained from which to calculate the regularity.

Another use to which the instrument can be put in certain cases is the measurement of the diameter of a yarn whilst *in situ* in a fabric. The piece of fabric is laid on the top plate, which is rotated to bring one set of yarns parallel to the slit and the usual setting made. So long as the fabric is fairly transparent, the observation can be made quite easily. This measurement might be of use, say, to obtain an estimate of the yarn lea, if only a very small sample was available, since the yarn count can be calculated from the diameter and the apparent density; the fabric would need to be in the loom-state or washed and rough-dried state, when the yarns can be assumed to be approximately circular in section. The method may conceivably also be of use, for example, to make a study of the flattening of yarns in fabric during the finishing processes; it has the advantage that the same sample may be subjected to repeated or varied treatments and the measurements always made at the same position.

Table IV
Swelling in Cold 4 per cent. Caustic Soda

Description	Diameter in mms.		Per cent. Increase
	Original	After Treatment	
YARN—			
120's lea, grey	0·138	0·185	34·1
,, boiled	·141	·181	28·4
100's lea, grey	·152	·189	24·3
,, boiled	·156	·194	25·0
75's lea, grey	·167	·197	18·0
,, boiled	·170	·194	14·1
40's lea, grey	·230	·258	12·2
,, boiled	·225	·250	11·1
,, 4/4 white... ...	·220	·238	8·2
FLAX FIBRE STRANDS—			
A	0·0805	0·0945	17·4
B	·0554	·0665	20·0
C	·0577	·0705	22·2
D	·0729	·0850	16·4
E	·0709	·0814	14·8
F	·0649	·0776	19·6

Swelling of Fibres and Yarns

Another purpose for which the instrument could be used with considerable advantage is the determination of the swelling or increase in diameter of fibres or yarns on soaking in water or solutions such as caustic soda. For this purpose it would be necessary to mount the specimens in parallel formation on a small frame so designed that the specimens could be left slack or held under any desired tension while being soaked in the liquid and then be made rigid before placing in the instrument. A series of readings would first be made along the centre line of the specimens. After the soaking treatment excess liquid could be removed by draining or dabbing with blotting paper and the measurements repeated again along the centre line. The same sample could be used for repeated treatments if desired, but in any case the repeat observations at the same place in the specimens before

and after treatment considerably reduces liability to inaccuracy through sampling errors. As examples of this application of the instrument some results are given in Table IV for the swelling of flax yarns and fibre strands after half an hour's immersion in cold 4 per cent. caustic soda solution, the specimens being held out to their original length the whole time. The different fibre samples used show considerable variation in the swelling after undergoing similar treatment. The yarn results also show interesting features such as a reduction in the swelling after boiling and bleaching and an increasing swelling in yarns of increasing count.

Diameter of other Textile Fibres

Measurements of the visual diameter of other textile fibres such as cotton, wool and silk have been made on a few odd samples which were available and results obtained were of the same order as typical published figures for these materials. Any straight long staple fibre gives a very clear diffraction pattern with very little trouble in arranging the sample. Fibres such as cotton and wool are more difficult to arrange on the sample plate in a straight and reasonably parallel form. In such cases it may be advisable to mount the fibres on a slotted card, until some experience has been gained with that particular fibre. If the fibres in the sample are not held straight, there will be a great deal of crossing and the fibres will not be parallel to the slit, causing a general blurring and indistinctness in the diffraction pattern.

In conclusion I wish to acknowledge the able assistance of Mr. J. L. Spencer-Smith, B.Sc., in carrying out the measurements. Mr. R. J. B. Keig, M.A., assisted with mechanical details of the design. The instrument was constructed by Messrs. Robinson Nelson & Co., Ltd., Manchester.

23rd November, 1931.

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7—THE OBSERVATION OF RAYONS IN POLARIZED LIGHT

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INTRODUCTION

In the identification of the rayons, the microscopic method has long been necessary in the cases of viscose and cupra rayons. Acetate and nitro rayons are easily distinguished by the microscope and also by chemical tests, but the identification of a rayon as viscose or cupra has depended principally upon the observations of fibre diameter and cross-section shape. With the advent of stretch-spun viscose, the determination has become more difficult because of the fact that the diameters are about the same for both types and that the shapes of both the stretch-spun viscose and the cupra rayons tend to approach the circular. Moreover, the serrated edge, once a fairly characteristic property of viscose, tends to be less and less conspicuous as the stretching process is carried further. It is desirable, therefore, that additional data be obtained to make the identification more certain, and the use of polarized light suggests itself.

Since the colour produced by polarized light passing through a fibre is due to retardation and interference, and since the amount of retardation is known to be affected only by the refractive indices of the fibre and its thickness, the possibility exists that the retardation of rayons of the same order of thickness might be sufficiently different to give characteristic colours.

QUALITATIVE OBSERVATIONS

Observations recorded in the literature show considerable diversity of results, but agree that acetate rayons show very faint or no colours by

Table I—Appearance of Rayons by Polarized Light

	Acetate	Nitro	Cupra	Viscose
Chamot and Mason[1]	Very weak	Strong	Moderately strong	Moderately strong
Lindsley[2]	Very faint	Bright	Polarizes well	Polarizes well
Matthews[3]		Bright blue	Uniform bluish grey	Uniform bluish grey
Hanausek[4]	Inactive	Strong	Feeble	Similar to cupra but weaker
Lawrie[5]	None	Very brilliant	Plain Yellow	Yellow ground with red or orange central band

polarized light and that nitro rayons give very brilliant colours. Table I, while incomplete, will illustrate the fact that the data on viscose and cupra rayons are very contradictory. It was, therefore, decided to attempt first to determine any qualitative relationship between the type of rayon and the colour produced by polarized light. Since it is at least possible that the strong colours produced by nitro rayons are due to residual nitro groups, the observations included nitro rayons as well as cupra and viscose, for it was known that the newer nitro rayons had been more completely denitrated than the older ones.

Although it has been stated[6] that polarization colours do not depend upon the refractive index of the substance as compared with the surrounding medium, preliminary tests were carried out to determine the effect of mounting media on the colours produced by polarized light. Two samples of nitro rayon were used since the colours were expected to be of a higher order and easier to differentiate. A single filament of each rayon was fastened on a slide (loosely, to prevent strain effects) at the ends and examined by a polarizing microscope at 200 × magnification in various mounting media in a position 45° to the plane of polarization. After each examination the microscope was racked up, the mounting medium blotted off with filter paper, the new mounting medium added and removed twice to displace any of the old, and examined in another mount. This was done so that the same spot on each filament should be examined and the possibility of differences in colour due to differences in thickness eliminated.

Table II—Effect of Mounting Media on Polarization Colours

Mounting medium	R I. of medium	New type nitro rayon			Old type nitro rayon		
		Top	Centre	Bottom	Top	Centre	Bottom
Air	1·00	Pink	Yellow	White	Red-purple	Yellow	Blue
Water	1·33	White	Yellow	White	Yellow	Blue	Yellow
Cedar Oil	1·52	Yellow	Blue	Yellow	Blue-violet	Bright yellow	Blue-violet
Monochlor-naphthalene	1·65	Yellow	Blue	Yellow	Blue-violet	Bright yellow	Blue-violet

The rayons appeared as broad fibres with central bands. The results of the colour observations are shown in Table II. It appears that for uniform results as to colours, it would be necessary to have a mounting medium of refractive index the same as, or higher than that of the fibre. In further examinations, Canada balsam mounts were used because this medium has approximately the same refractive index as the rayons and has the further advantage of permanence.

Mounts of single filaments in Canada balsam were examined at 45° to the plane of polarization. The results are shown in Table III and may be summarized as follows:—

1. The acetate rayons show consistently dim colours which are characteristic.

2. The nitro rayons tested gave more varied results than indicated in the literature. The newer type gave much dimmer colours than the old.

3. The cupra and stretch-spun viscose specimens were very similar.

4. The ordinary viscose rayons showed great variations, sufficient to make identification difficult by qualitative observations alone.

Table III—Polarization Colours of Rayons Tested

No.	Type of rayon	Date of manufacture	Interference colours
1	Acetate A	old	Dim light colours
2	Acetate A	1930	Cream central band on light blue ground—dim
3	Acetate B	1930	Same as 2
4	Acetate C	1930	Very dim light colours
5	Nitro A	1930	Dark with light streaks
6	Nitro A delustred	1930	Blue central band on yellow ground, suspended particles—bright colours
23	Nitro B	old	Bright yellow, red, orange, blue bands
7	Cupra A	old	Uniform bright yellow
8	Cupra A	1930	Uniform bright yellow
9	Viscose A	old	Bright yellow, blue, grey-green bands
10	Viscose A, dull	old	Same as 9, but dimmer
11	Viscose B	old	Blue central band on white background
12	Viscose C	1930	Bright yellow with occasional red or blue streak
14	Viscose D	1930	Blue-grey central band on white ground
15	Viscose E	1930	Bright yellow with red or blue streaks
16	Viscose F	1930	Same as 15
17	Viscose F delustered	1930	Light yellow, suspended particles
18	Viscose, hollow filament	old	Light yellow and white shot with blue and orange
13	Stretch viscose A	1930	Dull white
19	Stretch viscose B	1931	Yellow, occasional streak of orange

QUANTITATIVE OBSERVATIONS

The determination of the difference between the greatest and least refractive indices of crystal-sections has long been used in petrography for the identification of crystals. The following relationship exists[7]:—

$$R/M = n_2 - n_1$$

Where R = retardation.

M = thickness.

n_2 and n_1 = greatest and least indices of refraction of the section examined.

R and M may have any units provided the same unit is used for both.

If the crystal is uniaxial and the section examined contains the optic axis $n_2 - n_1$ is a maximum, and the equation becomes :—

$$R/M = \epsilon - \omega.$$

ϵ and ω = greatest and least indices of refraction of the material.

R/M or $\epsilon - \omega$ is, then, a characteristic of the material of the crystal and is independent of the size, shape, or thickness of the particular specimen being examined.

The cellulose micelle is in the form of a monoclinic biaxial crystal. Two of the axes of the index-ellipsoid are practically equal so that the above value of $\epsilon - \omega$, called by Herzog[8] " specific double refraction," may be determined and will be characteristic of the unif rmity of arrangement of the structural units of the particular form of cellulose. Table IV shows the results given by Chamot and Mason[9] and Table V the results obtained by Herzog[8] for various rayons.

Table IV—Chamot's Values of $\epsilon - \omega$

Rayon	ω	ϵ	$\epsilon - \omega$
Acetate	1·48	1·475	−0·005
Nitro	1·52	1·55	+0·030
Viscose	1·525	1·55	+0·025
Cupra	not reported		

Table V—Herzog's Values of $\epsilon - \omega$

Rayon	ω	ϵ	$\epsilon - \omega$
Cupra—fine	1·520	1·552	0·032
Cupra—coarse	1·527	1·548	0·021
Viscose -fine	1·514	1·550	0·036
Viscose—coarse	1·523	1·548	0·025
Viscose—coarse	1·524	1·548	0·024
Nitro- fine	1·514	1·556	0·042
Nitro—fine	1·515	1·548	0·033
Nitro—coarse	1·515	1·549	0·034
Nitro—coarse	1·517	1·549	0·032

Herzog's data shows that $\epsilon - \omega$ is so nearly the same for cupra and viscose rayons manufactured similarly (with or without stretch-spinning) that the method would be of little value for identification, but since this work had been nearly completed at the time of publication of Herzog's data, it was decided to extend the results to a greater number of rayons for more complete verification.

A polarising, chemical microscope with cross hairs fixed in the plane of polarization and perpendicular to it was used and the refractive indices were determined by the immersion method described by Preston[10] using the

microscope without the analyzer. A filament was mounted in one medium, focussed, and brought parallel to one cross hair. The microscope was then focussed upward slightly and the position of the Becke line noted. The Becke line is a bright line running along the outline of the filament inside the outline if the fibre has the higher refractive index and outside if the liquid has the higher refractive index. Additional mounts were made as indicated by the Becke line position until a liquid was found in which the filament was invisible and in which there was no Becke line. Liquids varying by 0·005 in refractive index were used; they were prepared as in Table VI and were calibrated with an Abbe refractometer.

Table VI—Preparation of Standard Media

Refractive index	Pine oil c.cm.	Nitrobenzene c.cm.	Aniline c.cm.
1·510	15·0	10·0	—
1·515	11·0	10·0	—
1·520	10·0	12·8	—
1·525	10·0	17·0	—
1·530	8·5	20·0	
1·535	7·0	24·6	—
1·540	3·5	20·0	—
1·545	1·6	20·0	—
1·550	-	25·0	—
1·555	-	14·0	3·1
1·560	- -	11·5	5·7
1·565	- -	9·0	9·0

Table VII—Experimental Values of $\varepsilon - \omega$

No.	Type	Date	Denier per filament	ω	ε	$\varepsilon - \omega$
23	Nitro A	old	—	1·515	1·545	0·030
5	Nitro B	1930	—	1·525	1·555	0·030
27	Nitro B	1931	5·00	1·520	1·550	0·030
28	Nitro B	1931	3·84	1·520	1·550	0·030
31	Nitro B dull	1931	3·84	1·510	1·540	0·030
18	Hollow filament viscose	old	—	1·520	1·540	0·020
11	Viscose A	old	- -	1·525	1·540	0·015
12	Viscose B	1930	-	1·525	1·540	0·015
14	Viscose C	1930	—	1·525	1·540	0·015
15	Viscose D	1930	—	1·520	1·535	0·015
16	Viscose E	1930	—	1·525	1·540	0·015
35	Viscose F	1931	3·75	1·525	1·540	0·015
19	Stretch Viscose A	1931	—	1·520	1·540	0·020
13	Stretch viscose B	1930	—	1·520	1·545	0·025
36	Stretch viscose B	1931	—	1·520	1·545	0·025
7	Cupra A	old	—	1·525	1·545	0·020
8	Cupra A	1930	—	1·520	1·545	0·025

The values obtained for $\epsilon - \omega$ are shown in Table VII and may be summarized as follows :—

1. The value of $\epsilon - \omega$ for each type of rayon is characteristic of the type of rayon, being ·030 for nitro rayons, ·015 for viscose rayons, ·020 to ·025 for stretch-spun viscose, and ·020 to ·025 for cupra rayons (also stretch-spun).

2. The absolute values of ϵ and ω seem to be dependent upon the details of manufacture.

3. In the case of nitro rayon, the value of $\epsilon - \omega$ is constant for all samples observed in spite of the fact that the amount of residual nitration as qualitatively observed by diphenylamine tests decreased in the order—old, 1930, 1931.

4. Stretch-spun viscose and cupra cannot be distinguished by the $\epsilon - \omega$ value.

5. Comparison of samples 27 and 28 shows that differences in thickness of the filaments not due to differences in manufacture have no effect on the optical properties of the rayon.

A possible application of observations by polarized light lies in obtaining the degree to which the cross-section of the rayon approximates a true circle. Since $R/M = \epsilon - \omega$, then $M = R/\epsilon - \omega$, and the thickness may be calculated if $\epsilon - \omega$ is measured or known and if R is known. R may be determined by observing the colour by polarized light of highest value and consulting the Newton Colour Scale or may be measured accurately by means of a compensating wedge. If the thickness is known and the breadth is measured, the ratio expresses the approximation to a circle of the cross-section. Illustrations of results obtained in this manner are given in Table VIII. Observations of this type would be very useful in determining the uniformity of rayons in many instances, since a single filament could be examined at intervals along its length without the use of cross-sections. The observations necessary are diameter, colour of the highest order, and the double refraction of the rayon. This last quantity need be determined only once for each sample of rayon.

GENERAL CONCLUSIONS

1. The value of the specific double refraction may be used to distinguish between various types of rayon with the exception th t it does not distinguish between stretch-spun viscose and stretch-spun cupra rayons.

2. The specific double refraction is little affected by residual nitro groups left in nitro rayons.

3. Differences in thicknesses of the rayons have no effect on the specific double refraction of rayon except when the difference in thickness is due to stretch-spinning.

4. The specific double refraction of a rayon in conjunction with two other easily determined observations may be used to determine the deviation of the cross-section of the rayon from the circular and this last value may be used as a measure of the uniformity of the rayon.

Table VIII—Determination of Deviation from Circular

Sample No.	Type	Date	Breadth-microns	Colour when the Nicols are crossed	parallel	B from Newton's Colour Scale -microns	$\epsilon - \omega$	Thickness -microns	Thickness ÷ Breadth	% deviation from circular
19	Stretch viscose A	1931	16·2	light yellow	blue	·306	·020	15·3	0·944	5·6
13	Stretch viscose B	1930	15·0	blue-grey	yellow-brown	·218	·025	8·7	0·580	42·0
36	Stretch viscose B	1931	8·9	yellow	blue	·332	·025	13·3	1·474	47·4
7	Cupra A	old	12·2	light yellow	blue	·306	·020	15·3	1·254	25·4
8	Cupra A	1930	13·0	bright yellow	blue	·332	·025	13·3	1·023	2·3

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TRANSACTIONS

8—AN INVESTIGATION OF THE ACTION OF CERTAIN SPECIES OF *PENICILLIUM* ON ARTIFICIAL SILK

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INTRODUCTION

It has frequently been observed that, when goods containing both cotton and artificial silk have been allowed to become " mildewed," the colonies of micro-organisms are invariably confined to the cotton. It was, therefore, considered to be of interest to determine whether certain common moulds known to be capable of producing " mildew " would grow on artificial silk, and if so, to discover the differences, if any, between the behaviour of the different kinds of artificial silks. An attempt was also made to find whether the infected material was modified chemically, and to what extent. After the commencement of our investigations, a paper was published by Thaysen and Bunker,[8] detailing certain experiments on artificial silk using mixtures of anaerobic bacteria and of soil and marine bacteria. They conclude that acetate silk is the most resistant to these bacteria followed in descending order of resistance by nitro-silk, viscose, and cuprammonium silk. They emphasise, however, that their experiments are only of a preliminary nature. Our own experiments do not indicate that these conclusions are applicable to mould growths except in so far that a sample of acetate silk examined appeared to be quite unaffected by any of the micro-organisms used by us, unless peptone was present. Karrer and Schubert[6] have investigated the action of snail zymase on various types of viscose silk and conclude that the chief factor influencing the zymolysis of this type of artificial silk is the character of the precipitating bath. Our experiments appear to show that the method of precipitation, or rather, the resultant condition of the surface layer[8] of the artificial silk is the principal characteristic which determines resistance to the growth of various *Penicillium* species. An exception to this is the acetate silk mentioned above ; in this case, almost perfect resistance to attack by moulds appears to be due to the chemical character of the material. We have found no reason to conclude that esterification of cellulose followed by saponification confers any immunity to mould growth.

The following species of *Penicillium* were used in this investigation :—

1. *Penicillium*, sp. 1. This micro-organism was isolated from a sample of mildewed American cotton yarn which was remarkable for its pink colour and its extreme tenderness. It is very closely allied to *P. purpurogenum* var. *rubri sclerotium* mentioned below and may be a second varietal strain of the same species. It differs from the former in being slightly less virulent in its action.

2. *P. pinophilum.* This micro-organism was obtained from the National Collection of Type Cultures. It is noted as being very virulent in its action on other forms of cellulose.

3. *Penicillium*, sp. 2. Isolated from a sample of black stained mercerised cotton yarn. This mould is of common occurrence in mildewed cotton goods and was not named by Dr. Thom.*

4. *P. purpurogenum* var. *rubri sclerotium.* This micro-organism was found as a contamination on a culture of *Mucor mucedo.* It was identified by Dr. C. Thom, of the U.S. Department of Agriculture.

5. *P. lilacinum* was obtained from the National Collection of Type Cultures.

Artificial Silks

The artificial silks used in this investigation were as follows :—

A1. An acetate silk of French origin.
N1. A nitro-silk of foreign manufacture.
V1. A viscose silk of Italian origin.
V2. A French viscose silk (unbleached).
V3. An English viscose silk.
V4. A Belgian viscose silk.
C1. A stretch spun Cuprammonium silk—English.
C2. A parallel spun English Cuprammonium silk.

The main characteristics of these materials are shown in Table I.

Table I

Silk	Denier	Filaments	Denier per Filament	Breaking load grammes	Breaking load per denier grammes	Extension at break	Copper No.	Sulphur
						%	%	%
A1	300	53	5·66	479	1·60	30	2·45	—
N1	147	22	6·69	see below	see below	17	see below	0·48 SO_3
V1	190	16	11·90	336	1·68	19	0·98	0·09
V2	159	18	8·83	289	1·82	25	0·92	0·15
V3	154	21	7·33	302	1·96	33	1·01	0·09
V4	206	25	8·24	331	1·60	23	1·14	0·08
C1	110	90	1·22	299	2·72	10	0·97	—
C2	490	90	5·44	520	1·04	30	2·46	—

With reference to silk N1. This silk was found to be subject to the gradual deterioration on storage to which all nitro silks are prone. This phenomenon is caused by the residues of combined SO_3 and is also observed in the case of modified cottons which have been degraded by the action of sulphuric acid.[4] The copper number rises and the breaking load sinks on storage. In the course of two years, the breaking load sank from 358 grms. to 268 grms. and the copper number rose from 4·15 per cent. to 4·47 per cent.

*The following characters were noted in culture :—Colonies dull green in colour turning dark smoky brown when older : narrow white margin : initial growth somewhat floccose : no colouration of medium or reverse of colony : conidiophores branching at least twice with conidial chains spreading : gelatin rapidly liquefied (5 days) with acid production : good typical growth on 3% glucose or sucrose agar, poorer growth on 3% lactose agar, slight growth on 3% glycerin agar or on butterfat.

Methods

The method of making the cultures was as follows :—

About 0·5 to 1 gramme of silk was wound off on to a small glass reel. These reels were made of thin glass rod and consisted of a piece of rod 3 ins. long bent to form a small hook at each end. The skein so obtained was enclosed in a test-tube plugged with cotton wool in the usual manner and the whole was steamed for 20 minutes. This process of sterilization was found to be quite sufficient to eliminate contaminating growths while not having any appreciable effect on the silk samples, as was seen from a comparison of the breaking loads and copper numbers of the blank tests with those of the original materials. The sterilized tubes were next filled to a depth of half an inch with sterile water or nutrient medium, according to the series of tests in view, this quantity just being sufficient to wet the bottom ends of the skeins. The silks were then inoculated with the requisite micro-organisms and growth was allowed to proceed for three months, the condition of the cultures being examined at weekly intervals and the amount and nature of the growths, colourations, etc., noted. In the case of each silk, five series of cultures were made using the following liquids for wetting out :—

(1) Distilled water, (2) 1 per cent. Asparagine, (3) 1 per cent. Ammonium Nitrate, (4) 1 per cent. Potassium Nitrate, (5) 1 per cent. Peptone.

The following cultures were included in each series :—*Penicillium*, sp. 1, *P. pinophilum*, *Penicillium*, sp. 2, *P. lilacinum*, and two control tubes. In some of the earlier series, cultures of *Mucor mucedo* were included, but these were replaced in later series by *P. purpurogenum* var. *rubri sclerotium*, as it was found that *M. mucedo* had no effect whatever on any of the earlier tested materials.

The following series were made in the same manner on American cotton yarn : Distilled Water, 1 per cent. Asparagine, 1 per cent. Ammonium Nitrate, using the five species of *Penicillium* mentioned above with two controls in each series. It was found, however, that the above-mentioned method of sterilization was not sufficiently rigorous for a highly contaminated material like raw cotton yarn. In consequence, only the series wetted with Ammonium nitrate gave typical results. In the other cases, the growth of the fungi was choked by spore forming aerobic bacteria which rendered the media alkaline and thus suppressed the mould growths. It may be noted that these bacteria, while causing the well-known brown " conditioning stains " had no effect whatever on the strength of the yarn.

After allowing growth to proceed for three months, the cultures were removed from the tubes, washed thoroughly in water, loose mycelium being removed as far as possible, and dried in air, conditioning for at least a week before testing. In the later series, the p_H of the culture solutions was determined before and after the period of growth. The values were determined by means of the B.D.H. capillator, using the " four-eleven " indicator. All the values found lay within the range $p_H 4$—$p_H 11$. The breaking load was determined by means of a Goodbrand hydraulic single thread tester, modified to take 3 inch lengths of yarn. Twenty-five tests were made on each culture. This was found to be more than sufficient for a true value of the breaking load, as the samples of silk examined were all very regular ; the mean deviation from the mean breaking load in no case exceeded 5 per cent. before any treatment was given to the silk. In the case of highly tendered samples, of course, the mean deviation frequently rose to high figures and became thus

a criterion of the tendering produced locally. Unfortunately, no constant humidity chamber was available and as the samples in each series could not all be tested at the same time, it was found that changes in temperature and humidity of the atmosphere resulted in quite noticeable differences between the mean breaking loads of controls which had undergone identical treatments. For this reason, apparent increases in breaking load have not been regarded as significant, nor have decreases in breaking load been so regarded unless they exceed 5 per·cent. of the breaking loads of the corresponding blanks. The humidity at the time of testing was recorded in each case. It was hoped that it would be possible to apply the data of Parker and Jackman[7] to our results, but this was unfortunately found to be impossible as they relate only to certain specific temperatures.

The broken ends of test pieces were examined microscopically. Before examination the threads were steeped 10 minutes in saturated aqueous Congo Red, and mounted in glycerine jelly. This treatment was found to show up the damage very well. It was found that there were several types of damage. In some cases, transverse cracks were found, cracks being stained deep red, in others the outer resistant layer, which was thus revealed, appeared to be pierced irregularly showing large blotches of deep red where the dye had penetrated to the inner part of the fibre. In the case of cuprammonium silks the fibre was uniformly dyed, no matter how bad the damage, thus showing that the fibre is uniform throughout in its dyeing properties and hence presumably in its molecular arrangement. It is noteworthy that quite appreciable amounts of damage may have taken place without any microscopic evidence being visible. In general, it may be said that damage is not visible until the breaking load has sunk to less than 75 per cent. of the control.

In addition to measuring the breaking load, the copper numbers of each culture were determined by the method of Heyes[5] modified in the case of the artificial silk cultures by the use of 0·1 g. of silk instead of 0·25 g. The reason for this was that some artificial silks, even before treatment, have copper numbers which are so high that the cupric solution would be well-nigh exhausted by the reducing groups present, and hence low values would be obtained. In the case of sample A1, the saponification value was also determined for each culture. No evidence was found of any saponification having taken place in any case.

PENICILLIUM, Sp. 1.

This micro-organism was found to grow quite well on all the samples except A1 when wetted out with water alone. When grown in the presence of organic nitrogen, it produces a wine-coloured red pigment which is readily soluble in water. This pigment is frequently produced when there is little other sign of growth. Its production always coincides with a considerable modification of the cellulose and results in a high copper number. Notes on the cultures follow.

Cultures wetted with Distilled Water

N1. Growth observed after one week becoming luxuriant after two weeks. A brownish colouration developed later. This often occurs in cultures not suitable for the production of the wine red colouration. The material was badly tendered especially at the top where growth was most pronounced. There was, however, little chemical modification as evidenced by the slight rise in the copper number. When examined microscopically,

it was found that fibrils had split off and, in fact, the whole structure broke up under gentle pressure. This type of destruction was not commonly found in the course of our experiments, fibres were found to break up rather transversely than longitudinally in most cases. This form of damage, namely longitudinal cracks, is associated with silks which have undergone considerable stretching during spinning and has been observed also in the case of fine filament viscose silk.

V1. Definite signs of growth from 12 days after inoculation. There was distinct formation of aldehyde groups as evidenced by the rise of copper number from 1·04 (blank test) to 1·29 per cent. and slight tendering as shown by the drop of breaking load to 91 per cent. of the blank (relative humidities at the time of testing, 68 per cent. for blank and 73 per cent. for culture).

V2. This culture was found to be growing luxuriantly seven days after inoculation. A slight pink colouration developed. The material had lost all its strength and could not be tested, breaking up when unwinding was attempted.

V4. Grew luxuriantly after several weeks. When stained with Congo Red, the broken ends of the test pieces showed no cracks but curious blotches where the outer layer had been pierced.

C1. Positive from first week. Slight discolouration. The tests showed local tendering but no damage was visible under the microscope.

Cultures wetted with 1 per cent. NH_4NO_3

V2. Showed pitting under the microscope, but no cracks.

V4. Positive from first week. Some discolouration. No increase of copper number. No damage could be observed microscopically but the breaking load was only 54 per cent. of blank.

C1. Positive from first week. Finally quite luxuriant. No damage observed microscopically but breaking load was down to 73 per cent. of blank and Copper number up to 1·76 per cent. from 1·05 per cent. for blank.

C2. Grew without showing much mycelium. Somewhat discoloured. Considerable acidity developed—p_H4·5—and the material fell apart on washing. Microscopically the fibre appeared free from wasting but on slight pressure it broke up transversely into short lengths. Copper number increased from 2·56 to 4·98 per cent. A determination of the denier showed that no appreciable loss of substance had taken place. The denier was 499 against 498 for the original substance.

Cultures wetted with 1% KNO_3

V4. Growth was not very luxuriant but nevertheless the copper number was distinctly high and the breaking load only 38 per cent. of blank. As in the case of 1 per cent. NH_4NO_3 culture, there was little sign of damage visible under the microscope.

C1. Growth died down after nine weeks, but distinct tendering had taken place. The silk was discoloured and under the microscope the fibres had a roughened appearance.

C2. Grew well throughout with a pinkish colouration towards the end. Culture had become distinctly acid, p_H4·5. The material fell apart on washing but showed no signs of damage microscopically.

Cultures wetted with 1% Asparagine

A1. Grew luxuriantly with a pink colouration (not the deep wine red colouration mentioned below) but without the slightest effect of any kind on the silk.

N1. Positive from first week. A deep wine red colour developed quickly.

V1. Grew luxuriantly throughout. Typical wine red colouration. Too tender to test.

V2. Positive throughout but only a faint pink colouration. There was no formation of aldehyde groups.

V4. Wine red stain. Too tender to test.

C1. Similar to N1, V1 and V4, but apparently owing to the resistant nature of this silk, its breaking load was 51 per cent. The copper number had increased from 1·07 to 2·84 per cent.

Cultures wetted with 1% Peptone

N1. Luxuriant growth with pink colouration. As often observed in the case of cultures wetted with 1 per cent. peptone, the extremely nutrient character of the medium appeared to protect the silk. In this case, there was no tendering whatever. The experiment was repeated with the same result.

V2. Luxuriant growth took place but with only a yellowish colour. No damage was visible under the microscope.

C1. Luxuriant growth with a pink colouration. The material was very brittle and distinctly tender. High copper number.

C2. Luxuriant throughout with wine colour. This culture showed more damage than any other made during this research. When it was attempted to unwind the silk it fell to dust. Examined microscopically this dust was found to consist of short lengths of fibre which yet appeared in themselves quite unwasted.

The results obtained with this micro-organism are shown in Table II.

Table II

Series	Sample	Growth	Colour	% Br. Load	p_H	Cu. No.
Water	A1	Slight	nil	100	—	2·51
	N1	Strong	Brown	48	—	4·31
	V1	Medium	Brown	91	—	1·29
	V2	Strong	Pink	nil	5·8	1·91
	V3	Medium	Orange	75	6·5	1·44
	V4	Strong	Brown	53	6·5	1·40
	C1	Slight	Brownish	92	5·5	1·49
	C2	Medium	Brown	57	4·5	3·08
1% NH_4NO_3	A1	Slight	nil	98	—	2·79
	N1	Medium	nil	98	6·25	4·19
	V1	Strong	Brown	84	—	1·54
	V2	Strong	Brown	nil	5·25	2·09
	V3	Medium	nil	nil	5·0	1·27
	V4	Slight	Yellow	54	5·0	1·22
	C1	Medium	nil	73	5·0	1·76
	C2	Slight	Pink	nil	4·5	4·98

Table II—*Continued.*

Series	Sample	Growth	Colour	% Br. Load	p_H	Cu No.
1% KNO_3	A1	Medium	Pale Brown	97	—	2·59
	N1	Medium	Pale Brown	92	5·25	4·30
	V1	Medium	Yellow	44	—	1·27
	V2	Strong	Brown	nil	5·2	2·62
	V3	Medium	Brownish	38	5·0	2·23
	V4	Medium	Yellow	38	5·0	1·72
	C1	Slight	Brownish	64	5·0	2·07
	C2	Medium	Pink	nil	4·5	5·25
1% Asparagine	A1	Strong	Pink	100	—	2·94
	N1	Strong	Red	40	—	6·26
	V1	Strong	Red	nil	—	1·95
	V2	Medium	Pink	72	7·0	0·81
	V3	Medium	Pink	86	7·5	1·33
	V4	Slight	Red	nil	—	2·15
	C1	Slight	Red	51	—	2·84
	C2	Slight	nil	85	7·8	2·71
1% Peptone	A1	Medium	nil	91	—	2·71
	N1	Medium	Brownish	99	7·5	4·29
	V1	Strong	Red	35	—	1·33
	V2	Strong	Yellowish	95	7·0	1·18
	V3	Medium	Brown	89	7·8	1·25
	V4	Medium	Pale Brown	85	7·8	1·21
	C1	Strong	Pink	68	7·2	2·09
	C2	Strong	Red	nil	—	10·82

P. PINOPHILUM

This micro-organism, which is said to be very destructive to cellulose, grew somewhat irregularly on the artificial silks examined. Occasionally, cultures failed to show any sign of growth whatever, while some cultures showed good growth and pronounced tendering. When grown on cotton yarn in presence of Ammonium nitrate, it was quite as destructive as *Penicillium*, sp. 1. The mould produces a pigment the colour of which appears to vary with the p_H of the solution. The following list shows the colours observed corresponding to different p_H values :—

p_H 5·2 Brownish or yellow.
5·75 Yellow.
6·0 Orange.
6·5 Orange.
7·2 Bluish red.
7·5 Pink or red.
7·75 Red.

In general, the copper numbers of the artificial silks damaged by this micro-organism were not much higher than those of the controls, though occasionally cultures were encountered which had quite high copper numbers, where there had been considerable damage. Notes on several of the cultures follow.

Cultures wetted with Distilled Water

N1. Orange colouration fading later, probable owing to increasing acidity of culture though this was not confirmed as the p_H was not determined. Possibly some slight tendering—93 per cent. of control.

V2. Medium growth with orange colouration, a considerable amount of tendering had taken place though the copper number was lower than that of the control.

V3. Visible growth was slight though an orange colouration developed, nevertheless, considerable damage was done as shown by the low breaking load. The copper number was also high. Microscopical examination showed the presence of cracks and pitting of the filaments.

C2. Stained orange at first changing later to brown with slight growth of mycelium. Only slight tendering.

In general it may be said that this micro-organism does not grow well on artificial silk without some additional source of nutriment.

Cultures wetted with 1% NH_4NO_3

V2. Positive throughout. An orange yellow stain was visible at first but this faded later through increase of acidity. Considerable tendering took place chiefly where the stain had been. The copper number showed no significant increase over that of the control. Fibres slightly pitted.

V3. No sign of growth was observed but considerable tendering took place, nevertheless, with a slight increase of copper number. Fibres cracked and pitted.

C2. Positive throughout, with brownish staining, and final low p_H value. The tenderness represented by the breaking load, 54 per cent. of the control, is less than the actual tendering as the material broke in many places on unwinding. The copper number was 0·88 per cent. above the control.

Cultures wetted with 1% KNO_3

V2. Medium growth throughout. Orange stain. Badly tendered though the copper number was normal.

V3. Medium growth. No staining. The tendering was very irregular, thus the breaking load was 85 per cent. of that of the control, yet the mean deviation was 23·6 per cent. as against the usual figure of 2 to 3 per cent. for this material. The outer layer was badly damaged.

C2. The damage was similar in character and amount to the corresponding culture in the Ammonium nitrate series.

Cultures wetted with 1% Peptone

A1. Growth slow in starting but finally luxuriant with distinct local tendering.

C2. Medium growth with distinct tendering and high copper number.

The results are summarised in Table III. It will be seen that there are few of these silks that show much sign of being damaged under these conditions except sample C2. The column headed (1) gives copper numbers of cultures and (2) those of the corresponding controls.

Table III

Series	Sample	Growth	Colour	% Breaking load	p_H	Cu. No. 1	Cu. No. 2
Water	A1	Slight	Orange	100	—	2·41	2·45
	N1	Medium	Orange	93	—	4·10	4·20
	V1	Slight	Brownish	99	—	1·01	1·04
	V2	Medium	Orange	70	6·0	0·86	1·04
	V3	Slight	Orange	53	6·2	1·42	1·19
	V4	Slight	None	98	6·5	1·22	1·25
	C1	Slight	Orange	91	6·0	2·01	1·15
	C2	Slight	Orange to Brown	91	5·8	2·87	2·68

Table III—*Continued.*

Series	Sample	Growth	Colour	% Breaking load	p_H	Cu. No. 1	Cu. No. 2
1% NH_4NO_3	A1	None	None	105	—	2·76	2·82
	N1	Slight	None	97	6·25	4·15	3·98
	V1	Slight	None	99	—	1·17	1·00
	V2	Medium	Orange to Brown	51	5·2	0·85	0·74
	V3	None visible	None	51	5·2	1·34	1·16
	V4	Slight	None	85	5·5	1·28	1·18
	C1	Medium	Brownish	84	5·2	1·22	1·05
	C2	Medium	Brownish	54	4·8	3·44	2·56
1% KNO_3	A1	None	None	97	—	2·63	2·76
	N1	Slight	Yellow	91	5·75	4·20	4·13
	VI	Slight	None	96	—	1·16	1·13
	V2	Medium	Orange	35	6·5	0·78	0·88
	V3	Medium	None	85	6·0	1·12	1·15
	V4	Slight	None	97	5·5	1·14	1·23
	C1	Slight	Brownish	92	5·2	1·16	0·98
	C2	Slight	Orange	47	4·5	3·37	2·56
1% Asparagine	A1	Slight	Brown	102	—	2·73	2·71
	N1	Medium	Red to Yellow	77	—	4·81	4·19
	V1	Slight	Pink	100	—	0·99	1·04
	V2	Medium	Red	106	7·5	0·85	0·93
	V3	Slight	Pink	101	7·5	1·28	1·19
	V4	Medium	Orange to Pink	97	6·5	1·24	1·19
	C1	Slight	Red	102	6·2	1·15	1·07
	C2	Medium	Pink	69	6·8	2·99	2·62
1% Peptone	A1	Strong	Pink	87	7·5	2·86	2·74
	N1	Slight	Pink	98	7·5	4·24	4·40
	V1	Strong	Red	98	—	1·02	0·93
	V2	Strong	Red	105	7·75	1·28	0·88
	V3	Medium	Brown	99	7·8	1·33	1·12
	V4	Strong	None	99	8·0	1·26	1·30
	C1	Medium	Pink	111	7·2	1·43	1·12
	C2	Medium	Pink	83	7·5	3·06	2·56

PENICILLIUM, Sp. 2

This micro-organism grows very well on artificial silk of any kind, but without, as a rule, causing any tenderness whatever. When grown on cotton, it causes distinct tendering and when the tendered material is examined by the Congo Red technique,[1] it shows sausage shaped, spirally striped swellings which indicate that the cuticle of the cotton hair is damaged without any of those signs of growth in the central canal, which are typical of *P. purpurogenum* or *Penicillium*, sp. 1, for example. There are no distinct signs of formation of aldehyde groupings either in the case of the artificial silks examined or in the case of the cotton. The growths of individual cultures show few differences and will be presented simply in tabular form in Table IV, together with the breaking load and other results. The column headed " Colour " has been omitted in this case as this mould does not produce any distinctive colouration apart from a general darkening due to its spores. Many of the cultures showed vigorous growth at first which fell away later and died down. It will be observed that only one culture in the whole of this series is badly tendered, namely, V2 wetted by distilled water.

Table IV

Series	Sample	Growth	% Breaking load	p_H	Copper Number 1	Copper Number 2
Water	A1	Medium	106	—	2·59	2·54
	N1	Medium	96	—	4·24	4·20
	V1	Medium	96	—	1·06	1·05
	V2	Medium	39	6·0	0·96	1·04
	V3	Medium	103	6·0	1·11	1·19
	V4	Medium	103	6·2	1·11	1·25
	C1	Medium	98	6·8	1·21	1·17
	C2	Medium	106	6·8	2·66	2·68
1% NH_4NO_3	A1	Medium	102	—	2·66	2·76
	N1	Strong	72	6·75	4·38	3·98
	V1	Medium	98	—	1·15	1·00
	V2	Strong	75	5·5	0·82	0·74
	V3	Strong	96	5·8	1·18	1·16
	V4	Medium	103	5·8	1·13	1·18
	C1	Medium	107	5·0	1·12	1·05
	C2	Medium	84	5·8	2·28	2·56
1% KNO_3	A1	Medium	103	—	2·75	2·76
	N1	Strong	92	4·75	4·19	4·13
	V1	Medium	92	—	1·03	1·13
	V2	Medium	92	6·2	0·86	0·88
	V3	Medium	108	6·5	1·12	1·15
	V4	Strong	104	6·2	1·44	1·27
	C1	Medium	100	5·2	1·05	0·98
	C2	Medium	111	7·0	2·67	2·56
1% Asparagine	A1	Strong	110	—	2·94	2·71
	N1	Strong	110	—	4·31	4·19
	V1	Medium	102	—	1·14	1·04
	V2	Slight	102	6·5	0·92	0·93
	V3	Medium	99	6·8	1·20	1·19
	V4	Medium	90	6·5	1·32	1·19
	C1	Medium	110	6·0	1·08	1·07
	C2	Medium	94	6·0	2·66	2·62
1% Peptone	A1	Strong	88	7·5	3·07	2·74
	N1	Strong	90	7·5	4·54	4·40
	V1	Strong	90	—	0·93	0·93
	V2	Strong	104	7·0	0·98	0·88
	V3	Strong	96	7·0	1·15	1·12
	V4	Strong	103	7·5	1·19	1·30
	C1	Strong	103	7·5	0·92	1·12
	C2	Strong	99	7·5	2·43	2·56

P. PURPUROGENUM VAR. *RUBRI SCLEROTIUM*

The only silks used for cultures of this micro-organism were V3, V4, and C2. The behaviour of the micro-organism with regard to them was entirely analogous to that of *Penicillium*, sp. 1, to which it appears to be closely allied. As mentioned above, it appears in general to be slightly more virulent in its action than is that mould. Notes on some of the cultures follow.

Cultures wetted with Distilled Water

V4. Luxuriant growth with brownish staining. The outer layers of the filaments were badly damaged, giving the blotches with Congo Red typical of this silk.

C2. Luxuriant growth. A few well developed cracks were observed near the broken ends of the test pieces, but there was no wasting as evidenced by the fact that the yarn had a titre of 509 d. as against 494 for the control. The copper number was (as was usually found) higher than that of the corresponding culture with *Penicillium*, sp. 1, and the breaking load lower.

Cultures wetted with 1% NH_4NO_3

V3. Luxuriant, pinkish turning to pale brown. The silk was too tender to unwind. Stained preparations showed pits, wasting and a few cracks.

V4. Positive throughout, much stronger than the corresponding growth of *Penicillium*, sp. 1. Though the yarn was tender, there was little damage visible under the microscope. The Congo Red showed differential staining only at the broken ends of the test pieces.

As with *Penicillium*, sp. 1, there was only a slight rise in the copper number.

C2. Medium growth. Brownish discolouration. In this case, this micro-organism appears to have caused less damage than *Penicillium*, sp. 1, since the breaking load was easily determined. Nevertheless, even here, the copper number was higher, being 5·67 per cent. against 4·98 per cent. for that mould, and 2·56 per cent. for the control.

Cultures wetted with 1% KNO_3

V3. Medium growth with slight pink colouration. The breaking load as determined is not thoroughly representative, as the weakest places broke in unwinding. Under the microscope, pits, wasting and cracks were all visible.

C2. Luxuriant growth with pinkish colouration. Broke on washing.

Cultures wetted with 1% Asparagine

V4. Wine red colour. Very badly tendered. Under the microscope the outer layer was seen to be pierced and there was some wasting.

C2. As in the case of *Penicillium*, sp. 1, there was only slight growth and no perceptible tendering except perhaps a little locally as evidenced by the high mean deviation of the breaking load, 9·3 per cent. compared with 5·37 per cent. and 3·68 per cent. for the control.

Cultures wetted with 1% Peptone

C2. Luxuriant growth with pink stain. The entire culture broke in two on removing from the spool. Not so badly tendered as the corresponding culture of *Penicillium*, sp. 1.

The various data with regard to this series are summarised in Table V.

Table V

Series	Sample	Growth	Colour	% Breaking Load	p_H	Copper Number 1	Copper Number 2
Water	V4	Strong	Brownish	34	5·8	1·67	1·25
	C2	Strong	None	47	4·5	3·53	2·68
1% NH_4NO_3	V3	Strong	Brownish	nil	5·0	2·92	1·16
	V4	Medium	Brownish	36	5·2	1·39	1·18
	C2	Medium	Brownish	47	4·8	5·67	2·56

Table V—*Continued.*

Series	Sample	Growth	Colour	% Breaking Load	p_H	Copper Number 1	Copper Number 2
1% KNO_3	V3	Medium	Pink	39	5·0	2·39	1·15
	V4	Medium	None	42	5·2	1·52	1·27
	C2	Strong	Pink	nil	4·5	5·62	2·56
1% Aspara-gine	V3	Strong	Pink	79	7·2	1·33	1·19
	V4	Medium	Wine	25	—	2·32	1·19
	C2	Slight	None	96	7·0	2·70	2·62
1% Peptone	V3	Strong	Brownish	78	7·8	1·27	1·12
	V4	Strong	Brown	61	7·5	1·09	1·30
	C2	Strong	Pink	nil	7·2	6·83	2·56

PENICILLIUM LILACINUM.

In general, this micro-organism was found to grow with some difficulty on the artificial silks examined. The growth was frequently confined to the immediate neighbourhood of the inoculum. Tendering was often observed at this point on the culture though the remainder was quite sound. When grown on American cotton, the tendering was of the same nature as that observed with *Penicillium*, sp. 2. Only in a few cases was there more than a slight rise in the copper number of the material.

The results of these series are summarised in Table VI.

It will be noted that while there is some tendering, mostly of a local nature, in most of the cultures, some of the materials notably A1, V1 and C1, show great resistance and others, especially V2 and C2, are quite noticeably affected.

Table VI

Series	Sample	Growth	Colour	% Breaking Load	p_H	Copper Number 1	Copper Number 2
Water	A1	Slight	—	99	—	3·07	2·54
	N1	Medium	—	81	—	5·05	4·20
	V1	Medium	Lilac	99	—	1·02	1·05
	V2	Medium	—	74	6·2	1·02	1·04
	V3	Medium	—	81	6·2	1·24	1·19
	V4	Medium	—	103	6·5	1·20	1·25
	C1	Slight	—	93	6·5	1·22	1·17
	C2	Medium	—	89	7·2	2·65	2·68
1% NH_4NO_3	A1	Slight	—	98	—	2·60	2·76
	N1	Slight	—	89	6·8	4·17	3·98
	V1	Slight	—	96	—	1·07	1·00
	V2	Medium	—	87	5·8	0·75	0·74
	V3	Medium	—	nil	5·8	1·14	1·16
	V4	Slight	—	88	5·8	1·16	1·18
	C1	Medium	Lilac	92	5·5	1·36	1·05
	C2	Medium	—	79	5·8	2·54	2·56
1% $KHNO_3$	A1	None	—	102	—	2·76	2·76
	N1	Slight	—	95	6·5	4·19	4·13
	V1	Slight	—	88	—	1·04	1·13
	V2	Medium	Lilac	85	6·0	0·89	0·88
	V3	Slight	Lilac	88	6·5	1·16	1·15
	V4	Medium	—	102	6·2	1·05	1·27
	C1	Slight	—	101	6·8	1·40	0·98
	C2	Medium	—	77	7·2	3·61	2·56

Table VI—*Continued.*

Series	Sample	Growth	Colour	% Breaking Load	p_H	Copper Number 1	Copper Number 2
1% Asparagine	A1	Strong	Brownish	97	—	3·01	2·71
	N1	Medium	—	100	—	4·34	4·19
	V1	Medium	Lilac	93	—	1·10	1·04
	V2	Medium	—	86	7·2	0·75	0·93
	V3	Medium	—	71	7·8	1·31	1·19
	V4	Slight	—	88	8·0	1·31	1·19
	C1	Medium	—	105	7·2	7·2	1·07
	C2	Medium	—	95	8·0	2·62	2·62
1% Peptone	A1	Strong	Yellow	78	8·0	3·25	2·74
	N1	Strong	Brownish	93	8·0	4·66	4·40
	V1	Strong	Red	91	—	1·19	0·93
	V2	Strong	—	84	8·0	1·02	0·88
	V3	Strong	Brown	82	7·8	1·32	1·12
	V4	Strong	—	87	7·8	1·73	1·30
	C1	Strong	Violet	101	8·0	1·19	1·12
	C2	Strong	—	46	7·2	7·52	2·56

Susceptibility of Artificial Silks

From the above results, these samples may be graded as regards their susceptibility to moulds by adding up the percentages of the breaking loads of the controls of the different cultures and expressing the result as a percentage of the total number of the results, multiplied by 100. The results are shown in the following Table VII.

Table VII

Sample	Total	Percentage
A1	1960	98·0
N1	1752	87·6
V1	1706	85·3
V2	1362	68·1
V3	1501	75·0
V4	1677	83·9
C1	1838	91·9
C2	1366	68·3

In calculating these figures, the results for *P. purpurogenum* have been omitted, as cultures were not made with this mould on all the samples. The order of decreasing resistance is hence, A1, C1, N1, V1, V4, V3, C2, V2. These figures show that the resistance of an artificial silk to mould growth is not to be deduced directly from the fact that it has been prepared by any particular process, except for the special case of acetate silk, which is chemically distinct from the others. Nor is it dependent on the degree of degradation of the cellulose, since N1 and C2, the most degraded of the samples, are at opposite ends of the list. From the shape of its cross section, N1 is a dry spun silk and is hence stretched in process of manufacture. C1 is also a stretch spun silk and hence it seems probable that stretch spinning confers resistance. C2, which is also a cuprammonium silk, has a very low resistance, being spun without stretching. The type of damage observed microscopically is tabulated below, the materials being arranged in order of increasing susceptibility :—

A1. No damage observable.
C1. Striated appearance but nothing else of note.
N1. Fibres pitted and split longitudinally.
V1. Fibres pitted, transverse cracks.
V4. Outer layer pierced, no cracks or pits.
V3. Fibres pitted, transverse cracks.
C2. A few cracks visible. When badly tendered the material breaks up transversely into short lengths.
V2. The fibres showed pitting and cracks similar to V3.

From these results no more can be deduced than that the type of damage done by the species of *Penicillium* here investigated, varies with the process by which the silk has been made, and hence depends not on the chemical composition of the materials (except in the special case of A1) but on their physical properties. Chemically speaking, there appears little difference between samples V1, V2, V3 and C1, yet their susceptibilities to damage by these types of *Penicillium* vary enormously. So far as can be observed, the various species, where they cause damage at all, each cause the same type of damage on any one sample of silk.

Cultures on American Cotton

As mentioned above, the only successful cultures made on American cotton were those wetted with 1 per cent. Ammonium nitrate, where the reaction of the solution was such as to favour the mould growth and suppress the contaminating bacteria. The yarn used was a twofold yarn; count, 42·5/2; breaking load, 313 grms.; Copper No., 0·97 per cent.; "Insoluble" Copper No., 0·32 per cent.;* Fluidity of 0·5 per cent. solution in cuprammonium, 2·12; Fluidity after boiling in dilute alkali, 5·11. The fluidities were determined by the method of Clibbens and Geake (*J.T.I.* 19, T77, 1928). The yarn after incubation for three months was examined in the same way as the artificial silks, except that the copper numbers were determined in the ordinary way, using 0·25 grms. of material, and that the method of microscopical examination used was that of Bright[1] instead of simple staining by Congo Red. The results are summarised in Table VIII. The columns under "Fluidity" headed 1 and 2 are, respectively, the fluidities before and after boiling with dilute alkali.

Table VIII

Species	Growth	Colour	Breaking load %	p_H	"Insoluble" Copper No.	Fluidity 1	Fluidity 2
Control 1	—	—	—	5·8	0·32	1·88	3·29
Control 2	—	—	—	5·8	—	—	3·59
P., sp 1	Medium	Pink	14	5·8	1·00	3·75	6·17
P. Pinophilum	Medium	Pink to Yellow	14	5·8	0·34	—	3·72
P., sp 2.	Medium	None	87	5·8	0·40	—	3·69
P. purpurogenum	Strong	Pink	15	5·5	0·77	—	4·54
P. lilacinum	Slight	None	79	5·8	0·40	—	3·22

Microscopical examination showed that there were two types of damage. *Penicillium*, sp. 2, had caused weakening of the cuticle, with the result that on swelling in caustic soda, the cotton hairs assumed a sausage-shaped appearance, the sausage-shaped swellings being deeply stained and marked

*The "Insoluble" Copper Number of a cotton is the copper number of the material after washing to remove soluble reducing substances.

by spiral bands where the spiral elements of the cuticle had separated. It is not certain that this is not merely the first form assumed by the damaged fibres, to develop later into the second form of damage noted. This form of damage was also noted in the case of the culture of *Penicillium*, sp. 1, wetted with 1 per cent. Asparagine. Owing to bacterial choking, little mould growth was observed on this culture, but the breaking load was 9·3 per cent. of the mean of the controls. The other form of damage observed in the cases of the remaining four cultures of this series, consisted of an irregular enlargement of the central canal through the penetration of hyphae into it. The enlargement had been carried to such an extent in some cases that only the cuticle was left in spiral fragments. The removal of part of the inner portion of the fibre naturally resulted frequently in incomplete swelling, when the fibre was immersed in 18 per cent. caustic soda. In addition to the enlargement of the central canal, heavily dyed spiral markings were also occasionally observed where the spiral elements of the cuticle had parted. These markings were, however, comparatively infrequent.

The fluidities of the solutions in cuprammonium are all rather low and of quite a different order from those which would have been observed in the case of material tendered to the same extent by acid or ordinary oxidation. In fact, the only fluidities which are significantly different from those of the controls, are the fluidities of the cultures made with *Penicillium*, sp. 1, and *P. purpurogenum*. These are also the only cultures in which the copper numbers are significantly higher than those of the controls. The fact that the fluidity of the culture of *Penicillium*, sp. 1, after alkali boiling is considerably higher than the corresponding fluidity without that process, indicates that the copper number is due to the formation of oxycellulose and not of hydrocellulose [2, 3].

SUMMARY AND CONCLUSIONS

The growth of five species of *Penicillium* on samples of five types of commercial artificial silk, with and without the addition of organic and inorganic nitrogen has been investigated. Several distinct types of damage have been noted microscopically. It is concluded :—

(1) That acetate silk is more resistant than any other type.

(2) That stretching in the spinning process appears to confer some power of resistance on non-esterified silks.

(3) That the degree of the previous degradation of the cellulose is without influence on its susceptibility to *Penicillium*.

(4) That the type of damage observed under the microscope does not vary from one species of *Penicillium* to another for any one sample of artificial silk.

(5) That considerable tendering may take place as a result of mould growth without any sign of damage being visible microscopically.

(6) That *P. purpurogenum* var. *rubri sclerotium* and the allied *Penicillium*, sp. 1, are particularly apt to damage artificial silks of the non-esterified classes whereas *P. pinophilum* does not possess the same power of damaging these silks in contrast to the behaviour of these species towards cotton which is equally badly tendered by all three under the conditions here employed.

(7) That *P. purpurogenum* and *Penicillium*, sp. 1, normally cause the formation of additional reducing groups, presumably aldehyde groups, when acting on either cotton or non-esterified artificial silks.

(8) That the formation of these reducing groups takes place in a similar manner to that in which oxycellulose is formed.

In conclusion, the authors wish to express their thanks to Messrs. Henry Ashwell & Co., Ltd., in whose laboratory was performed much of the chemical and textile work involved in this paper, and to Dr. Thom for identifying certain species of *Penicillium*.

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TRANSACTIONS

9—THE OXIDATION BY GASEOUS OXYGEN OF COTTON IMPREGNATED WITH SODIUM HYDROXIDE SOLUTION

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I—INTRODUCTION AND SUMMARY

It has long been known that the presence of air in the kier during the scouring of cotton with dilute solutions of sodium hydroxide leads to the formation of oxycellulose, with consequent tendering of the goods. The experimental difficulties involved in the investigation of the oxidation of cellulose that takes place under such conditions are considerable, and consequently the oxidation process is but little understood. It is also known that if cellulose is impregnated with 5*N* sodium hydroxide solution, as in the preparation of " alkali cellulose," which constitutes the first stage in the manufacture of viscose rayon, and the alkali cellulose is allowed to " age " for a day or two, appreciable oxidation by atmospheric oxygen takes place even at the ordinary temperature. That this oxidation is the essential feature of the ageing has been recognised by Courtaulds Ltd., Glover and Wilson[1], who have patented the acceleration of the process by the use of temperatures above 30° C., or by the use of oxidising agents other than air or oxygen. The conditions obtaining in the ageing of alkali cellulose, unlike those in the scouring of cotton, offer the possibility of exact measurement of the rate of absorption of oxygen, and consequently conditions approximating to the former rather than to the latter have been adopted in the

work to be described. This work, which deals with the oxidation by gaseous oxygen of cotton impregnated with sodium hydroxide solutions of concentrations from 2·5*N* to 15·2*N*, at temperatures from 20° to 60° C., was begun partly with the object of investigating the oxidation process and the properties of the oxycellulose produced, and partly to discover whether the oxidation would provide an easily controlled laboratory method for the preparation of chemically modified cottons.

The swelling that takes place when cotton is treated with sodium hydroxide solutions more concentrated than about 3*N* has been the subject of much controversy. It is widely believed that an addition compound is formed, and this supposed compound has been termed " soda cellulose." Recently, however, Neale[19] has shown that the swelling of cellulose in sodium hydroxide solutions is well explained by a theory of salt formation. Whatever the true explanation may be the term " soda cellulose " is convenient, and it will be used in this paper in the most general sense of cotton impregnated with sodium hydroxide solution, even when the concentration of the latter is below the minimum required to produce swelling.

As the oxidation of soda cellulose by oxygen is rather slow at room temperature, most of the experiments recorded here have been made at 40° C., with a smaller number at 60° C., and only a few at 20° C. Weltzien and zum Tobel[27,28,29] have oxidised soda cellulose by means of oxygen at 60° C., but the oxidation was carried to such a stage that the degradation of the cellulose was far beyond that ever occurring in textile practice or viscose manufacture. Whereas the smallest absorption recorded by them for the concentration of sodium hydroxide that produced the maximum rate of oxidation was 41·8 cc. per gm. of cellulose, and the largest 170 cc. per gm., the maximum absorption dealt with here, except in two special experiments, is about 3·5 cc. per gm. This absorption represents the limit of the range of modification of cellulose that is of interest for cotton technology or viscose manufacture.

In all the experiments performed, it has been found that the rate of absorption increases for some time and then becomes practically constant. This is well explained by the hypothesis that the oxidation consists of several consecutive reactions. A similar hypothesis has been suggested by Birtwell, Clibbens, Geake and Ridge[3], to account for the copper numbers and methylene blue absorptions of oxycelluloses produced by the action of alkaline hypobromite on cotton, but in the present work more direct evidence for such a mechanism of oxidation is obtained.

Since the rate of absorption of oxygen is not constant for any concentration of sodium hydroxide, it cannot be expressed by a single number. This renders comparison of the rates of oxidation at different temperatures rather difficult, but an idea of the relative rates of oxidation at 20°, 40°, and 60° C., may be obtained from the statement that, when 10·3*N* sodium hydroxide solution is used in the preparation of the soda cellulose, the volume of oxygen absorbed in 48 hours at 20° C is absorbed in about 6 hours at 40° C and in about 1·2 hours at 60° C.

The rate of oxidation of soda cellulose at both 40° and 60°C increases rapidly when the concentration of sodium hydroxide is increased from 2·5*N* to 5*N*. It then increases less rapidly as the concentration rises to about

10*N*, where a well-defined maximum rate of oxidation is observed; as the concentration is still further increased the rate of oxidation falls. Weltzien and zum Tobel[18,19] obtained a curve of somewhat similar shape, but their maximum rate of absorption occurs at sodium hydroxide concentrations of about 6·5*N* and 8·5*N* for soda celluloses prepared from cotton yarn and cuprammonium rayon respectively. Possible causes of this difference are discussed.

The presence of iron in soda cellulose has a very important catalytic effect on the rate of oxidation. This effect decreases as the concentration of the sodium hydroxide used increases, becoming relatively small at concentrations above 10*N*. The presence of iron has the effect of making the maximum in the rate of oxidation curve, which occurs at about 10*N*, even more pronounced. Even the best samples of sodium hydroxide contain sufficient iron to affect the rate of oxidation of soda celluloses made from them, since iron dissolved in sodium hydroxide solutions as sodium ferrite is concentrated on cotton by adsorption during the steeping process. A method of purifying sodium hydroxide solutions from iron based on this adsorption by cotton is described.

Copper and nickel have considerable accelerating effect on the oxidation of soda cellulose made with 5*N* sodium hydroxide solution, but their effects, which are approximately equal, are less than that of iron. Manganese, on the other hand, greatly retards the oxidation of cotton impregnated with 5*N* sodium hydroxide solution. As the concentration of alkali is raised, this retarding effect becomes less and less; with a 7·4*N* solution, it is still pronounced; with 10·3*N* solution the reaction is at first slower, but ultimately becomes faster, than the reaction in absence of manganese, while with 15·2*N* solution the manganese has a slight accelerating effect throughout the oxidation.

If cotton is swollen in concentrated sodium hydroxide solutions, and, after washing and drying, is oxidised in the presence of 2·5*N* sodium hydroxide solution, the rate of oxidation is from 2 to 2½ times that of cotton not previously swollen. This increased reactivity of cotton that has been subjected to a swelling treatment is similar to that found by other methods.

The fluidity in cuprammonium solution and the copper number of oxycelluloses prepared by oxidation of soda cellulose have been determined. Oxidation leads to increase of fluidity and copper number, the increase of both properties being rapid at first and slowing off as the oxygen absorption increases. The copper number—oxygen absorption curve is thus of the same type as that obtained on oxidising cotton by alkaline hypobromite[4], and attributed by Birtwell, Clibbens, Geake and Ridge[3], to the occurrence of consecutive reactions. The two types of oxycellulose also behave in a similar way as regards methylene blue absorption. Both the fluidity and the copper number for a given oxygen absorption depend on the concentration of the sodium hydroxide solution used in preparing the soda cellulose, and the copper number also varies considerably with the iron content of the cotton during oxidation.

The rate of oxidation of soda cellulose by oxygen is not affected by the closeness of packing of the soda cellulose within the limits likely to occur in practice. The oxidation provides a controllable method of preparing chemically modified cottons of relatively low copper number.

II—MEASUREMENT OF THE RATE OF OXIDATION OF SODA CELLULOSE

(a) At 20° and 40° C

The rate of oxidation of the soda cellulose was determined by measuring the rate of absorption of oxygen in the apparatus shown in Fig. 1. D is a bulb of about 50 cc. capacity, provided with a ground joint by means of which it can be attached to the rest of the apparatus. The tube C is made from a previously calibrated 5 cc. pipette, graduated from the top downwards in tenths of a cubic centimetre. The internal diameter of this tube was 6·2 mm. so that the length corresponding to 0·1 cc. was 3·3 mm.; the volume could therefore be easily read to hundredths of a cubic centimetre. The taps and ground joint were lubricated with a mixture of 3 parts lanoline and 1 part beeswax.

The moisture content of the cotton to be used was determined and a quantity equivalent to 1·000 gm. of dry cotton weighed out. This cotton was steeped in 50 cc. of the sodium hydroxide solution for half an hour, care being taken to wet out the cotton and remove air by working the cotton in the solution with a glass rod. Most of the solution was removed by filtration on a coarse Jena fritted-glass filter under suction, and the soda cellulose was put in the upper part of a stoppered tube constricted at its middle, and centrifuged for 5 minutes at 2,000 R.P.M. The soda cellulose was then transferred to a stoppered weighing bottle and its weight determined. The amount of sodium hydroxide solution retained by the cotton after centrifuging was from 270 to 310 per cent. of the weight of the cotton with solutions of concentrations of 5*N* and upwards, but with 2·5*N* solution only about 130 per cent. was retained. The soda cellulose was teased out with forceps and put in the bulb D, which was then attached to the apparatus. Mercury was run into the manometer bend so that it stood a little above the lowest graduation of tube C. Tap B was closed, tap A opened and the apparatus rapidly evacuated to a pressure of about 15 mm. of mercury with a water pump. Tap A was then closed and the apparatus put in a thermostat at the required temperature, so that tap A was immersed. After 15 minutes the apparatus was filled with dry oxygen from a gas-holder through tap A, the pressure reduced to atmospheric by allowing the excess gas to bubble out through a trap, tap A closed and tap B opened. Readings of the mercury level in tube C on the volume scale, the height of the mercury levels in the limbs of the manometer, and the barometric pressure, were then taken at intervals during the course of the experiment. The volume and manometer readings were taken with a cathetometer reading to 0·1 mm. In order to obviate the effects of sticking of the mercury in the manometer, the mercury surfaces were moved and allowed to come to their equilibrium positions, by touching the surface in the open limb with a glass rod before each set of readings was taken. During the course of an experiment the total pressure in the apparatus was kept approximately constant and equal to the atmospheric pressure by running mercury into the open limb of the manometer as required; the variation of pressure in any one experiment was not more than 10 mm. of mercury.

(b) At 60° C

The apparatus used to make measurements of the rate of absorption of oxygen at 20° and 40° C. was not suitable for use at 60° C., owing to the

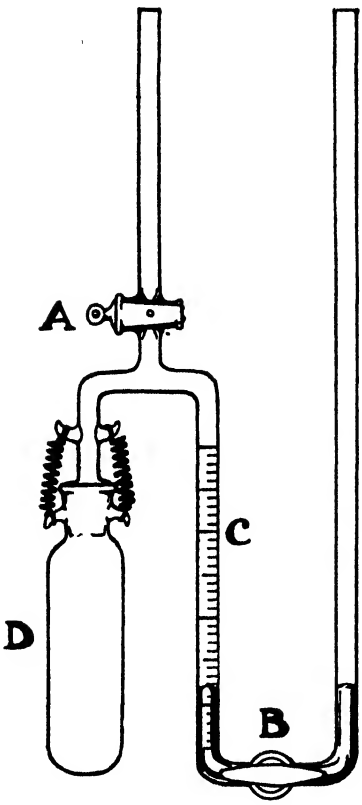


FIG. 1

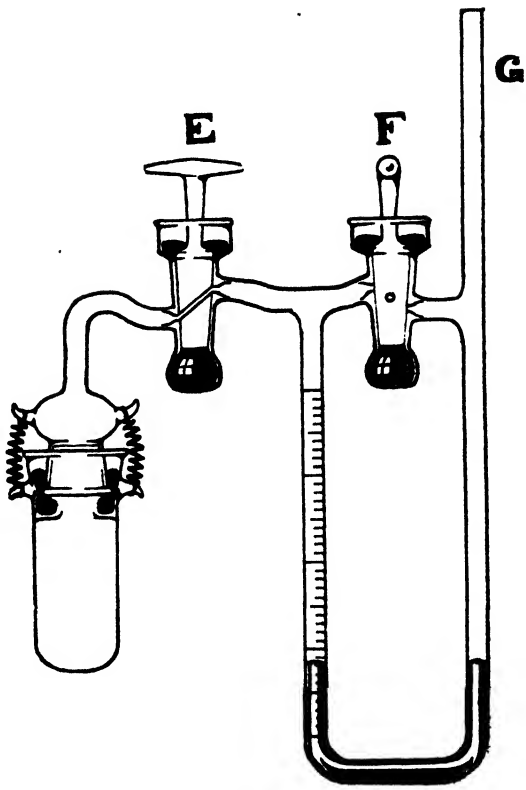


FIG. 2

impossibility of finding a tap grease that would render the taps and ground joint water-tight at 60° C. and yet allow the taps to be turned at room temperature. The modified apparatus shown in Fig. 2, in which mercury-sealed taps and a mercury-sealed ground joint were incorporated, was therefore employed. The taps and joint were lubricated with a mixture of 7 parts of pure rubber and 3 parts of beeswax. Here the procedure was to evacuate the apparatus at room temperature as before, close tap E, and close the end of tube G by means of a piece of pressure tubing and a screw clip. The apparatus was then put in the thermostat, and after 15 minutes, tap E, and immediately afterwards the screw clip, were opened to admit dry oxygen from the gasholder. After the pressure had been reduced to atmospheric as before, tap F was closed, the rubber tubing removed from tube G, and the measurements were begun.

(c) Calculation of the Rate of Absorption of Oxygen

In order to calculate the volume at N.T.P. of the oxygen in the apparatus at any time, it was necessary to know the volume occupied by the oxygen, and its pressure. This volume is equal to the volume of the bulb and connecting tube to the zero graduation *plus* the volume reading in tube C, *minus* the volume of the soda cellulose. The volume of the bulb to the

zero graduation was obtained by enclosing a quantity of air in the apparatus and observing the volume reading in tube C for different pressures, at constant temperature. The volume of the bulb could then be readily calculated. As it is only necessary to know this volume because of the small variations of pressure during an experiment, it is evident that it need not be known very accurately. The volume of soda cellulose is calculated with sufficient accuracy from the weight and density of the cotton and of the retained sodium hydroxide solution.

The total pressure in the apparatus is obtained from the difference in the heights of the mercury in the two limbs of the manometer, and the barometric pressure. The barometer reading was always corrected to 0° C., and a correction to the manometer readings for the difference between the two meniscus heights was also applied when necessary. In order to obtain the partial pressure of the oxygen, it is necessary to deduct from the total pressure the vapour pressure of the sodium hydroxide solution on the cotton. Now this absorbed solution must have the same vapour pressure as the solution with which it was in equilibrium during steeping. The final concentrations obtained by steeping 1 gm. of cotton in 50 cc. of sodium hydroxide solutions of various concentrations can be calculated from the results of Vieweg[16] and Coward and Spencer[11] on the preferential absorption of sodium hydroxide by cotton, and when the vapour pressures corresponding to the concentrations so calculated are obtained by reference to tables, it is found that even at 60° C. they do not differ from the vapour pressures of the steeping solutions by more than 0·7 mm. of mercury. When it is remembered that the total pressure of oxygen is about 700 mm. of mercury, it is clear that no appreciable error in the oxygen absorption is introduced by assuming that the vapour pressure of the soda cellulose is the same as that of the sodium hydroxide solution used in preparing it. The vapour pressures required for the present work were obtained from International Critical Tables[15], and are given in Table I.

Table I.

Concentration of sodium hydroxide in steeping solution.		Vapour pressure of soda cellulose (mm. of mercury)		
gm. NaOH per 100 gm. solution	Normality at 18° C.	20° C.	40° C.	60° C.
9·09	2·50	—	50·6	137
16·86	5·00	13·8	44·0	120
23·42	7·37	—	36·2	100
30·86	10·33	7·6	24·9	72·3
33·60	11·48	—	20·4	—
36·44	12·72	—	16·8	51·1
41·92	15·20	—	10·2	32·2

The gas used was obtained from a cylinder, and analysis showed that it contained 98·4 per cent. of oxygen. A further correction to the pressure for the impurity—probably nitrogen—was therefore necessary. The initial partial pressure of nitrogen is 1·6 per cent. of the pressure obtained by deducting the vapour pressure of the soda cellulose from the total pressure. As the volume decreases during the course of an experiment the partial

pressure of nitrogen obviously increases; at any time it is equal to the product of the initial gas volume and the initial partial pressure of nitrogen, divided by the volume at the time in question. Thus the partial pressure of oxygen is equal to $(P - p_s - p_N)$, where P is the total pressure, p_s the vapour pressure of the soda cellulose, and p_N the partial pressure of the nitrogen. The volume at N.T.P. of the oxygen in the apparatus is then given by the expression

$$V = \frac{273{\cdot}1 \times (P - p_s - p_N)\, v}{(273{\cdot}1 + t) \times 760}$$

where V is the volume of oxygen at N.T.P., v the observed volume of gas and t the temperature in °C. The variation with time of the volume at N.T.P. of the oxygen in the apparatus being known, the rate of absorption is readily obtained.

At the beginning of an experiment the observed gas volume increased at first to a maximum before starting to decrease. This effect was due to the oxygen entering the apparatus at a lower temperature than that of the thermostat, and the difficulty was partially overcome by allowing the oxygen to pass through a bulb immersed in the thermostat before entering the apparatus. It could not be overcome entirely, however, particularly with the lower concentrations of sodium hydroxide, where the vapour pressure is highest. Consequently in order to find the volume of enclosed gas at zero time it was necessary to extrapolate back from the curve obtained after the initial increase of volume was over. As the rate of absorption is least at the lower concentrations of alkali, where the longest extrapolations are necessary, the error thus introduced cannot be serious.

In order to discover whether the evacuation of the apparatus changed the concentration of the sodium hydroxide solution on the cotton by evaporation or absorption of water, tests were made with cotton impregnated with 5·0N solution. It was found that the loss in weight of the soda cellulose was less than 1 mg. on 4 gm., so that this effect may be neglected. The water pump evacuation has the disadvantage that the pressure cannot be reduced below about 15 mm. of mercury. On this account complete removal of air from the apparatus is not obtained, especially with the most concentrated solutions where the vapour pressure is lowest. Consequently the calculated partial pressure of oxygen throughout an experiment is slightly too high. Even under the most unfavourable circumstances, the error caused by the retention of nitrogen cannot exceed 1·4 per cent. of the oxygen absorption, and is not likely to reach this figure. As will be seen later, two experiments under apparently identical conditions often gave oxygen absorptions that differed by more than 1·4 per cent., so that this error may be admitted for the sake of the convenience of the water pump.

III—CONSECUTIVE REACTIONS IN THE OXIDATION OF SODA CELLULOSE

(a) Features of the Rate of Absorption Curve

In preliminary experiments at 40° C., it was found that the rate of absorption of oxygen increased for several hours, and then remained constant. It was thought that this might be due to the slow attainment, throughout the gas volume, of the full vapour pressure of the sodium hydroxide solution on the cotton, and in order to test this hypothesis experiments were carried out with nitrogen instead of oxygen in the apparatus. The results are

shown graphically in Fig. 3, and it is evident that, even with the solutions of highest vapour pressure employed in this work, thermal equilibrium is attained in twenty minutes or less. It is thus clear that the increase of rate of absorption of oxygen is not due to this cause.

The next explanation thought of was that of consecutive reactions. To test this hypothesis, an experiment was carried out with cotton impregnated with 12·72*N* sodium hydroxide solution. The soda cellulose was allowed to absorb oxygen for 8 hours at 40° C., when the initial increase in the rate of absorption had ceased and the rate had been constant for about 4 hours. The apparatus was then removed from the thermostat, cooled to room temperature, evacuated and left overnight. Next morning, it was again filled with oxygen in the usual way, and the experiment was repeated.

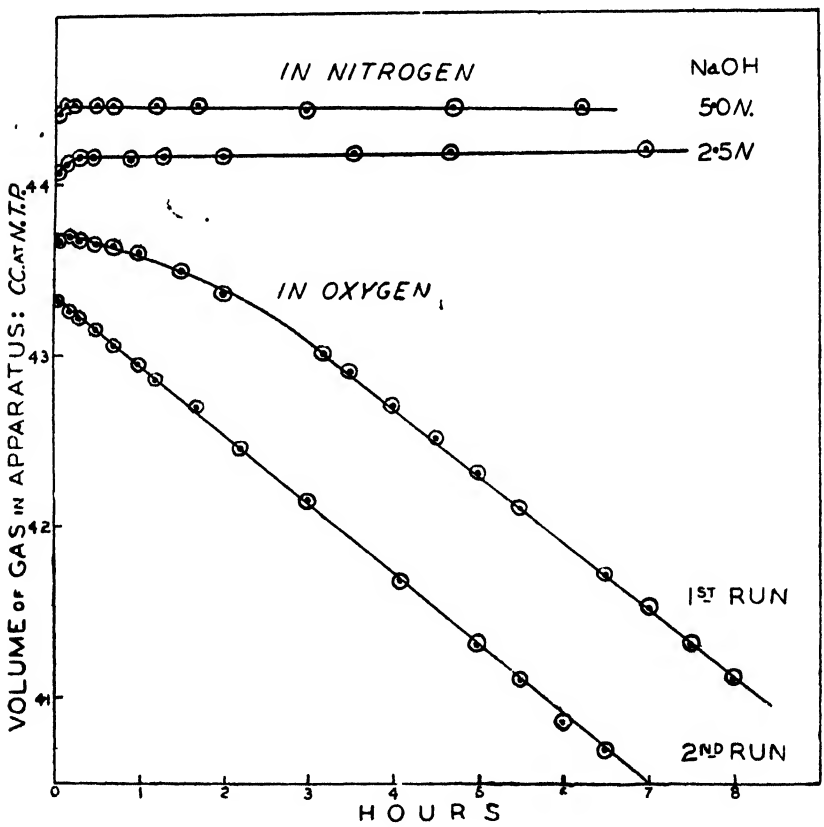


FIG. 3

Here, except for the usual slight disturbance near the beginning, corresponding to the attaining of thermal equilibrium, the rate of absorption was constant from the start, and equal to the maximum rate reached in the first run. The results are shown in Fig. 3. They may be explained by the following mechanism of oxidation. The first reaction consists of an oxidation of cellulose, which, in the region of relatively slight oxidation here dealt with, will proceed at an approximately constant rate. The product of this reaction is in its turn oxidised, and as the product increases in amount, the

rate of absorption of oxygen in this second reaction will increase. When the oxidation has been in progress for some time, a stage will be reached when the product of the first reaction is oxidised as fast as it is formed ; its amount will then remain constant, and hence its rate of oxidation will also remain constant. Beyond this stage, since both reactions are proceeding at constant rates, the total rate of absorption must remain constant. In order that an increase in the rate of oxidation may occur, it is clear that the velocity constant of the second reaction must be great compared with that of the first reaction, since the active mass of the intermediate product must be small compared with that of the cellulose. This statement of the mechanism of oxidation can be given precision by mathematical expression, and this will be done in the next sub-section.

Birtwell, Clibbens, Geake and Ridge[8] have been led to a similar theory of consecutive reactions for the oxidation of cotton cellulose by alkaline hypobromite solution, by the study of the chemical properties of the oxycellulose so produced. When cotton is acted on by alkaline hypobromite, its copper number increases rapidly at first, but soon attains a value that remains very nearly constant for some time. On the other hand, the absorption of methylene blue increases continuously with the time of oxidation. This is explained by a consecutive reaction theory, which assumes that the first product of oxidation has an aldehydic character, and is responsible for the copper number, while the oxidation of this product in the second reaction causes it to lose its reducing properties and acquire acidic properties characterised by high methylene blue absorption. As will be seen later, the relation between copper number and oxygen absorption obtained for cotton oxidised by oxygen in the presence of concentrated sodium hydroxide solution is very similar to that obtained for cotton oxidised by alkaline hypobromite. It therefore appears probable that the consecutive reactions taking place in the two instances are similar.

(b) Kinetics of Consecutive Reactions in the Oxidation of Soda Cellulose

Since the actual chemical reactions that take place during the oxidation of cellulose are not known, the investigation of the kinetics of the reactions must necessarily be of the simplest and most general form. In the following treatment, it has been assumed that each " oxidizable point " in the cellulose requires one atom of oxygen for its oxidation to the intermediate product, and that the product so formed consumes a further atom of oxygen in the second reaction. It has also been assumed that the active masses of the cellulose and the intermediate product of oxidation are proportional to the amounts of the respective substances present ; i.e., that the reactions take place in a homogeneous system.

Let the first reaction be

$$\text{Cellulose} + \text{O} \longrightarrow \text{A}$$

and the second

$$\text{A} + \text{O} \longrightarrow \text{B}$$

At time t, let x and y be the amounts of oxygen absorbed in the first and second reactions respectively, and z the amount of the intermediate product A present.

$$\text{Then} \frac{dx}{dt} = k \left[\text{Cellulose}\right] \left[\text{O}\right],$$

where the square brackets denote concentration.

Since the pressure of oxygen is constant, the concentration of oxygen in the soda cellulose is constant, and since Weltzien and zum Tobel[18,19] have shown that 1 gm. of cellulose can absorb over 200 cc. of oxygen in this reaction the amount of cellulose may be assumed to be constant over the absorption range of from 0 – 3·5 cc. per gm. dealt with in this work.

$$\text{Hence } \frac{dx}{dt} = \text{constant} = k_1, \text{ say}$$

$$\text{Rate of accumulation of A} = \frac{dz}{dt} = \text{Rate of formation of A} - \text{rate of oxidation of A}$$

$$= \frac{dx}{dt} - \frac{dy}{dt}$$

$$= k_1 - \frac{dy}{dt}.$$

$$\frac{dy}{dt} = k'[\mathrm{A}][\mathrm{O}]$$

$$= k_2 z$$

$$\therefore \frac{dz}{dt} = k_1 - k_2 z$$

$$\therefore z = \frac{k_1}{k_2}(1 - e^{-k_2 t})$$

$$\frac{dy}{dt} = k_2 z = k_1(1 - e^{-k_2 t})$$

$$\text{Total rate of absorption of oxygen} = \frac{da}{dt}$$

$$= \frac{dx}{dt} + \frac{dy}{dt}$$

$$= k_1 + k_1(1 - e^{-k_2 t})$$

$$= 2k_1 - k_1 e^{-k_2 t}$$

$$\therefore a = 2k_1 t + \frac{k_1}{k_2} \cdot e^{-k_2 t} + C$$

When $t = 0$, $a = 0$ $\quad \therefore C = -k_1/k_2$

$$\therefore a = 2k_1 t - \frac{k_1}{k_2}(1 - e^{-k_2 t}) \qquad (1)$$

The experimental data can be well fitted by an equation of the form

$$a = K_1 t - K_2(1 - e^{-K_3 t})$$

but K_2 is not equal to $K_1/2K_3$, as it should be for agreement with the above equation for two consecutive reactions. Equation (1) shows that a asymptotically approaches the value $2k_1 t - k_1/k_2$ as t increases, and hence the limiting value of the rate of absorption is $2k_1$, or twice the rate of the first reaction. This means that the maximum slope of the absorption curve should theoretically be twice the slope of the curve at the origin; actually the experimental curves show a maximum slope that is more than twice—usually from three to four times—the slope at the origin. This suggests that more than two consecutive reactions take place, and indeed it would be surprising if the oxidation were as simple as is assumed in the above treatment. If three consecutive reactions are assumed, then the equation for the rate of absorption of oxygen is

$$a = 3k_1 t - \frac{(2k_1 k_3 - k_1 k_2)}{k_3(k_3 - k_2)} \cdot (1 - e^{-k_2 t}) + \frac{k_1 k_2}{k_3(k_3 - k_2)} \cdot (1 - e^{-k_3 t}) \qquad (2)$$

The curve corresponding to this equation is of the same form as that corresponding to equation (1), and the maximum rate of absorption is $3k_1$, or three times the rate of the first reaction.

The above explanation of the observed fact that the maximum slope of the absorption curves is more than twice the slope at the origin is based on the assumption that the consecutive reactions absorb equal quantities of oxygen. A similar experimental result would be obtained, however, if the ratio of the oxygen absorptions in the reactions were not unity. For example, if there were two consecutive reactions and if the second reaction absorbed twice as much oxygen as the first, the maximum rate of absorption would be three times the rate of the first reaction. It is also possible that the various reactions are not single reactions, but each may consist of two or more side reactions. In the experiments of Weltzien and zum Tobel[29], after prolonged oxidation about 50 per cent. of the absorbed oxygen was present as carbon dioxide, so that the reactions are evidently complex. In view of this complexity, all that may be concluded is that the experimental results are consistent with the existence of two or more consecutive reactions.

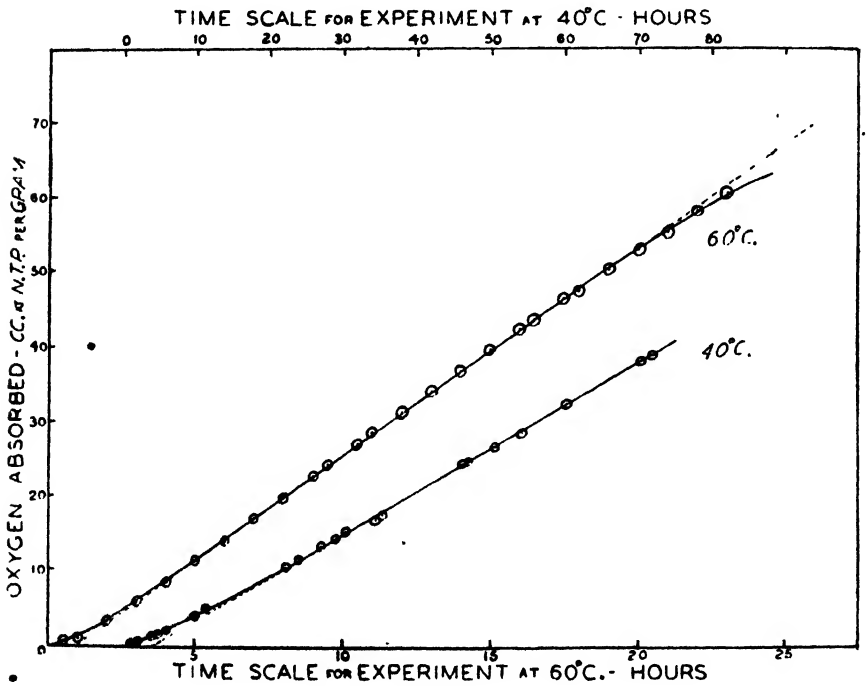


FIG. 4

(c) Prolonged Oxidation

In the experiments with a maximum oxygen absorption of about 3·5 cc. per gm. of cotton, the rate of absorption appeared to become constant in about 5 hours at 40° C. and in less than 1·5 hours at 60° C., with sodium hydroxide concentrations of $5N$ and upwards. Two experiments with smaller quantities of cotton, where much greater absorptions were possible, showed, however, that the rates of absorption do not really become constant after the times given above, but go on increasing slowly for considerably longer

periods. The results obtained are shown graphically in Fig. 4. In the first experiment, 0·1 gm. of cotton, impregnated with 10·33*N* sodium hydroxide solution, was oxidised at 40° C., and after 72 hours 39·1 cc. of oxygen per gm. of cotton had been absorbed. Here the rate of absorption did not become constant until about 20 hours from the start. In the other experiment, 0·2 gm. of cotton was oxidised at 60° C.; when the gas volume had decreased to about the zero graduation of the graduated tube, the absorption was stopped, some of the mercury removed, the apparatus evacuated and re-filled with oxygen in the usual way, and another absorption begun. This was repeated until the total oxygen absorption amounted to 60·7 cc. per gm. of cotton. In this experiment, the rate of absorption increased for about 3 hours, remained constant until about 16 hours from the start, and then a gradual decrease in the rate became noticeable. This decrease was to be expected, since a time must come when the rate of absorption must begin to fall off appreciably owing to the gradual decrease of the active mass of cellulose. This point had evidently not been reached in the experiment at 40° C. The simplest case of two consecutive reactions being assumed, and allowance being made for the decrease in the amount of cellulose present, the equation for the rate of absorption of oxygen can be shown to be

$$a = a\left\{2 - \frac{2k_2 - k_1}{k_2 - k_1} \cdot e^{-k_1 t} + \frac{k_1}{k_2 - k_1} \cdot e^{-k_2 t}\right\} \qquad (3)$$

where a is the initial amount of cellulose and k_1 and k_2 are the velocity constants of the two reactions respectively. This equation gives a curve of the same form as that obtained in the above experiment at 60° C. If k_1 is small compared with k_2, and t is small, it reduces to the equation

$$a = a\left\{2k_1 t - \frac{k_1}{k_2}(1 - e^{-k_2 t})\right\}$$

which is identical with equation (1), except that in the latter a is included in the constant k_1.

(d) Method of Expression of Rate of Absorption of Oxygen

From what has been said above, it is clear that the rate of absorption of oxygen cannot be expressed by one number. It may be expressed by an empirical equation containing three constants, but this makes comparison between rates of absorption under different conditions very difficult. It has therefore been thought advisable to express the rate of absorption as the volume of oxygen (at N.T.P.) absorbed per gm. of cotton in certain arbitrarily chosen times. For experiments at 40° C., 3, 6, and 9 hours, and for those at 60°C., 1, 1·5 and 2 hours, have been chosen.

IV—THE VARIATION OF THE RATE OF OXIDATION WITH THE CONCENTRATION OF THE SODIUM HYDROXIDE SOLUTION USED IN PREPARING THE SODA CELLULOSE

(a) The Purification from Iron of the Cotton and Sodium Hydroxide

It was found during the course of the work, as will be shown in Section V, that the presence of ferric hydroxide has a strong accelerating effect on the oxidation of soda cellulose by oxygen, and it was therefore necessary to remove iron as completely as possible from both the cotton and the sodium hydroxide to be used.

The cotton employed (No. 103R) was in the form of sliver, and had been boiled with 2% caustic soda solution for ten hours, at an excess pressure of 37 lb. per square inch. It had not been acidified after soda-boiling, and its initial iron content was 0·0083%. In order to remove the iron as far as possible, 50 gm. of cotton was shaken for 1½ hours with 1 litre of *N*/2 sulphuric acid solution, washed, and the acid treatment repeated. After being washed to neutrality, the cotton was allowed to dry in the air. That this acid treatment had no appreciable hydrolytic effect on the cotton was shown by the copper number and fluidity of the acid washed material, which were 0·03 and 4·7 respectively. The final iron content of the cotton was 0·00069%.

Sodium hydroxide usually contains an appreciable amount of iron, and when a concentrated solution is prepared the iron dissolves as sodium ferrite. Two samples of sodium hydroxide made from sodium were obtained from different sources, but their iron contents were little less than that of a sample described as " purified sticks."

It was discovered during the investigation of the catalytic effect of iron, to be described in Section V, that cotton immersed in concentrated sodium hydroxide solution strongly adsorbs this dissolved iron, and this property was accordingly used as the basis of a method of purification of sodium hydroxide from iron. A solution containing about 47 gm. of sodium hydroxide per 100 gm. of solution was prepared from sodium hydroxide " from sodium," which had an iron content of about 0·6 mg. per 100 gm. anhydrous sodium hydroxide. This solution was shaken with 2 gm. of acid-washed cotton per 100 cc. for half an hour, the solution then decanted, and the cotton pressed on a Buchner funnel to remove as much of the solution as possible. Birtwell, Clibbens and Geake[1] have shown that concentrated solutions of sodium hydroxide dissolve very little from even highly modified cottons, so that there is little danger of any cellulosic material being dissolved in this treatment. After three successive treatments in this way, the solution was filtered through a No. 4 Jena fritted-glass filter on the filter pump to remove carbonate and fragments of cotton hairs. This filtration was extremely slow, so that during its progress it was necessary to protect the solution from atmospheric carbon dioxide by means of soda-lime tubes. The concentration of the clear solution was then determined by titration of weighed amounts with *N*-hydrochloric acid. Solutions of the required concentrations were prepared by weight dilution of this stock solution, and the concentration checked by titration. The iron content of the purified material was 0·090 mg. per 100 gm. anhydrous sodium hydroxide. Later, a sample of specially pure sodium hydroxide with an iron content of 0·28 mg. per 100 gm. was obtained, and this was used as starting material for another preparation of purified sodium hydroxide by the above method. In this preparation the solution was treated with cotton five times, but the greater purity of the original material and the additional treatments only resulted in a reduction of the iron content to 0·060 mg. per 100 gm. It is probable that the factor limiting purification is the iron content of the acid-washed cotton, and if a raw cotton were specially selected for low iron content, and purified entirely by laboratory methods, it is possible that even better purification of sodium hydroxide from iron might be obtained by the method described.

(b) Oxidation at 40° C

Acid-washed cotton, 103R, of iron content 0·00069%, was oxidised at 40° C. in the presence of sodium hydroxide solutions of various concentrations, the iron content of the sodium hydroxide being 0·090 mg. per 100 gm. The rate of absorption curves obtained with the various concentrations are given in Fig. 5, and they show that for concentrations of 5*N* and upwards, the rate of absorption increases for some time and ultimately becomes

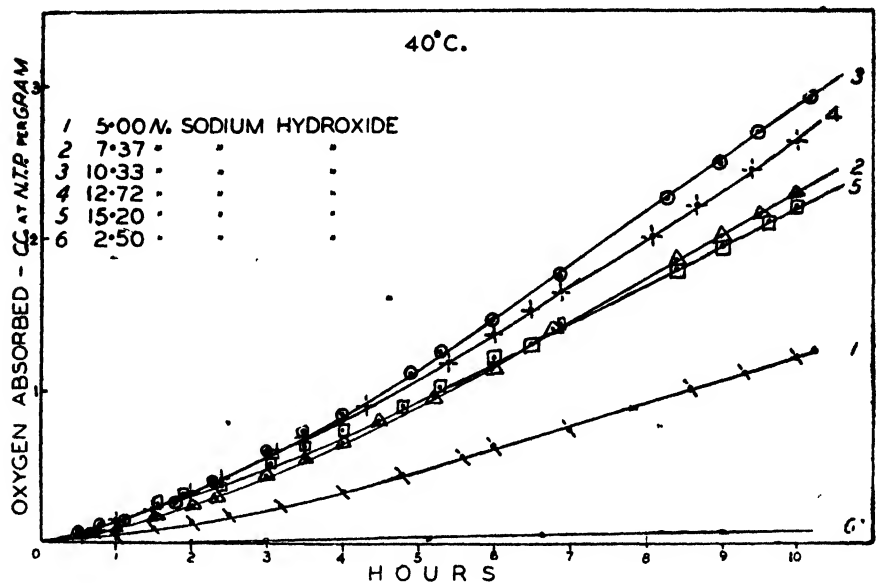


FIG. 5

appreciably constant ; in the portion of the curve for 2·5*N* sodium hydroxide solution shown, the constant rate has not yet been attained, but it was actually reached after about twelve hours.

Fig. 6 and Table II show the variation of the absorption in 3, 6, and 9 hours with the concentration of sodium hydroxide used in the preparation of the soda cellulose. The absorption is very slow with 2·5*N* sodium hydroxide solution, and gradually increases in rate as the concentration increases up to about 10*N*, above which concentration the rate falls off again.

In determining the value of this method of oxidation as a means of preparing modified cotton, it is important to know whether the rate of oxidation is dependent on the closeness of packing of the soda cellulose, within the limits of compactness likely to occur in practice, since such a dependence would affect the uniformity of the product. An experiment was therefore made in which the soda cellulose, instead of being teased out as usual, was compressed into the bottom of the bulb by means of a flat-ended glass rod. It was found that the rate of oxidation was not significantly different from that obtained with similar material well teased out. This was to be expected since under such compression the overall specific volume of the

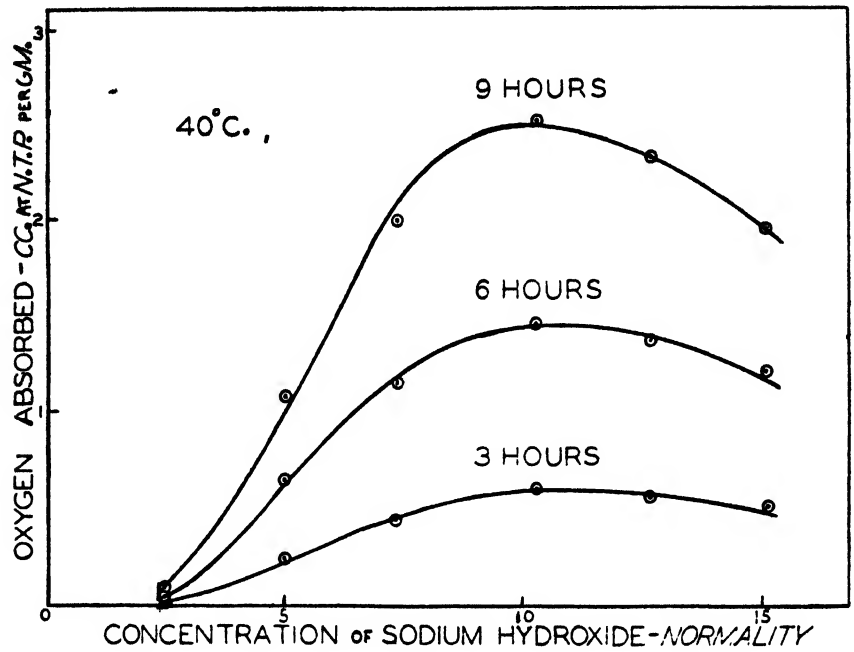


FIG. 6

Table II.

40° C. Cotton 103R, acid-washed. Purified Sodium Hydroxide.

Concentration of sodium hydroxide solution (normality).	Mean Pressure of oxygen (mm. of mercury).	Volume of oxygen absorbed at completion of experiment (cc. at N.T.P. per gram.)	Duration of experiment (hours).	Fluidity of resultant oxycellulose.	Volume of oxygen (cc at N.T.P. per gm.) absorbed in		
					3 hours	6 hours	9 hours
2·50	697	0·34	25·5	13·3	0·02	0·05	0·09
5·00	698	1·32	10·8	30·9	0·24	0·64	1·07
7·37	703	2·28	10·0	39·7	0·44	1·16	2·01
10·33	711	2·93	10·2	45·9	0·58	1·46	2·51
12·72	707	2·63	10·0	45·4	0·55	1·37	2·32
15·20	726	2·21	10·0	41·8	0·50	1·20	1·95

soda cellulose is still considerably greater than the true specific volume; it should therefore be easy for the oxygen to penetrate between the swollen cotton hairs.

(c) Oxidation at 60° C

Similar data obtained with the same materials on oxidation at 60° C. are shown in Table III and Figs. 7 and 8. The absorption is much more rapid than at 40° C., but the results are similar. Here also a well-defined maximum in the rate of absorption of oxygen is obtained with about 10*N* sodium hydroxide solution.

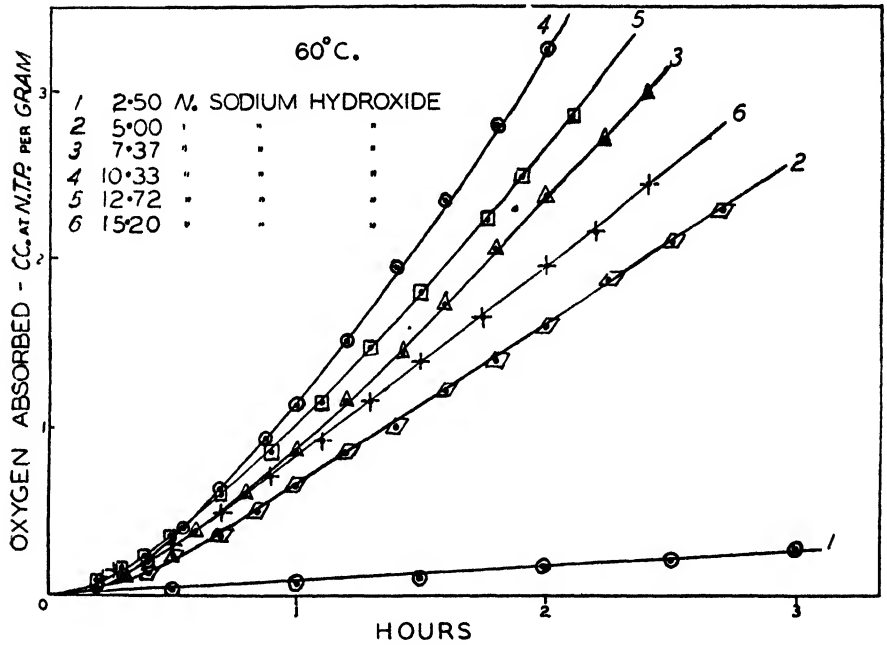

60°C.
1 2·50 N. SODIUM HYDROXIDE
2 5·00 " " "
3 7·37 " " "
4 10·33 " " "
5 12·72 " " "
6 15·20 " " "
OXYGEN ABSORBED - CC. AT N.T.P. PER GRAM
HOURS
0
1
2
3
4
5
6

FIG. 7

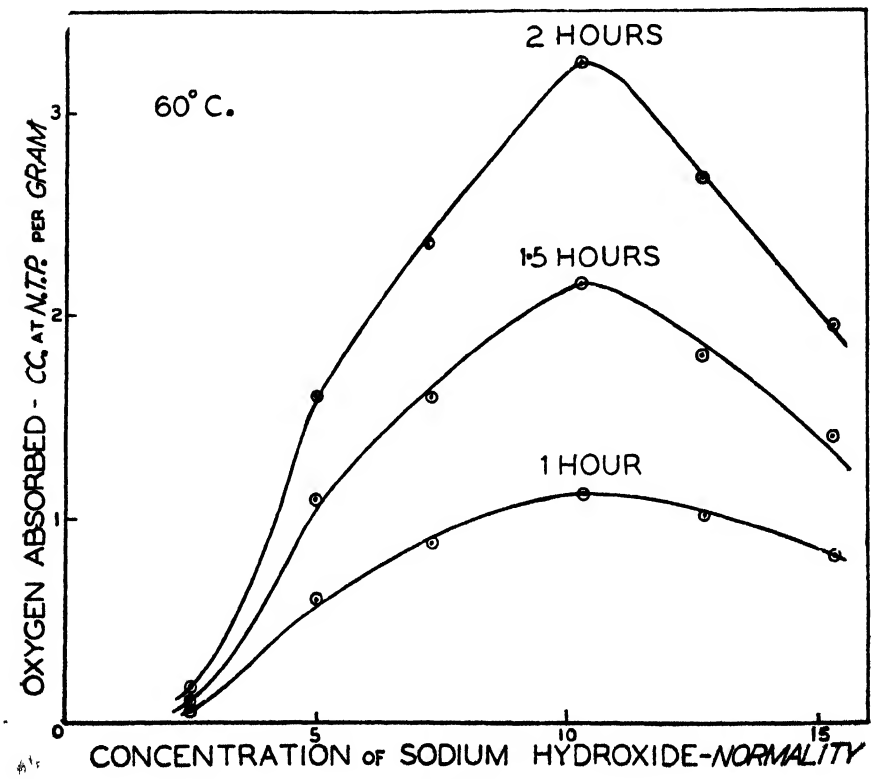

2 HOURS
60° C.
1·5 HOURS
1 HOUR
OXYGEN ABSORBED - CC. AT N.T.P. PER GRAM
0
5
10
15
CONCENTRATION OF SODIUM HYDROXIDE-NORMALITY

FIG. 8

Table III.

60° C. Cotton 103R, acid-washed. Purified Sodium Hydroxide.

Concentration of sodium hydroxide solution (normality)	Mean Pressure of oxygen (mm. of mercury)	Volume of oxygen absorbed at completion of experiment (cc. at N.T.P. per gm.)	Duration of experiment (hours)	Fluidity of resultant oxycellulose	Volume of oxygen (cc. at N.T.P. per gm.) absorbed in		
					1 hour	1·5 hours	2 hours
2·50	634	0·96	6·8	22·2	0·06	0·10	0·17
5·00	627	2·35	2·73	37·6	0·64	1·10	1·60
7·37	649	3·05	2·43	45·3	0·87	1·60	2·37
10·33	674	3·28	2·03	46·8	1·13	2·16	3·23
12·72	696	2·89	2·13	46·6	1·02	1·81	2·67
15·20	711	2·47	2·43	43·7	0·82	1·38	1·96

(d) Discussion of Results

The rate of oxidation of soda cellulose is probably due to the combined effects of four separate factors, *viz.* (1) the reactivity of the cellulose, which is known to be increased by swelling treatments; (2) the concentration of sodium hydroxide in the cellulose phase; (3) the solubility of oxygen in soda cellulose; (4) the rate of diffusion of oxygen in soda cellulose. These factors might be expected to lead to curves of the shape found when rate of oxidation is plotted against concentration of sodium hydroxide, the increase in the rate of oxidation up to a concentration of 10*N* being explained as due to the increase of reactivity that takes place at the onset of swelling (about 3*N*), and to the progressive increase in the concentration of sodium hydroxide in the soda cellulose. Meanwhile, the solubility and rate of diffusion of oxygen probably decrease gradually as the alkali concentration increases, and at concentrations above 10*N*, they become the predominant factors, and so produce a diminution of the rate of oxidation.

The magnitudes of the solubility and diffusion coefficients of oxygen in soda cellulose in relation to the rate of consumption of oxygen determine whether the oxidation is uniform throughout the material. Since oxygen has to diffuse into the soda cellulose to replace that consumed by the oxidation, there must theoretically be an oxygen concentration gradient between the outside and the centre of the cotton hairs, and hence a corresponding variation in the rate of oxidation. If the diffusion process is sufficiently rapid, however, this difference in concentration, when a steady state has been reached, will be negligible. Hill[14] has discussed mathematically a process very similar to the oxidation of soda cellulose, *viz.*, the diffusion of oxygen into tissues in which it is being used up at a constant rate by metabolic processes. He points out that for systems of small dimensions such as single nerve fibre 7μ thick, and with diffusion coefficients of the order of magnitude of those found for crystalloids in aqueous solutions, the process of diffusion is an extremely rapid one; for example, he calculates that if such a nerve fibre were suddenly placed in oxygen, it would attain 90 per cent. of its full saturation with that gas in 0·0054 second. Where oxygen diffuses from a gaseous phase in which its concentration is maintained constant, into a cylindrical solid in which it is used up at a constant rate by metabolic processes, the fraction f of the full saturation amount actually dissolved when the steady state has been reached is given by the equation :

$$f = 1 - ar^2/8ky_0$$

where a is the rate of consumption of oxygen (cc. at N.T.P. per cc. of tissue per min.), r is the radius of the cylinder (cm.), k is the diffusion coefficient (cm.^{2}/min.), and y_0 is the solubility of oxygen (cc. at N.T.P. per cc. of tissue). At 20° C., for a resting frog's muscle, $a = 7 \times 10^{-4}$, $k = 4{\cdot}5 \times 10^{-4}$, $y_0 = 0{\cdot}031$ for an oxygen pressure of 1 atmosphere; hence for a cylinder of the radius of a swollen cotton hair (about 10^{-3} cm.), $f = 1 - 6{\cdot}3 \times 10^{-6}$, i.e., the gradient is negligible. Unfortunately, since the solubility and the diffusion coefficient of oxygen in soda cellulose, or even concentrated sodium hydroxide solutions, are not known, it is impossible to apply the formula to the oxidation of soda cellulose. It is known that crystalloids diffuse almost as fast in concentrated gels as in water, so that the diffusion coefficient of oxygen in soda cellulose is probably not less than one tenth of that in water. The sole data found for the solubility of oxygen in sodium hydroxide solutions extend only to $2N$ solution, but the decrease of solubility with increasing alkali concentration within this range suggests that in soda cellulose made with concentrated solutions, the solubility of oxygen is very considerably less than in water. Nevertheless, the margin of safety is so large in the above example, that it seems probable that even for the maximum rate of oxidation, which at 40° C. is about 4 times that used in the calculation, the concentration gradient can be neglected.

Table IV.

Cotton 103R, acid-washed. Purified Sodium Hydroxide.

Concentration of sodium hydroxide solution (normality)	Rate of absorption of oxygen (c.c. at N.T.P. per gm. per hour)			Temperature coefficient per 10° C.	
	20° C.	40° C.	60° C.	20°-40° C.	40°-60° C.
2·50	—	0·016	0·197	—	3·51
5·00	0·017	0·143	1·00	2·90	2·64
7·37	—	0·283	1·58	—	2·36
10·33	0·042	0·350	2·14	2·89	2·47
12·72	—	0·317	1·72	—	2·33
15·20	—	0·250	1·16	—	2·16

In support of this conclusion, the temperature coefficient of the oxidation of soda cellulose is of a magnitude characteristic of chemical reactions, and greater than that ever found for diffusion. In Table IV, the rates of oxygen absorption, when the rate had become constant, are given for the various temperatures and concentrations employed together with the derived temperature coefficients. The latter are all greater than 1·5, which is about the limit for diffusion processes, so that they indicate that diffusion is not the predominant factor in determining the rate of oxidation. As the temperature increases, the partial pressure of oxygen for a given concentration of sodium hydroxide decreases owing to the increase of the vapour pressure, and the solubility coefficient of oxygen also decreases; hence if rates could be compared for equal concentrations of oxygen in the soda cellulose, the temperature coefficients would be rather higher than those given. The table shows that the temperature coefficient decreases as the concentration of sodium hydroxide increases, until at 15·2N it is 2·16. This suggests that at the highest concentrations, diffusion may begin to exert an influence on the rate of reaction, and this suggestion is supported by two further observa-

tions. In the first place, with 15·2*N* sodium hydroxide solution, the rate of oxidation is at first about as fast as with 10·3*N* solution, but the increase of rate due to consecutive reactions is much less than with the latter (cf. Figs. 5 and 7). Secondly, as will be shown in Section V, the rate of oxidation of soda cellulose prepared with 15·2*N* solution cannot be much increased by a catalyst that has a great effect at lower concentrations. Both these observations suggest that at the beginning of the reaction the oxidation is proceeding almost as fast as the rate of diffusion of oxygen will allow.

Weltzien and zum Tobel[28,29] found maximum rates of oxidation at concentrations of about 6·5*N* and 8·5*N* for soda celluloses prepared from cotton yarn and cuprammonium rayon respectively. Their curves are not strictly comparable with those in Fig. 8, since they measure the rate of oxidation by the absorption in 24, 48 and 72 hours, and the highest absorptions shown in Fig. 8 are those in 2 hours. If, however, Weltzien and zum Tobel's results for 24 hours are divided by 12, comparison with those for 2 hours in Fig. 8 shows that their absorptions at low concentrations are much greater, and at high concentrations much less, than those found in the present work. A possible explanation of this discrepancy is to be found in the inadequacy of their experimental technique. In their apparatus the bulb containing the soda cellulose was at 60°C., while the gas measuring apparatus was at room temperature. In order to prevent distillation of water from the soda cellulose into the gas measuring apparatus the bulb was surmounted by a condenser. As a result of this arrangement there would always be a certain amount of moisture from the soda cellulose condensed in the condenser, and, consequently, the concentration of sodium hydroxide on the cotton would always be higher than it was supposed to be; this provides at least a partial explanation of the differences found.

V—THE CATALYTIC EFFECT OF IRON

(a) Introductory

In the first experiments a soda-boiled cotton in the form of sliver ($73R_2$) was used without previous treatment. This cotton had not been acidified after soda-boiling, and therefore contained both iron originally present in the raw cotton, and iron introduced during soda-boiling in an iron kier. It was found that acid-washing, which removed most of the iron, considerably reduced the rate of oxidation of soda cellulose made from the cotton, and hence the importance of the iron content of the cotton was recognised. This effect had been previously observed by Wilson[10,21], who states that the addition of 0·1 per cent. of ferrous oxide increases the rate of air oxidation of soda cellulose four-fold.

During the oxidation at 40° C. of soda cellulose made from cotton to which ferric hydroxide had been added in sufficient quantity to colour the soda cellulose, it was noticed that with concentrations of sodium hydroxide of 10*N* and upwards, the colour due to the ferric hydroxide gradually disappeared, leaving the soda cellulose white. This was evidently due to solution of the ferric hydroxide in the sodium hydroxide solution. Löw[18], and van Bemmelen and Klobbie[1] observed that hot concentrated sodium hydroxide solutions dissolved appreciable quantities of ferric hydroxide, while Zirnité[33] found that on passing a current of air into a hot concentrated solution of sodium hydroxide containing ferric hydroxide in suspension, an appreciable quantity of iron passed into solution without colouring the liquid.

This he attributed to the formation of sodium ferrate. Haber[18] has shown, however, that the substance formed is in the same state of oxidation as ferric hydroxide, and terms it sodium ferrite, $NaFeO_2$. A characteristic reaction of solutions of sodium hydroxide containing sodium ferrite, according to Haber, is that they give a red coloration with sodium sulphide ; soda cellulose containing ferric hydroxide which had been decolorised by keeping at 40° C. responded to this test. If the decolorised soda cellulose is washed with water, the brown colour of ferric hydroxide gradually returns, evidently due to hydrolysis of the ferrite. That oxygen is not essential to this solution of ferric hydroxide in concentrated caustic soda solution was shown by keeping the soda cellulose, coloured by ferric hydroxide, in an atmosphere of nitrogen at 40° C., when decolorisation took place as before.

A solution containing 6·70 mg. of iron per 100 gm. of sodium hydroxide was prepared by adding a few drops of ferric chloride solution to 100 cc. of 15·2*N* sodium hydroxide solution, keeping the solution at 40° C. for 24 hours, and filtering through a fritted glass filter. This solution was colourless, and gave a deep red coloration with 20 per cent. sodium sulphide solution. When cotton was immersed in it, it was noticed that much of the iron was adsorbed by the cotton. This observation suggested that small amounts of iron in the sodium hydroxide solutions used to make soda cellulose might be very important when concentrated on the cotton in this way, and experiments showed that after acid-washed cotton had been steeped in concentrated solutions of sodium hydroxide made from " purified sticks," it contained an easily detectable quantity of iron. As a result of quantitative experiments, in which 1gm. of cotton was steeped for half an hour in about 50 cc. of 15*N* solution made from " purified sticks " containing 0·70 mg. iron per 100 gm., it was found that about 50 per cent. of the iron present was adsorbed by the cotton. The considerable effect of the iron content of the sodium hydroxide used in preparing soda cellulose on its rate of oxidation will be shown in the sequel.

(b) Variation of the Rate of Oxidation of Soda Cellulose with its Iron Content

In order to find how the rate of oxidation of soda cellulose varied with the iron content, a series of experiments was made in which soda celluloses, prepared from cotton to which various amounts of ferric hydroxide had been added, were oxidised at 40° C. The concentration of sodium hydroxide was 10·33*N* in all the experiments. The iron was added by steeping the cotton in a solution of ferrous sulphate of suitable concentration and *N*/10 in sulphuric acid, and centrifuging. The cotton was then steeped in *N*/5 sodium hydroxide solution, exposed to the air for a few minutes to allow the ferrous hydroxide to be oxidised to the ferric state, and then thoroughly washed with distilled water.

The results obtained are given in Table V, while Fig. 9 shows how the absorption of oxygen per gm. of cotton in 3 and 6 hours varies with the iron content. A small correction to the iron content of the cotton is made for the iron adsorbed from the sodium hydroxide solution, on the assumption that 50 per cent. of the iron present in the solution is adsorbed.

The results show that the rate of oxidation of soda cellulose increases rapidly with increasing iron content when the iron content is small, but that the effect of further addition gradually becomes less and less. The steepness of the curves at low iron contents suggests that if total absence of iron could be obtained, the rate of the oxidation might be still further reduced.

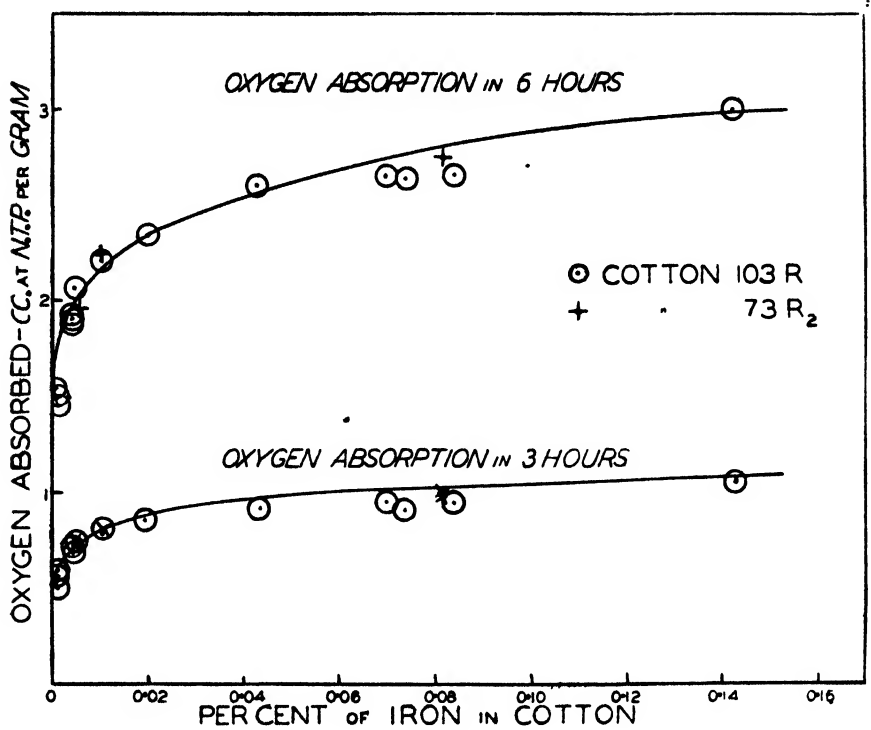
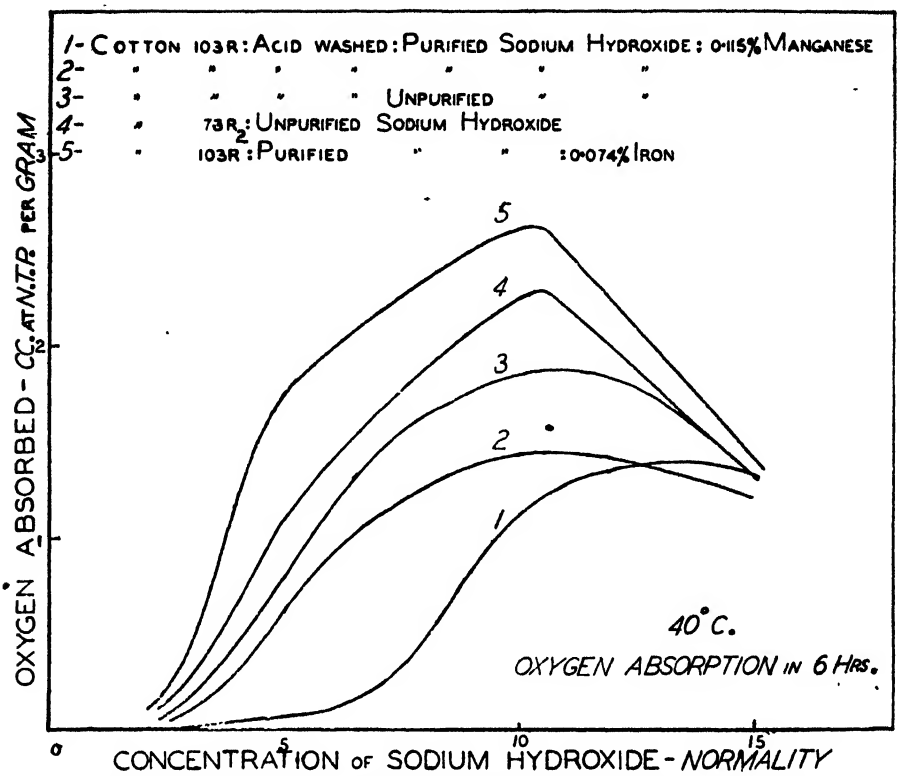


FIG. 9

Table V.

40° C. 10·33 *N* Sodium hydroxide solution.

Cotton	% Iron	Volume of oxygen absorbed at completion of experiment (cc. at N.T.P. per gm.)	Duration of experiment (hours)	Fluidity of resultant oxy-cellulose	Volume of oxygen (cc. at N.T.P. per gm.) absorbed in	
					3 hours	6 hours
103R	0·0010	2·23	8·0	41·2	0·50	1·51
	0·0010	3·03	10·0	47·4	0·54	1·51
	0·0010	1·62	6·2	39·7	0·55	1·54
	0·0012	2·93	10·2	45·9	0·58	1·46
	0·0040	3·17	9·0	52·3	0·69	1·88
	0·0040	2·35	7·0	48·7	0·72	1·92
	0·0040	1·69	5·5	45·3	0·69	1·90
	0·0044	2·31	6·5	45·4	0·75	2·07
	0·0117	2·41	6·4	47·4	0·81	2·21
	0·0192	2·34	6·0	47·4	0·85	2·34
	0·043	2·79	6·3	49·8	0·92	2·60
	0·070	2·34	5·5	46·6	0·94	2·65
	0·074	2·94	6·5	50·6	0·92	2·64
	0·084	2·84	6·3	41·2	0·94	2·65
	0·143	3·00	6·0	49·8	1·04	3·00
$73R_2$	0·0048	2·56	7·4	—	0·72	1·96
	0·011	2·80	7·1	47·2	0·77	2·23
	0·082	0·99	3·0	—	1·00	—
	0·082	3·01	6·5	—	0·98	2·74



Curve 1, cf. Table XIV; curve 2, cf. Table II; curve 3, cf. Table VII; curve 4, cf. Table IX; curve 5, cf. Table VI.

FIG. 10

(c) The Effect of Added Iron with Various Concentrations of Sodium Hydroxide

In order to find the catalytic effect of a given iron content on the rate of oxidation of soda cellulose for different concentrations of sodium hydroxide experiments were made in which samples of cotton 103R to which had been added 0·074 per cent. iron were impregnated with sodium hydroxide solutions of various concentrations, and oxidised at 40° C. The results are given in Table VI, and the absorptions in 6 hours are included in Fig. 10. The

Table VI.

40° C. Cotton 103R, iron content = 0·074%

Concentration of sodium hydroxide solution (normality)	Mean Pressure of oxygen (mm. of mercury)	Volume of oxygen absorbed at completion of experiment (cc. at N.T.P. per gm.)	Duration of experiment (hours)	Fluidity of resultant oxycellulose	Volume of oxygen (cc. at N.T.P. per gm.) absorbed in	
					3 hours	6 hours
2·50	686	2·21	25·6	35·4	0·07	0·20
5·00	711	1·98	6·5	41·8	0·58	1·76
7·37	705	2·50	6·5	46·0	0·73	2·23
10·33	717	2·94	6·5	50·6	0·92	2·63
12·72	713	2·28	6·5	46·6	0·76	2·06
15·20	713	1·54	6·5	41·3	0·58	1·39

effect of the iron is relatively greatest at the low concentrations of sodium hydroxide, and causes the maximum in the rate of absorption-concentration curve (Fig. 10) to be more pronounced than it is with purified materials.

As previously mentioned, with solutions of concentrations of 10·33*N* and upwards the brown colour imparted to the soda cellulose by the ferric hydroxide ultimately disappeared during the oxidation. This has been shown to be due to solution of the ferric hydroxide as ferrite in the sodium hydroxide solution, so that during a considerable portion of the time of oxidation the catalyst was sodium ferrite and not ferric hydroxide. In two experiments the soda cellulose made with 10·33*N* solution was kept in an atmosphere of nitrogen at 40° C. until the brown colour had disappeared, and then oxidised in the usual way; the rate of oxidation was found to be the same as when the oxidation was started with the iron present as ferric hydroxide. Thus it appears that at concentrations of 10·33*N* and upwards the catalyst is sodium ferrite and not ferric hydroxide. With lower concentrations of sodium hydroxide, the ferric hydroxide is not completely dissolved during the course of the oxidation. That sodium ferrite, adsorbed from caustic soda solution by acid-washed cotton, has a catalytic effect at these concentrations will be shown in the next sub-section, but it cannot be determined whether the undissolved ferric hydroxide contributes to the effect observed when iron is present in both forms.

(d) Oxidation of Acid-Washed Cotton (103R) Impregnated with Sodium Hydroxide Solutions not Purified from Iron.

A series of experiments was made with acid-washed cotton 103R impregnated with sodium hydroxide solutions prepared from a sample of sodium hydroxide described as " purified sticks," and having an iron content of 0·70 mg. iron per 100gm. of the anhydrous alkali. The solutions used were of the same concentrations as before, and the oxidation was done at 40° and 60° C. The results obtained are given in Tables VII and VIII, while the absorptions in 6 hours at 40° C. and in 1·5 hours at 60° C. are included in Figs. 10 and 11 respectively.

Table VII.

40° C. Cotton 103R, acid washed. Sodium hydroxide not purified from iron.

Concentration of sodium hydroxide solution (normality)	Mean Pressure of oxygen (mm. of mercury)	Volume of oxygen absorbed at completion of experiment (cc. at N.T.P. per gm.)	Duration of experiment (hours)	Fluidity of resultant oxy-cellulose	Volume of oxygen (cc. at N.T.P. per gm.) absorbed in		
					3 hours	6 hours	9 hours
2·50	700	0·87	29·0	25·3	0·02	0·07	0·15
5·00	707	1·97	12·0	38·6	0·26	0·79	1·37
7·37	716	2·61	9·0	47·5	0·55	1·53	2·61
10·33	720	3·18	9·0	52·3	0·69	1·87	3·18
11·48	720	3·23	9·0	50·8	0·72	1·90	3·23
12·72	727	2·64	8·0	42·3	0·69	1·82	(3·05)
15·20	730	2·79	1·15	52·8	0·51	1·30	2·12

(The figure in brackets is extrapolated.)

In these experiments the iron content of the soda cellulose depends on the concentration of the sodium hydroxide solution used in preparing it, since the more dilute solutions contain less dissolved iron than the concentrated.

Table VIII.

60° C. Cotton 103R, acid washed. Sodium hydroxide not purified from iron.

Concentration of sodium hydroxide solution (normality)	Mean Pressure of oxygen (mm. of mercury)	Volume of oxygen absorbed at completion of experiment (cc. at N.T.P. per gm.)	Duration of experiment (hours)	Fluidity of resultant oxycellulose	Volume of oxygen (cc. at N.T.P. per gm.) absorbed in		
					1·0 hour	1·5 hours	2·0 hours
2·50	614	1·93	6·7	31·9	0·10	0·21	0·35
2·50	621	1·38	5·0	26·5	0·11	0·21	0·35
5·00	616	3·23	2·42	44·1	0·92	1·71	2·53
7·37	631	3·44	2·02	47·9	1·41	2·41	3·40
10·33	669	3·43	1·62	49·7	1·73	3·10	(4·48)
12·72	679	3·34	2·02	49·9	1·36	2·34	3·31
15·20	694	2·37	2·22	44·3	0·94	1·53	2·12

(The figure in brackets is extrapolated.)

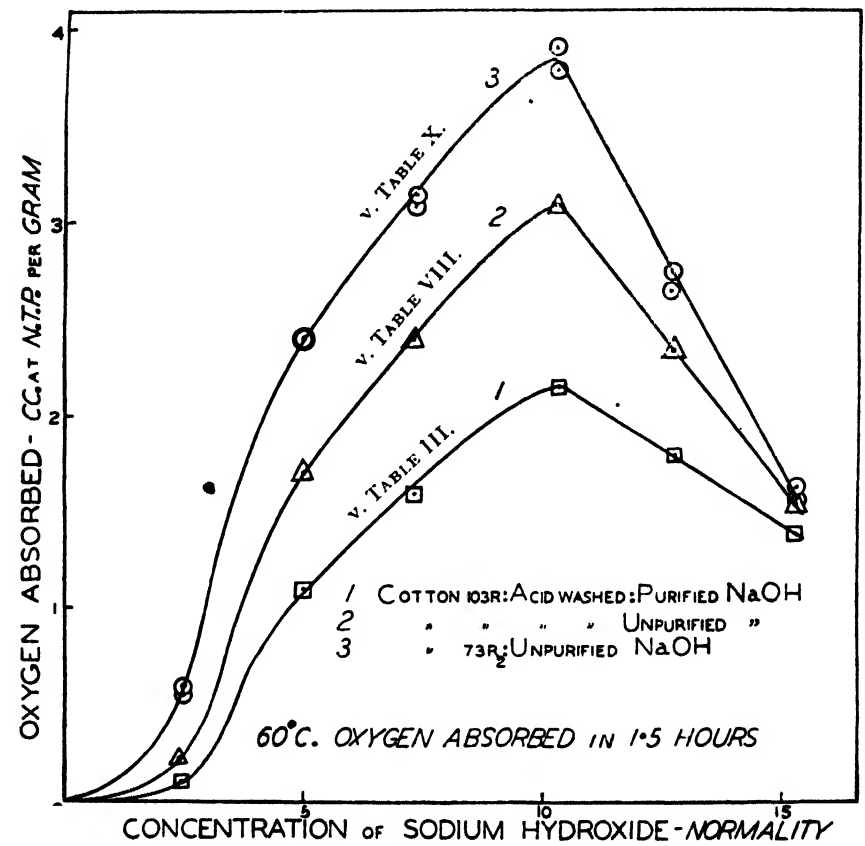


FIG. 11

The catalytic effect of iron is evident at all concentrations, and at both temperatures. At 40° C., the maximum rate occurs at a slightly higher concentration than was found for the purified cotton and sodium hydroxide.

(e) Oxidation of Cotton 73R$_2$ (not acid-washed) Impregnated with Sodium Hydroxide Solutions not Purified from Iron

As previously stated, the first experiments made were with a soda-boiled cotton No.73R$_2$, which had not been acidified after soda-boiling, and sodium hydroxide solutions prepared from "purified sticks," which had not been specially purified from iron. The cotton contained 0·0070 per cent. iron, and the caustic soda 0·70 mg. per 100 gm. The data are included as representative of results obtained when no special precautions are taken to free the materials used from iron. Table IX gives the results of the experiments at 40° C., while Table X gives similar data for 60° C. The absorptions of oxygen in 6 hours at 40° C. and 1·5 hours at 60° C. are included in Figs. 10 and 11 respectively.

Table IX.

40° C. Cotton 73R$_2$. Sodium hydroxide not purified from iron.

Concentration of sodium hydroxide solution (normality)	Mean Pressure of oxygen (mm. of mercury)	Volume of oxygen absorbed at completion of experiment (cc. at N.T.P per gm.)	Duration of experiment (hours)	Fluidity of resultant oxycellulose	Volume of oxygen (cc. at N.T.P. per gm.) absorbed in		
					3 hours	6 hours	9 hours
2·50	700	1·93	33·0	34·1	0·10	0·22	0·37
2·50	674	1·54	30·0	31·4	0·09	0·19	0·33
5·00	705	2·69	11·5	41·9	0·42	1·10	1·95
5·00	688	2·00	9·2	39·6	0·40	1·12	1·95
7·37	696	2·63	8·0	42·6	0·65	1·81	(3·05)
7·37	693	2·87	9·0	42·1	0·58	1·66	2·87
10·33	726	3·38	8·0	47·2	0·85	2·31	(3·91)
10·33	726	3·35	8·0	47·3	0·86	2·33	(3·89)
12·72	710	2·63	8·0	—	0·65	1·80	(3·04)
12·72	729	2·67	8·0	48·1	0·67	1·84	(3·07)
15·20	716	2·14	9·0	41·6	0·51	1·32	2·14
15·20	715	1·86	8·0	42·4	0·55	1·33	(2·13)

(The figures in brackets are extrapolated.)

Table X.

60° C. Cotton 73R$_2$. Sodium Hydroxide not purified from iron.

Concentration of sodium hydroxide solution (normality)	Mean Pressure of oxygen (mm. of mercury)	Volume of oxygen absorbed at completion of experiment (cc. at N T.P. per gm.)	Duration of experiment (hours)	Fluidity of resultant oxycellulose	Volume of oxygen (cc. at N.T.P. per gm.) absorbed in		
					1·0 hour	1·5 hours	2·0 hours
2·50	615	1·85	3·25	32·6	0·29	0·58	0·94
2·50	614	3·29	5·25	—	0·27	0·54	0·87
5·00	636	3·54	2·05	44·4	1·36	2·40	3·44
5·00	626	3·57	2·05	—	1·34	2·39	3·46
7·37	648	3·43	1·63	46·3	1·80	3·08	(4·38)
7·37	643	3·49	1·63	—	1·85	3·14	(4·43)
10·33	675	3·70	1·43	49·1	2·30	(3·92)	(5·51)
10·33	670	3·56	1·43	—	2·17	(3·78)	(5·40)
12·72	688	3·49	1·83	48·0	1·65	2·75	(3·86)
12·72	688	3·40	1·83	—	1·58	2·66	(3·77)
15·20	705	3·36	3·03	42·1	0·95	1·56	2·15
15·20	715	3·43	2·93	—	1·00	1·63	2·25

(The figures in brackets are extrapolated.)

The effect of the extra iron in the cotton is to increase the rates of absorption at both 40° and 60° C. over those observed with acid-washed cotton 103R, and the same sodium hydroxide. At 40° C., the two curves are almost coincident at the highest concentrations (Fig. 10), while at 60° C. the increase in rate at these concentrations is small.

(f) The Effect of the Iron Content of the Sodium Hydroxide

In Table XI are collected the data obtained from the oxidation at 40° C. of soda cellulose made from acid-washed cotton (103R) and 10·33*N* sodium hydroxide solutions prepared from samples of sodium hydroxide of various iron contents. The results show the importance of small amounts of iron in the caustic soda used for the preparation of soda cellulose.

Table XI.

40° C. Cotton 103R, acid washed. 10·33 *N* sodium hydroxide solution.

Description of sodium hydroxide	Iron content of sodium hydroxide mg./100 gm.	Mean Pressure of oxygen (mm. of mercury)	Volume of oxygen (cc. at N.T.P. per gm.) absorbed in		
			3 hours	6 hours	9 hours
Purified from iron in laboratory ...	0·09	711	0·58	1·46	2·51
" From sodium "	0·51	709	0·66	1·74	—
" Purified sticks "	0·70	720	0·69	1·87	3·18
Contained added iron	6·70	700	0·87	2·49	—
	6·70	720	0·85	2·43	—

(g) Estimation of Iron

The iron content of the sodium hydroxide solutions was determined by the colorimetric method with thioglycollic acid, developed by Jones.[16] It is expressed in mg. of iron per 100 gm. of the anhydrous substance. With the purified solutions, the iron content was too small to be determined directly in the solution obtained by neutralising the sodium hydroxide solution with 20 per cent. hydrochloric acid solution, so it was necessary to concentrate the iron before estimation. Three cc. of a solution of ammonium alum containing 1 gm. Al_2O_3 per litre was added to the neutralised solution, and the aluminium and ferric hydroxides precipitated by the addition of ammonia. The precipitate was filtered off, washed and dissolved in iron-free hydrochloric acid, and the usual procedure for the determination of iron by the thioglycollic acid method continued. As the final solutions for colorimetric comparison contain ammonia, the aluminium was precipitated and interfered somewhat with the comparison. In order to avoid this difficulty, the solution was centrifuged and an aliquot part of the supernatant liquid pipetted out for comparison with the standard iron solution. The validity of this procedure was confirmed by means of experiments with known quantities of iron.

The iron content of the cotton samples was determined by one of two different methods according to its magnitude. If the cotton contained more than 0·005 per cent. iron, the iron content was determined by the method described by Ridge, Parsons and Corner,[22] in which the iron solution, reduced to the ferrous state by means of magnesium, is titrated with *N*/50 potassium dichromate solution in a micro-titration apparatus, diphenylamine being used as an internal indicator. When the iron content was less than

0·005 per cent., it was determined by the colorimetric method with thioglycollic acid.

As stated by Haber,[18] concentrated solutions of sodium hydroxide containing sufficient iron dissolved as ferrite, give a deep red coloration with concentrated sodium sulphide solutions. If the iron content is small as it is in sodium hydroxide solutions not containing added iron, the coloration obtained is golden yellow, and this provides a good test for iron in sodium hydroxide solutions when other heavy metals are absent. Sodium hydroxide solution purified from iron as previously described gave only an extremely faint coloration. The reaction has also been used as a quantitative test, by comparing the colour given by the solution of unknown iron content with that obtained by adding a known amount of a standard ferric ammonium sulphate solution to the purified sodium hydroxide solution. The results obtained agreed well with those found by the thioglycollic acid method, but the method has the disadvantages that the sodium hydroxide must be in the form of a clear concentrated solution, and that the iron content of the purified solution must be determined by another method.

VI—THE CATALYTIC EFFECT OF NICKEL

The effect of the presence of nickelous hydroxide on the rate of oxidation of soda cellulose was determined at 40° C., with soda cellulose prepared from acid-washed cotton (103R) containing 0·07 per cent. nickel, and 5·0*N* sodium hydroxide solution made from purified sodium hydroxide. The nickel was added by steeping a weighed amount of cotton in a solution of nickel sulphate ($NiSO_4.7H_2O$) of known concentration, centrifuging until about 50 per cent. of solution was retained, weighing and air-drying. The amount of nickel on the cotton was calculated from the weight of solution retained, on the assumption that there was no preferential absorption of nickel, and is therefore to be regarded as approximate. The rate of absorption of oxygen by soda cellulose containing nickelous hydroxide is given in Table XII, and compared with the rate for purified materials. The curve for one of the experiments is included in Fig. 12. The

Table XII.

40° C. 5·0 *N* Sodium hydroxide solution. Cotton 103 R.

% Nickel	Mean Pressure of oxygen (mm. of mercury)	Volume of oxygen absorbed at completion of experiment (cc. at N.T.P. per gm.)	Duration of experiment (hours)	Fluidity of resultant oxy-cellulose	Volume of oxygen (cc. at N.T.P. per gm.) absorbed in	
					3 hours	6 hours
0	698	1·32	10·8	30·9	0·24	0·64
0·07	681	1·23	6·5	33·2	0·42	1·12
0·07	698	1·25	6·6	35·9	0·43	1·10

results show that nickel has a considerable catalytic effect on the oxidation, although much less than that of an equal amount of iron under similar conditions.

VII—THE CATALYTIC EFFECT OF COPPER

The effect of copper on the rate of oxidation of soda cellulose was determined under conditions similar to those used for nickel. The copper

was added to the cotton by steeping the latter in a solution of copper sulphate, centrifuging and steeping in $N/5$ sodium hydroxide solution to precipitate the cupric hydroxide. The cotton was then washed with distilled water and air-dried. The copper content was determined by the micro-method described by Brownsett, Farrow and Neale[8], which depends on the catalytic effect of traces of copper on the reaction between sodium thiosulphate and hydrogen peroxide.

Cupric hydroxide is soluble in concentrated sodium hydroxide solutions to an extent that depends on the concentration of the alkali. It is therefore probable that some, at least, of the cupric hydroxide on the cotton is dissolved in the $5{\cdot}0N$ sodium hydroxide solution during steeping. It has been observed, however, that copper hydroxide dissolved in concentrated caustic soda solution is very strongly adsorbed by cotton, so it is unlikely that much copper is lost during the preparation of the soda cellulose.

The results obtained for the rate of oxidation of soda cellulose in the presence of 0·076 per cent. copper are given in Table XIII, and one curve showing the course of the absorption is included in Fig. 12. The catalytic effect is less than that of nickel in the early stages of the oxidation, but the increase of rate of absorption due to consecutive reactions is greater than that with nickel, so that the catalytic effect of copper ultimately becomes the greater.

Table XIII.

40° C. Cotton 103R. 5·0 *N* Sodium hydroxide solution.

% Copper	Mean Pressure of oxygen (mm. of mercury)	Volume of oxygen absorbed at completion of experiment (cc. at N.T.P. per gm.)	Duration of experiment (hours)	Fluidity of resultant oxy-cellulose	Volume of oxygen (cc. at N.T.P. per gm.) absorbed in	
					3 hours	6 hours
0	698	1·32	10·8	30·9	0·24	0·64
0·076	702	1·39	7·0	35·5	0·31	1·09
0·076	698	1·41	6·9	33·7	0·33	1·14

VIII—THE EFFECT OF MANGANESE

Acid-washed cotton (103R) was impregnated with manganous sulphate by steeping in a solution of the latter and centrifuging. It was then immersed in $N/5$ sodium hydroxide solution, exposed to the air for a few minutes, whereby the manganous hydroxide first formed was oxidised to hydrated manganic oxide, MnO(OH). The cotton was then thoroughly washed with distilled water and air dried. The manganese content was determined by the colorimetric method of Willard and Greathouse[10], in which the manganese is oxidised to permanganate by means of potassium periodate.

The rate of oxidation at 40° C. of soda cellulose prepared from cotton containing manganese and purified $5N$ sodium hydroxide solution was determined as for nickel and copper. It was found that instead of accelerating the oxidation, as the other metals had done, manganese had the effect of greatly reducing the rate of absorption of oxygen. For example, the oxygen absorption in 9 hours at 40° C was only about one-twelfth of that in the absence of manganese. In view of this result, further experiments with other concentrations of sodium hydroxide and two samples of cotton

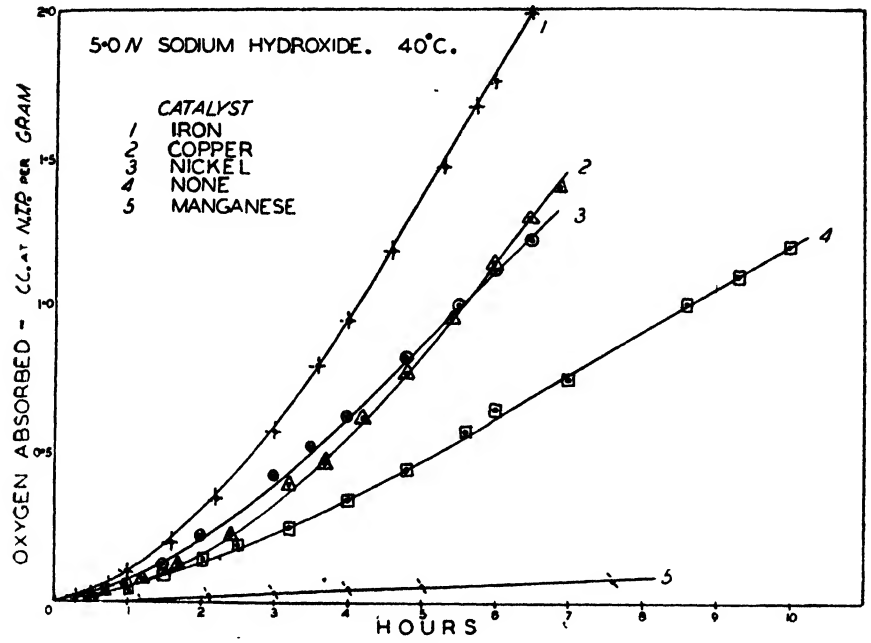

5·0 N SODIUM HYDROXIDE. 40°C.
CATALYST
1 IRON
2 COPPER
3 NICKEL
4 NONE
5 MANGANESE
OXYGEN ABSORBED - CC. AT N.T.P. PER GRAM
HOURS

FIG. 12

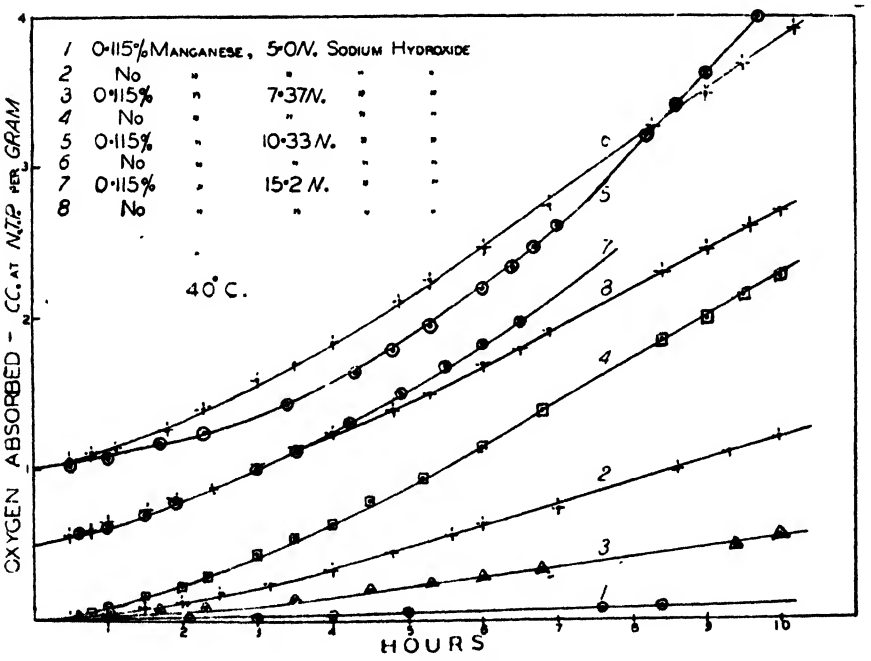

1 0·115% MANGANESE, 5·0N. SODIUM HYDROXIDE
2 No " " " "
3 0·115% " 7·37N. " "
4 No " " " "
5 0·115% " 10·33N. " "
6 No " " " "
7 0·115% " 15·2N. " "
8 No " " " "
40°C.
OXYGEN ABSORBED - CC. AT N.T.P. PER GRAM
HOURS

FIG. 13

TABLE XIV.
40° C. Cotton 103R.

Concentration of sodium hydroxide solution (normality)	% Manganese	Mean Pressure of oxygen (mm. of mercury)	Volume of oxygen absorbed at completion of experiment (cc.at N.T.P. per gm.)	Duration of experiment (hours)	Fluidity of resultant oxycellulose	Copper Number of resultant oxycellulose	Volume of oxygen (cc. at N.T.P. per gm.) absorbed in		
							3 hours	6 hours	9 hours
5·00	0	698	1·32	10·8	30·9	0·23	0·24	0·64	1·07
5·00	0·051	694	0·25	30·3	8·9	0·034	0·02	0·04	0·07
5·00	0·115	716	0·28	45·5	8·4	0·034	0·03	0·07	0·09
7·37	0	703	2·28	10·0	39·7	—	0·44	1·16	2·01
7·37	0·115	712	1·71	25·0	28·4	0·52	0·13	0·28	0·47
10·33	0	711	2·93	10·2	45·9	1·38	0·58	1·46	2·51
10·33	0·051	699	1·64	7·2	43·4	1·58	0·32	1·14	—
10·33	0·115	734	2·97	9·7	45·9	2·03	0·37	1·19	2·63
15·20	0	726	2·21	10·0	41·8	—	0·50	1·20	1·95
15·20	0·051	731	1·57	6·7	38·6	1·33	0·50	1·36	—
15·20	0·115	744	1·46	6·5	36·4	1·10	0·51	1·32	—

TABLE XV
20° C.

Cotton	% Iron in Cotton	Concentration of sodium hydroxide solution (normality)	Mean Pressure of oxygen (mm. of mercury)	Volume of oxygen absorbed at completion of experiment (cc. at N.T.P. per gm.)	Duration of experiment (hours)	Fluidity of resultant oxycellulose	Volume of oxygen (cc. at N.T.P. per gm.) absorbed in		
							12 hours	24 hours	48 hours
$73R_2$	0·0112	10·33	723	2·47	54·0	47·3	0·28	0·77	2·11
103R	0·0010	10·33	731	1·70	53·0	38·5	0·23	0·59	1·49
103R	0·159	10·33	731	2·60	49·0	48·9	0·34	0·92	2·53
103R	0·0008	5·00	719	1·03	78·3	26·2	0·07	0·20	0·51

with different manganese contents were made. The results obtained are given in Table XIV, and the rate of absorption curves for a manganese content of 0·115 per cent. are shown in Fig. 13. There is little difference between the rates of oxidation of cottons with manganese contents of 0·051 per cent. and 0·115 per cent. With 7·37*N* sodium hydroxide solution, the protective action of the manganese is considerable, the absorption in 9 hours in the presence of manganese being only 23 per cent. of that in its absence. At a concentration of 10·33*N* the oxidation is at first slower with manganese present than without it, but as the oxidation proceeds the rate increases until ultimately the manganese exerts a positive catalytic effect. When 15·2*N* sodium hydroxide solution is used in the preparation of the soda cellulose, the presence of manganese has a slight accelerating influence throughout the course of the oxidation.

The absorptions of oxygen in 6 hours at 40° C. by soda cellulose made from the cotton containing 0·115 per cent. of manganese and caustic soda solutions of various concentrations, are also included in Fig. 10.

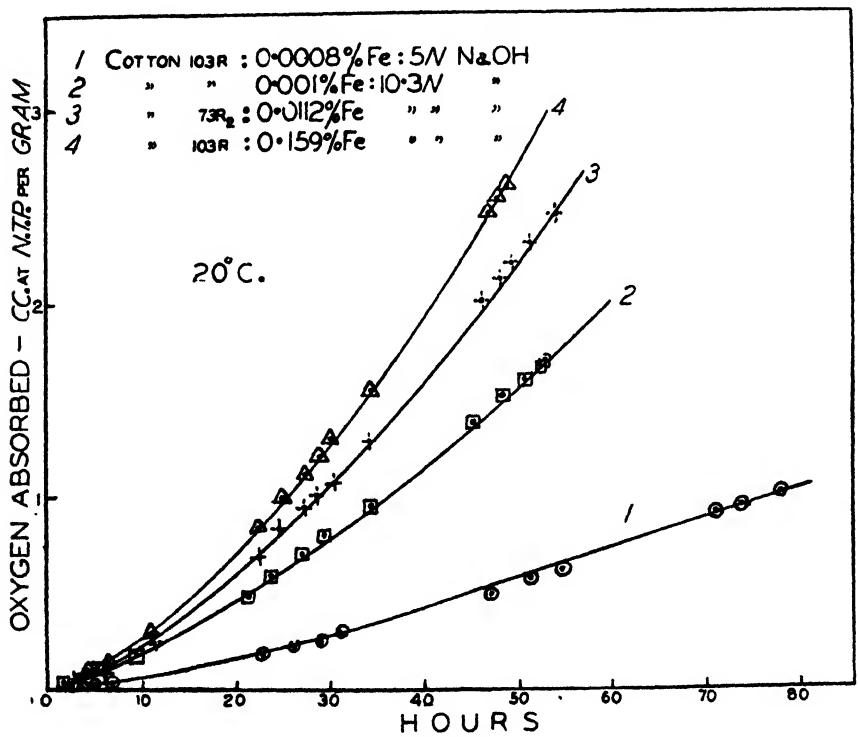


FIG. 14

IX—THE RATE OF OXIDATION OF SODA CELLULOSE AT 20° C.

As the absorption of oxygen by soda cellulose is very slow at the ordinary temperature, few experiments have been done. Table XV and Fig. 14 give the results obtained in several isolated experiments at 20° C. The iron content given is the sum of the iron content of the cotton and the calculated amount of iron absorbed from the sodium hydroxide solution used in preparing the soda cellulose.

The rate of absorption curves show the usual increase of rate near the beginning of the oxidation, and the catalytic effect of iron is well marked. The volume of oxygen absorbed in 48 hours in these experiments is equal to that absorbed in 5-6 hours at 40° C by soda cellulose made from the same materials so that the rate of oxidation at 20° C. is only about one-ninth of that at 40° C.

X—THE EFFECT OF PREVIOUS SWELLING OF COTTON ON ITS RATE OF OXIDATION BY OXYGEN IN THE PRESENCE OF 2.5*N* SODIUM HYDROXIDE SOLUTION

It is well known that cotton that has been treated with sodium hydroxide solution more concentrated than about 3*N*, and then washed and dried, acquires an increased reactivity as regards many properties characteristic of cellulose, such as, for example, absorption of moisture[24,25] and dyestuffs,[17] rate of oxidation by alkaline hypobromite[8], rate of hydrolysis by acids,[23] preferential absorption of sodium[20,26] and barium hydroxides[21], and of copper from dilute solutions of cuprammonium hydroxide[5]. It was therefore thought probable that cotton that had been previously swollen with concentrated sodium hydroxide solution would show an enhanced rate of oxidation by oxygen in the presence of sodium hydroxide solution not sufficiently concentrated to produce swelling, and that the increase of rate of oxidation would vary with the concentration of sodium hydroxide used in the preliminary swelling, as other measures of the reactivity of " swollen " cotton have been found to do.

The effect of previous swelling on the rate of oxidation was investigated with materials prepared as follows. Acid-washed cotton (103R) was steeped in sodium hydroxide solutions of concentrations of 5*N* and upwards for half an hour, washed with 15 per cent. common salt solution to prevent the transient swelling that takes place when cotton in equilibrium with concentrated sodium hydroxide solution is washed with water,[19,20] washed with *N*/10 sulphuric acid to remove traces of iron adsorbed from the sodium hydroxide solution, and finally washed to neutrality with distilled water. After air-drying, the samples were impregnated with 2·5*N* sodium hydroxide solution and oxidised at 60° C. in the usual way. Table XVI gives the results obtained, expressed as the ratio of the volume of oxygen absorbed in

Table XVI.

Concentration of sodium hydroxide in swelling solution (normality)	—	5·00	7·37	10·33	12·72	15·20
Relative rate of oxidation in the presence of 2·5*N* sodium hydroxide solution ...	1·00	2·09	2·20	2·42	2·56	2·51

5 hours by the previously swollen cotton, to the corresponding absorption by the cotton when not previously swollen. The results show that the rate of oxidation by oxygen in the presence of 2·5*N* sodium hydroxide solution is a measure of the reactivity of cotton that has been previously swollen.

Comparison of the results in Table XVI with those in Table III shows that oxidation at 60° C. is much more rapid if cotton is oxidised in the presence of a given concentration of sodium hydroxide, than if it is previously swollen with sodium hydroxide solution of that concentration and then oxidised in

the presence of 2·5*N* solution. For example, in the oxidation of cotton 103R impregnated with 10·33*N* caustic soda solution, 3·23 cc. per gm. are absorbed in two hours ; if the cotton were first swollen with 10·33*N* solution and then oxidised in the presence of 2·5*N* solution, the absorption in the same time would be only about 0·41 cc. per gm., or about one eighth of that under the former conditions.

XI—THE PROPERTIES OF OXYCELLULOSES PREPARED BY OXIDATION OF SODA CELLULOSE BY OXYGEN

In order to investigate the effect on cotton of oxidation by gaseous oxygen in the presence of sodium hydroxide solution, the properties selected for study were the fluidity of solutions of the oxycellulose in cuprammonium hydroxide solution and the copper number. The former was chosen because it provides the most generally useful measure of the degree of chemical modification of cotton, and the latter in order to compare the oxycelluloses with those produced by the action of alkaline hypobromite solutions, for which a theory of consecutive reactions, similar to that suggested in Section III, had already been put forward.[8]

In all the oxidations, when the required absorption of oxygen had taken place the apparatus was removed from the thermostat, and the soda cellulose cooled to room temperature by immersing the bulb in cold water. The soda cellulose was then removed from the bulb and immersed in 100 cc. of 15 per cent. common salt solution. By this procedure the solution of a portion of the modified cellulose, which was found to take place if the soda cellulose was put directly into water, was largely avoided. The oxycellulose was then washed with water, with *N*/10 acid, and finally to neutrality with distilled water. It was then allowed to dry in the air.

(a) Fluidity

The fluidity was determined in 0·5 per cent. solution at 20° C. by the method of Clibbens and Geake[6], and is expressed in absolute units. The fluidities of almost all the samples oxidised during the course of the work have been determined, and have been included in the various tables that record the rates of oxidation. In addition, special experiments at 40° C. were made to determine the relation between the oxygen absorption and the fluidity of the oxycellulose produced. In these experiments, series of oxycelluloses were prepared with oxygen absorptions varying from about 0·5 cc. to about 3 cc. per gm. Such series were prepared from the following materials. (1) Cotton 103R, acid-washed, and sodium hydroxide purified from iron, (2) Cotton 103R, acid-washed, and sodium hydroxide not purified from iron, (3) Cotton $73R_2$, not acid-washed, and sodium hydroxide not purified from iron, and in each case the preparations were duplicated, 5·0*N* and 10·33*N* sodium hydroxide solutions being used in the preparation of the respective soda celluloses. The variation of the fluidity with the oxygen absorption for the various series of oxycelluloses is shown in Table XVII, and also in Figs. 15 and 16. The fluidity—oxygen absorption curve is always steep for small oxygen absorptions, but as the absorption increases the slope of the curve gradually decreases. Cotton oxidised in presence of 10·33*N* sodium hydroxide solution gives a rather higher fluidity for a given oxygen absorption than that oxidised in presence of 5·0*N* solution, and isolated results obtained for a concentration of 2·5*N* show fluidities lower than those for 5*N* solution.

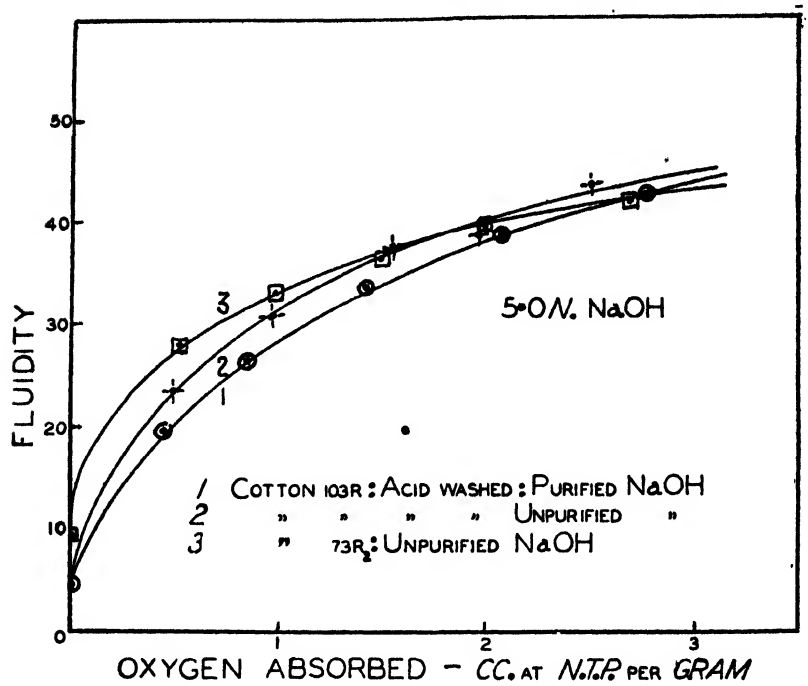


FIG. 15

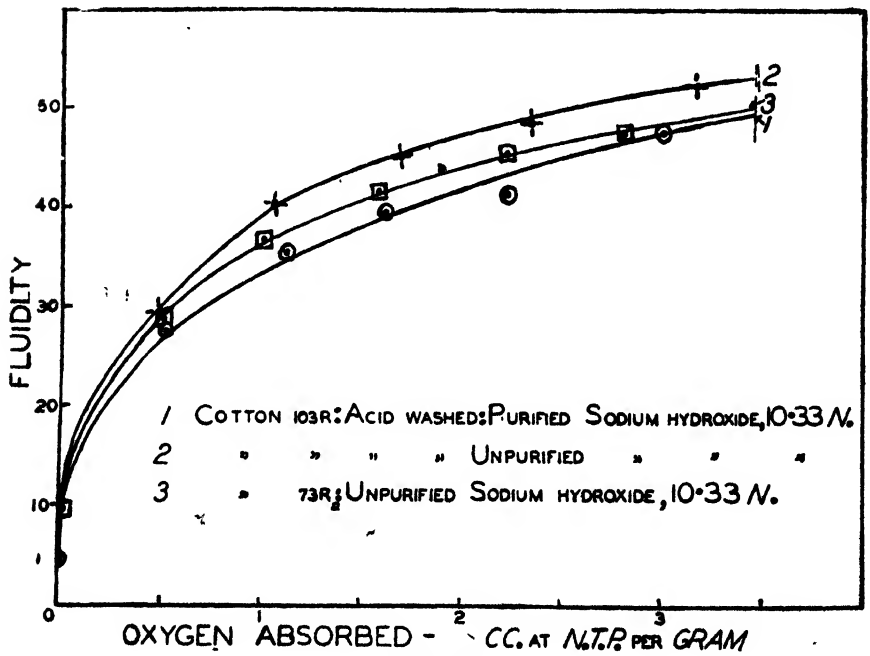


FIG. 16

(b) Copper Number

The oxycelluloses used for the determination of the variation of fluidity with oxygen absorption were also employed for the investigation of the

relation between oxygen absorption and copper number. The copper number was determined by the modification of the Schwalbe-Braidy method described by Heyes[18], 0·25 gm. samples being used. The copper numbers obtained are included in Table XVII, and the variation of copper number with oxygen absorption for the various series of oxycelluloses is shown in Fig. 17. In all the series the copper number rises rapidly at first, but the rate of increase with increasing oxygen absorption gradually falls. The copper number—

Table XVII.

Iron content of cotton (%)	Iron content of sodium hydroxide (mg. per 100 gm.)	Concentration of sodium hydroxide (normality)	Volume of oxygen absorbed (cc. at N.T.P. per gm.)	Time (hours)	Fluidity	Copper number
	Cotton 103R, *acid washed and purified sodium hydroxide.*					
0·00069	0·060		0	—	4·7	0·03
		5·0	0·47	5·3	19·9	0·18
			0·84	8·0	26·3	0·27
			1·42	11·8	33·8	0·29
			2·07	16·2	38·7	0·36
			2·77	20·0	42·7	0·42
		10·33	0·52	3·0	27·4	0·59
			1·12	4·9	35·6	0·89
			1·62	6·2	39·7	1·04
			2·23	8·0	41·2	1·34
			3·03	10·0	47·4	1·57
	Cotton 103R *acid washed and unpurified sodium hydroxide.*					
0·00069	0·70		0	—	4·7	0·03
		5·0	0·50	4·3	23·6	0·33
			0·98	7·0	31·0	0·48
			1·56	9·4	37·8	0·59
			1·97	12·0	38·6	0·65
			2·51	14·2	43·6	0·60
		10·33	0·48	2·4	29·1	0·61
			1·08	4·0	40·6	1·06
			1·69	5·5	45·3	1·49
			2·35	7·0	48·7	1·74
			3·17	9·0	52·3	1·89
	Cotton 73R$_2$ *not acid washed and unpurified sodium hydroxide.*					
0·0070	0·70		0	—	9·5	0·024
		5·0	0·52	3·6	28·0	0·46
			0·99	5·75	33·1	0·51
			1·50	7·6	36·7	0·58
			2·00	9·2	39·6	0·70
			2·69	11·5	41·9	0·79
		10·33	0·50	2·15	28·8	0·90
			1·02	3·7	36·7	1·12
			1·59	4·85	41·8	1·63
			2·23	5·8	45·4	1·82
			2·80	7·1	47·2	1·96

oxygen absorption relation therefore resembles that obtained when cotton is oxidised by alkaline hypobromite[3,4] and the two types of oxidation are also similar in that they both give rise to relatively low copper numbers. Since the shape of the oxygen absorption—copper number curve obtained on oxidising cotton with alkaline hypobromite provided part of the evidence

on which Birtwell, Clibbens, Geake and Ridge[8] based their theory of consecutive reactions, these resemblances give support to the similar theory advanced for the oxidation of soda cellulose by oxygen, deduced in the first instance from the kinetics of the absorption of oxygen.

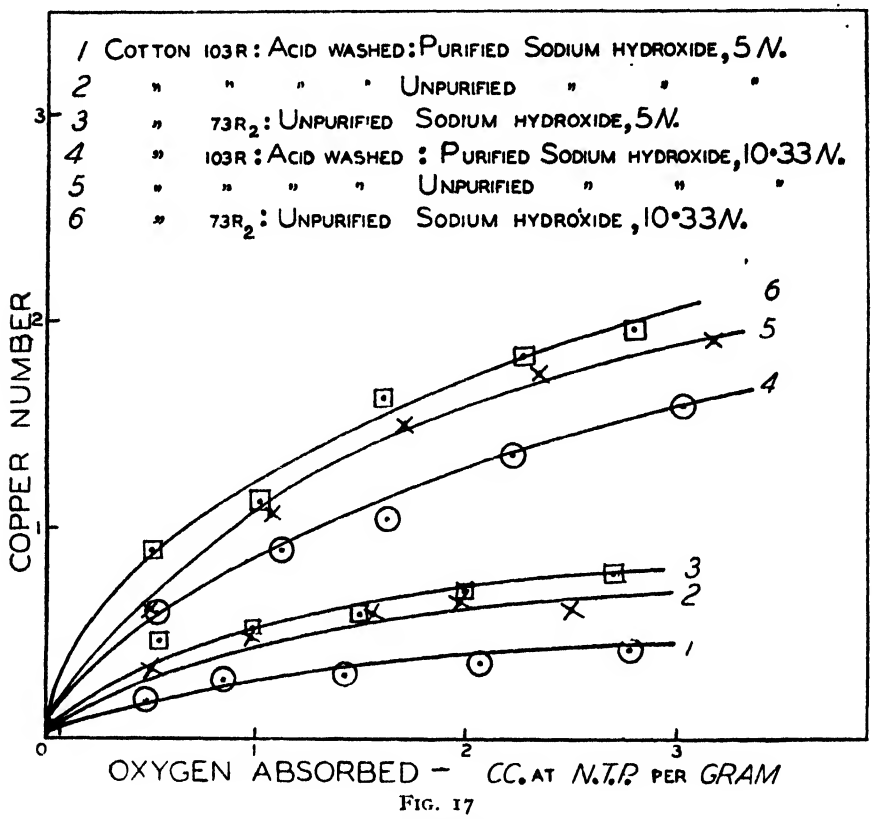


Fig. 17

Fig. 17 shows that the copper number for a given oxygen absorption is considerably lower when 5*N*, than when 10*N*, sodium hydroxide solution is used to prepare the soda cellulose, and that the amount of iron present has also a considerable effect. These differences are presumably due to differences in the relative rates of the consecutive reactions under the various conditions of caustic soda concentration and iron content, which would lead to differences in the proportions in which the total oxygen absorption is distributed among the various reactions.

The copper numbers and fluidities of oxycelluloses prepared by the oxidation of soda celluloses containing manganese are included in Table XIV. When these are compared with the results given in Table XVII it is found that not only does the presence of manganese greatly reduce the rate of oxidation when 5·0*N* caustic soda solution is used, but it also leads to a lower copper number and fluidity for the same oxygen absorption. When 10·33*N* sodium hydroxide solution is used, the copper number for a given oxygen absorption is considerably greater than when manganese is absent, while the fluidity is not much affected. This increase in copper number may be accounted for by the shape of the rate of absorption curves (Fig. 13) obtained when cotton containing manganese is oxidised in the presence of 10·33*N* caustic soda solution, which seems to indicate that the distribution of the total

amount of oxygen absorbed among the various consecutive reactions is different from that in the absence of manganese.

XII—LARGER SCALE PREPARATION OF OXYCELLULOSES BY OXIDATION OF SODA CELLULOSE BY OXYGEN

One of the objects of this work was to discover whether the oxidation of soda cellulose by gaseous oxygen would provide a controllable method for the preparation of oxycelluloses. The results already described have shown that it does, and have indicated the factors which are of importance in determining the rate of oxidation. The next step was therefore to try the oxidation on a larger scale and to measure the properties of the oxycelluloses obtained by oxidation for various times. The preparation of larger samples also permitted the determination of methylene blue absorptions, which was impossible in the work already described owing to lack of material. As has already been indicated, this property is of interest in comparing the oxycellulose obtained by the action of oxygen on soda cellulose, with that obtained by the action of alkaline hypobromite on cotton.

(a) Preparation

It has been shown that the rate of oxidation of soda cellulose depends greatly on the amount of iron present when that amount is small, but that as the iron content is increased, a stage is reached at which the effect of a further increase is small. In order to obtain as uniform oxidation as possible, it was considered advisable to use a cotton with an iron content in this region. The cotton (No. 217, soda boiled, in sliver form) was therefore impregnated with ferric hydroxide by the method previously described, the iron content being 0·101 per cent.

Fifty grams of cotton was steeped in 1,000 cc. of 10*N* sodium hydroxide solution, and centrifuged for 5 minutes whereby the amount of solution retained was reduced to about 260 per cent. The soda cellulose was teased out, and put in a wide-necked bottle of 1,000 cc. capacity. This bottle was provided with a rubber stopper through which passed a glass tube, and on the end of this tube which went inside the bottle, there was a small trap containing mercury. The stopper was then inserted, the bottle tilted so that the end of the inlet tube in the trap was not covered by mercury, and evacuated by the water pump. The inlet tube was closed by a piece of rubber tubing and a screw clip, and the bottle placed upright in a thermostat at 40° C. After 15 minutes, the inlet tube was connected to a gas-holder containing oxygen, and the bottle filled. As oxygen was absorbed by the soda cellulose, it was replaced by the gas bubbling in through the trap from the gas-holder, while the trap prevented evaporation of moisture from the soda cellulose. After oxidation for the required time, the bottle was removed from the thermostat and cooled to room temperature by immersion in cold water. In order to compare the effects of washing-off with water and with 15 per cent. common salt solution, in each experiment the oxidised soda cellulose was divided into two portions and these immersed in 20 times their weight of distilled water and 15 per cent. salt solution respectively. The salt-free washings contained a certain amount of degraded cellulose in solution that could be precipitated by acid, and which increased with the time of oxidation, whilst from the washings containing salt very little material could be precipitated by acidification, even with the most highly oxidised samples. Five oxycelluloses were prepared by this method, with times of oxidation of 1·4, 2·8, 4·2, 5·6, and 7·0 hours respectively.

(b) Properties

The fluidity, copper number and methylene blue absorption of the oxycelluloses prepared as above were determined, and are given in Table XVIII. The copper number was determined by the Schwalbe-Braidy method, the details being as given by Clibbens and Geake[6]; the methylene blue absorption was determined in a neutral buffered solution[7].

Table XVIII.

Time of oxidation (hours)	Washed off with 15% salt solution			Washed off with water		
	Copper Number	Methylene Blue Absorption	Fluidity	Copper Number	Methylene Blue Absorption	Fluidity
0	0·08	1·14	5·9	0·08	1·14	5·9
1·4	0·55	1·17	22·4	0·52	0·99	21·3
2·8	1·04	1·34	32·5	1·00	1·20	31·4
4·2	1·58	1·57	42·0	1·41	1·38	39·3
5·6	1·97	1·79	45·4	—	1·58	44·0
7·0	2·18	1·94	48·9	1·88	1·68	45·7

The fluidity and copper number results are similar to those already given (Table XVII), while the methylene blue absorptions resemble those obtained for oxycelluloses prepared by the action of alkaline hypobromite on cotton[4], in that the absorption increases steadily with increasing oxidation. The effect of washing-off the soda cellulose with water instead of brine is to reduce the value of all three properties, indicating that the most degraded portions of the material are dissolved out when water is used.

The results described show that the properties of the oxycelluloses obtained vary continuously with the time of oxidation, and that this method of oxidation provides an easily controlled means of preparing modified cotton cellulose.

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COMMUNICATION

"COMPARISON OF SOME FABRIC TESTING METHODS"

By J. A. MATTHEW

To the Editor

SIR,

In connection with my paper "Comparison of Some Fabric Testing Methods" (*J. Text. Inst.*, 1931, **22**, T497 *et seq.*), Dr. A. J. Turner has communicated with me, pointing out that my statement regarding four conclusions in his discussion of the stress-distribution in a test specimen of a fabric about to break in a tensile test (*J. Text. Inst.*, 1928, **19**, T158 *et seq.*) does not correctly represent his views. The passage referred to (p. T523) reads as follows: "Turner, however, makes various suppositions and draws several conclusions which are explicitly stated. He concludes (1) that the strength of the specimen will be at a maximum for a certain width, (2) the strength should increase with length of specimen, (3) on wetting, the strength of low twist yarn should increase much more than high twist yarn, (4) the tensile test gives a false idea of the strength of the warp (making it appear weak), but gives no false idea of the strength of the weft."

This passage is part of a paragraph following after a fairly lengthy summary of Dr. Turner's discussion. I regret that the wording should appear to misrepresent his views. The statements were not given as quotations, but possibly I should have made it plainer in the text that they were an attempt to give in the briefest possible form his conclusions as I understood they would apply to the conditions in my tests, for ease in comparison with experimental results. The summaries of the first two conclusions omit the effects of yarn irregularity (correctly referred to in the preceding summary of the discussion) as these were assumed to be a constant factor. The error in the third point is due to an unfortunate omission in typing which was overlooked; obviously reference was intended to the fabrics made from low and high twist yarns, and should have read: (3) on wetting the strength of fabrics made from low twist yarn should increase much more than that from high twist yarn.

In the circumstances it is, I feel, necessary to correct any misunderstanding on these points by giving Dr. Turner's views at length. These are given below with his approval, together with some additional explanations he has given in our correspondence.

On the first point, the effect of width of specimen, Dr. Turner's general conclusions are made up of four stages (p. T162), viz.:—

(*a*) From removal of corrugations wide specimens should be stronger;

(*b*) But if the specimens are very wide, the curvature of the edge threads may be so pronounced that these bear their full share of the load.

Therefore combination of (*a*) and (*b*) leads one to expect a certain width of any given fabric for which the effect of unequal stress-distribution is a maximum, and in consequence the strength is a minimum.

(*c*) Yarn irregularity causes narrow specimens to be stronger, but

(*d*) Loss of binding effect in *very* narrow specimens may cause these to be weaker.

Therefore combination of (*c*) and (*d*) may cause *very* narrow specimens to be weaker. Obviously the combination of (*a*), (*b*), (*c*) and (*d*) makes the situation very complex and makes possible many final combinations according to circumstances, especially when sampling difficulties also have to be contended with. In some circumstances, if a wide enough range of widths of test specimens could be used, with continuously increasing width the strength might be expected to increase, decrease, increase and again decrease.

He considers that the width required to show the final weakening may be well outside the limits possible in any ordinary testing machine and so be unattainable in practice. Dr. Barr used specimens varying in width from 1 to 5 inches and obtained fluctuations in strength which Turner says can be explained in terms of suitable combinations of these effects and occasional sampling errors; Barr himself does not claim his results to show any definite fluctuation with width. In my samples, ranging in width from 1 to 3½ inches, practical proportionality between strength and width was obtained; possibly this only represents some intermediate range where opposing effects counteract each other within the limits of experimental error.

As regards the second point, the effect of length, the conclusion that the strength should increase with length refers only to the case when inequality of stress-distribution alone is considered; in the following sentences it is pointed out that " the effect of yarn irregularity is in the opposite direction. Which effect will predominate must depend upon the particular circumstances." He now adds that in ordinary circumstances he would expect the effect of yarn irregularity to predominate and only with very regular yarns and wide specimens would, he expect a longer specimen to appear stronger than a shorter one. Barr found that both with wide and narrow specimens the long specimens were weaker than the short ones and the effect was more pronounced with the narrow specimens. To some extent therefore this confirms Turner's views but also appears to indicate that in these specimens the effect of inequality of stress-distribution was smaller than that of yarn irregularity.

As regards the third point, Turner considered the effect of increasing humidity, the extreme case of which may be regarded as equivalent to wetting. The factors affecting yarn strength were discussed, but no conclusion was reached as to the effect of humidity on yarns of different twists. Proceeding to deal with fabrics, he says, " We have to examine the possible effect of humidity on the following: (1) the individual yarns, (2) the binding effect at yarn intersections, (3) the stress-distribution at the breaking point. With regard to (2) the binding effect . . . increased binding effect is obtained from the greater yarn diameter, so that if soft yarns have been used in the construction of the fabric, it is conceivable that there will be not only an increased fabric strength because of the intrinsic increased fibre strength, and of the increased yarn strength brought about as mentioned above, but *an additional increase* due to the increased binding effect of intersecting yarns. The magnitude of *such an increase* must, of course, depend on circumstances. One would expect it to be negligibly small when hard twisted yarns were used in the construction of the cloth." Dr. Turner adds that as the effect of humidity on the fibre strength is probably the most important factor, he would actually doubt whether the strength of the fabric made from low twist yarn would increase *much more* than that of fabric made from high twist yarn; there might possibly be a slight difference but it is doubtful whether it would be possible to detect it among all the other effects.

In regard to point (4), Turner's conclusion was " that in a close woven cloth the inequality of stress-distribution due to the corrugation effect should be much more pronounced in the warp than in the weft," because, as stated in the preceding sentence, " the warp in the close-woven cloth is much more deeply corrugated than the weft." Later, on p. T163, he also states in the same connection, " However, it is important to observe that the effect of the inequality of stress-distribution is that the warp (in closely-woven cloth in which the warp is deeply corrugated) is regarded as being weaker than it really is, not that any false idea is created about the strength of the weft." I gave his conclusion in the latter form as being thus easier to compare with my results, from which it was concluded that the tensile tests on the fabrics used, gave a reliable indication of the actual strength of both *warp and weft* yarns as they are in the cloth, after modification by compressions acting on the intersections. It may be as well to point out that in my fabric samples, the warp yarns were not more deeply corrugated than the weft, but owing to the effects of the finishing and laundry treatments, the reverse was the case and the weft yarns were more deeply corrugated than the warp. This, however, according to the results obtained, did not lead to the tensile test showing the weft yarns as being weaker than they should be.

It is evident that in comparing any experimental results with a theory expressed entirely in words, much depends on the interpretation placed on the relative magnitudes of the different factors dealt with. I certainly gathered the impression from Dr. Turner's paper that the inequality of stress-distribution was regarded as of considerable importance, but of course varying according to the magnitude of the corrugations and of the yarn irregularity factor. As regards the comparison of the experimental results with the first three conclusions, Dr. Turner now points out that he would not expect the effects to be very pronounced, possibly not greater than the experimental error involved in sampling with twelve test specimens used. The remainder of my discussion does not appear to be affected, since it is based on the suggestion (p. T525) that " these effects (of stress inequality) should be considered as of very much less importance." It should perhaps be emphasised that the conclusions given were of course drawn from consideration of the results quoted, obtained from the one fairly extensive series of samples. In other conditions the effect may be of more importance. I agree with Dr. Turner when he maintains " that there are always effects due to inequality of stress-distribution, irregularity of yarns and the binding of the fibres and yarns, but the magnitudes of these several effects must always depend on actual circumstances." The need for confirmation was appreciated and the preparation of other samples was commenced for this purpose and testing will be carried out as opportunity permits.

(*Signed*) J. A. MATTHEW
(Linen Industry Research Association).

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TRANSACTIONS

10—THE MOISTURE RELATIONS OF COTTON
viii. THE EFFECT OF PROCESSING

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INTRODUCTION AND SUMMARY

In a previous paper of this series[10] some figures were given illustrating the effect of a few technical processes on the hygroscopicity of yarn. The processes whose effects were examined were limited to those for which samples happened to be available, and were all processes that were applied to yarn to be used for insulating purposes. The work now to be described was initiated in order to examine the effect of processing more systematically.

For this purpose a piece of cloth was passed through the normal routine of a bleachworks; after the kier-boil it was divided into two, one portion being bleached whilst the other was mercerised and bleached. The materials resulting from these processes were dyed with four typical dyes. Samples were withdrawn at each stage of the processing and examined by the methods described in previous papers. The results are presented in Tables in the third section of the paper, and are of interest mainly as data for reference purposes.

The effect of the time and temperature of drying on the subsequent adsorption* of water has also been examined, and it has been found that the hygroscopicity decreases slightly but steadily as the duration and temperature of drying are increased. If a damp sample is treated for a short time at not too high a temperature, however, its subsequent hygroscopicity may be slightly greater than that of the untreated sample.

The effect of the initial air-drying of a mercerised cotton has been examined in greater detail than hitherto,[5] and it is shown that the very great adsorptive capacity possessed immediately after the mercerisation process is impaired continuously as the material is dried down the primary desorption curve.

Finally, some figures are given for a few oxy- and hydro-celluloses, which show that chemical attack reduces the hygroscopicity of cotton; the reduction is small, however, except where the chemical attack is so serious as to cause almost complete loss of strength.

EXPERIMENTAL METHODS

Adsorption of Water

The vacuum and desiccator methods, both of which were used in this work, have already been described.[6,7,9] The results are presented as in

* The word " absorption " is used to denote the taking up of a vapour, " desorption " the giving up of a vapour, and " adsorption " the general process without special indication of gain or loss. The use of these terms does not imply any assumptions with regard to the mechanism of the processes they denote.

previous papers, i.e. in terms of the relative vapour pressure, p/P, and the weight of water adsorbed by one gram of dry cotton, a. Per cent. relative humidity and per cent. moisture regain are of course obtained by multiplying these quantities by 100.

Preparation of Samples

Effect of Bleaching, etc.

The material used for the investigation of the effect of bleaching and dyeing was a satin drill weighing about 7 oz. to the square yard. The processes to which it was subjected were as follows:

(*a*) Dried on cylinder drying machine.

(*b*) Singed (on face only).

(*c*) Wetted out, and malted in the kier for two hours at 50° C., the malt liquor being circulated continuously through the cloth. Concentration of liquor, 7 lb. of malt to 1,000 gallons; *p*H about 7. Washed.

(*d*) Soured for 30 minutes with 1 per cent. sulphuric acid in the cold, the acid being continuously circulated through the cloth. Washed.

(*e*) Boiled in the kier with caustic soda solution of initial concentration 1 per cent., at an excess pressure of 40 lb. Total duration of boil about 10 hours, about 7 hours of this being at the full pressure. Washed. Piece divided into two.

Portion A.

(*f*) Treated for 3 hours with approximately $N/25$ hypochlorite at *p*H 9-10. Washed.

(*g*) Soured with ½-1 per cent. sulphuric acid. Washed.

(*h*) Mangled, and dried on stenter.

Portion B.

(*i*) Dried on cylinder drying machine.

(*j*) Mercerised, soured, and washed.

(*k*) Chemicked as (*f*) and washed.

(*l*) Soured as (*g*) and washed.

(*m*) Mangled, and dried on stenter.

After each process a one-yard sample was cut from the piece and removed to the laboratory, where it was allowed to air-dry.

In order to examine the effect of dyeing the following samples were prepared: Bleached sample (*h*) and mercerised and bleached sample (*m*) dyed with (*a*) a direct dye (1 per cent. Diamine Sky Blue FF), (*b*) a sulphur dye (6 per cent. Thional Brilliant Blue), (*c*) a vat dye (15 per cent. Duranthrene Blue CC), (*d*) a basic dye (1 per cent. Methylene Blue, mordanted). The samples were dyed in the laboratory, under conditions as close as possible to those obtaining in technical practice. The material dyed with Duranthrene Blue was not very level, the small experimental jig available being unsuitable for this type of cloth, but the other dyeings were quite satisfactory. After the completion of the dyeing process the samples were allowed to air-dry at room temperature.

The examination of all these cloths was made by the vacuum method.

Effect of time and temperature of drying.

In the first investigation of this effect the soda-boiled sliver 85R, which has previously been examined,[6,7,8] was used, together with the same material mercerised in 15 per cent. and 25 per cent. caustic soda solutions. Small portions of the air-dry materials were placed in weighing bottles in an oven

at 110° C., and kept there for periods varying from five minutes to six hours. After the high temperature treatment the samples, together with untreated blanks, were dried out over phosphorus pentoxide at room temperature, after which the absorption figures given in the third section were determined in the usual way, the desiccator method being used.

The material used in the second series of experiments was an Egyptian (Sakel) yarn. It was wetted out in a Turkey Red Oil bath and mercerised on a small mercerising machine in the laboratory, the procedure followed being the same as that adopted in technical mercerisation. The damp yarns were wound off in suitable small portions, which were placed in weighing bottles and exposed for various times in an oven controlled to various temperatures between 40° and 120° C. The samples were damp when placed in the oven, and many of them were still damp when taken out; it is obvious therefore that none of the samples were themselves at the temperature of the oven for the full period of their stay in it, and that some of them could not have reached the oven temperature at all.

After the heat treatment the samples were divided into four groups, and each group was placed in a desiccator over a solution of sulphuric acid so chosen that the relative humidity of the atmosphere in the desiccator should correspond as closely as possible to the moisture content of the samples as withdrawn from the oven. The humidity changes subsequently imposed on them were in the absorption direction where the initial humidity was low, and in the desorption direction where the initial humidity was high. After a number of measurements had been made in this way the samples were dried out over phosphorus pentoxide at room temperature and the standard absorption curve[5] was determined.

The samples for the hygroscopicity determinations were prepared in duplicate, and larger (2-lea) samples were also given identical treatments. These were subsequently knitted into a continuous length of fabric with short lengths of black yarn indicating the break between the different samples; the fabric was then dyed with Diamine Sky Blue in order to illustrate the effect of the time and temperature of drying on the shade of dyed cotton.

Effect of drying to different extents at room temperature.

The mercerised Egyptian yarn described above was used in this investigation, the vacuum method being employed. Seven portions, each weighing 6 to 7 grams, were wound from the damp yarn. One portion was placed immediately in an adsorption bulb, and its desorption curve was determined directly from the wet condition; another portion was dried out during the evacuation and used to determine the standard absorption and desorption curves. The other portions were exposed to atmospheres of approximately 15, 30, 60, 70, and 80 per cent. relative humidity; when equilibrium was attained these also were placed in adsorption bulbs and evacuated (as previously described[5]) in such a way that their moisture contents changed little during the evacuation. They were then examined in the usual way, water being added in stages until the saturation points were reached, after which desorption curves were determined.

Effect of chemical attack

The materials used in this investigation were oxy- and hydro-celluloses prepared and described by Birtwell, Clibbens and Ridge,[1] and Birtwell, Clibbens and Geake.[2] The desiccator method was used for their examination.

EXPERIMENTAL RESULTS AND DISCUSSION

Effect of Bleaching, Mercerising, and Dyeing

The experimental results obtained from the examination of the processed cloths are given in Table I. These results were obtained by the vacuum method, and consequently entailed the examination of 22 bulbs. These, however, were not the only vacuum experiments in progress at the same time; at one period as many as 50 bulbs were under examination. In these circumstances it was impossible to give the individual bulbs the same attention that could be given to them when only a few were being examined; it was also impossible to duplicate any of the experiments. For these reasons the results here reproduced may not be so accurate as the results of vacuum experiments given in previous papers of this series.

The experimental figures do not permit the direct comparison of the hygroscopicities of the various samples. This comparison can best be made by plotting the curves on a large scale diagram, but, as these curves are not sufficiently different to be differentiated on a small scale reproduction, values of the amounts of water adsorbed at a series of fixed values of the partial vapour pressure have been taken from curves constructed separately for each sample; these are given in Tables II and III. As the effects of the various processes on the hygroscopicity of the cloth are evident from the Tables, there is no need to describe them verbally. A few comments, however, are desirable.

Whilst specific effects are apparent at very high humidities, the trend of the hygroscopicity change is in general downward from the malted sample C4 to the fully bleached C9; this is in conformity with previous observations[6,10] that the hygroscopicity of cotton decreases as its non-cellulosic constituents are removed. The process that is most effective in so reducing the hygroscopicity over the greater part of the humidity range is evidently kier-boiling (*cf.* figures for C5 and C6), yet at high humidities the decrease changes to an increase of such extent that above 90 per cent. relative humidity the kier-boiled sample is the most hygroscopic of all the unmercerised samples. No well-founded explanation of this behaviour is available, but it may be noted that kier-boiling might be expected to cause two opposing effects, a reduction of hygroscopicity due to the removal of hygroscopic non-cellulosic impurities, and an increase due to a change in the cellulose itself brought about by the action of an aqueous solution at a high temperature[4]. The observed behaviour might be explained in terms of these two effects, if it is assumed that the second predominates at high humidities.

It was also shown in the earlier work that drying at high temperatures reduces the hygroscopicity of cotton[6]; this is exemplified by a comparison of the figures obtained from samples C8 and C9, and C6 and C10. On the other hand Table II also provides examples of a high temperature treatment causing either little alteration (*cf.* C1, C2, and C3, though here there is at high humidities a slight trend in the expected direction), or a slight increase of hygroscopicity (C13 and C14). The effect of drying will be discussed in more detail below.

The "mercerisation ratio" of the mercerised samples is about 1·2, a fairly normal figure for a technically mercerised cloth.[8,10]

The most unexpected feature of Table II is the low hygroscopicity of samples C1, C2, and C3, at high humidities. These samples had not been

p/P	a	p/P	a	$p/$	p/P	a	p/P	a	p/P	a
C1 (Grey)		C2 (C1 Dried)		(C2)	C9 (C8 Dried)		C10 (C6 Dried)		C11 (Mercerised)	
									·001	·0048
·005	·0025	·002	·0031	·002	·012	·0045	·001	·0031	·040	·0152
·013	·0059	·015	·0078	·208	·053	·0143	·019	·0092	·126	·0274
·030	·0110	·055	·0156	·414	·163	·0259	·107	·0212	·245	·0397
·063	·0162	·122	·0233	·549	·256	·0335	·248	·0334	·385	·0544
·118	·0230	·211	·0310	·664	·373	·0430	·379	·0436	·477	·0641
·206	·0315	·311	·0402	·780	·486	·0525	·496	·0538	·584	·0761
·315	·0401	·402	·0463	·832	·593	·0620	·607	·0639	·669	·0882
·418	·0485	·496	·0540	·886	·715	·0773	·694	·0738	·748	·1004
·522	·0569	·582	·0618	·930	·796	·0905	·780	·0877	·830	·1195
·592	·0653	·653	·0694	·983	·859	·1038	·849	·1038	·888	·1362
·676	·0736	·732	·0786	1·002	·910	·1189	·909	·1236	·941	·1650
·753	·0819	·780	·0848	—3	·967	·1523	·987	·1884	·964	·1870
·806	·0901	·829	·0927	9	·984	·1797	1·000	·2257	·981	·2139
·842	·0986	·896	·1086	2	·987	·1845			·994	·2336
·917	·1171	·954	·1302	(C1)	1·000	·2064	·816	·1170	·998	·2596
·963	·1323	·982	·1431	6	1·000	·2416	·593	·0775		
·991	·1505	1·000	·1597	·001			·282	·0446	·968	·2284
1·000	·1638			·045	·981	·2112	·036	·0168	·935	·1970
				·13	·938	·1740			·874	·1636
·895	·1405	C13		·24	·879	·1415			·792	·1348
·785	·1076	(C12 Soured)		·495	·563	·0733	C21		·669	·1063
·525	·0675			·605	·231	·0386	(C9 Dyed Methylene Blue)		·356	·0607
·210	·0362	·010	·0053	·70—					·123	·0331
·097	·0270	·032	·0120	·77					·048	·0221
·041	·0181	·094	·0231	·83	C20		·008	·0044		
		·155	·0297	·87	(C14 Dyed		·054	·0139	C22	
		·268	·0407	·92c	Duranthrene		·136	·0234	(C14 Dyed	
C12		·446	·0583	·96	Blue)		·287	·0361	Methylene	
(C11		·587	·0738	·98			·548	·0586	Blue)	
Chemicked)		·700	·0893	·995	·015	·0105	·706	·0747		
		·816	·1112	·99	·109	·0257	·795	·0874	·006	·0059
·007	·0034	·917	·1461	1·000	·307	·0460	·857	·1000	·043	·0157
·034	·0143	·923	·1505	5	·503	·0664	·919	·1191	·114	·0256
·083	·0234	·941	·1605	·978	·667	·0868	·947	·1320	·235	·0386
·189	·0361	·955	·1786	·925	·796	·1124	·975	·1511	·362	·0516
·280	·0452	·976	·2097	·59	·878	·1377	·987	·1639	·497	·0646
·371	·0544	·990	·2338	·34	·924	·1631	1·000	·1860	·621	·0776
·466	·0634			·09	·957	·1890			·732	·0937
·606	·0795			·07	·973	·2150	·935	·1603	·816	·1098
				8	·994	·2709	·825	·1175	·931	·1483
·952	·1996				·998	·2956	·629	·0798	·958	·1645
·912	·1840				1·000	·3124	·333	·0466	·988	·1934
·848	·1495						·063	·0186	1·000	·2179
·769	·1281									
·667	·1057								·943	·1898
·475	·0774								·875	·1504
·353	·0633								·746	·1155
·225	·0489								·581	·0889
·149	·0393								·401	·0643
·058	·0245								·264	·0495
									·126	·0341
									·066	·0256

Table I

p/P	a	p/P	a	p/P	a	p/P	a	p/P	a	p/P	a	p/P	a	p/P	a	p/P	a	p/P	a	p/P	a
C1 (Grey)		C2 (C1 Dried)		C3 (C2 Singed)		C4 (C3 Malted)		C5 (C4 Soured)		C6 (C5 Kier-Boiled)		C7 (C6 Chemicked)		C8 (C7 Soured)		C9 (C8 Dried)		C10 (C6 Dried)		C11 (Mercerised)	
																				·001	·0048
·005	·0025	·002	·0031	·002	·0023	·016	·0094	·004	·0035	·005	·0042	·015	·0066	·011	·0052	·012	·0045	·001	·0031	·040	·0152
·013	·0059	·015	·0078	·205	·0319	·107	·0233	·017	·0077	·029	·0101	·083	·0177	·036	·0108	·053	·0143	·019	·0092	·126	·0274
·030	·0110	·055	·0156	·410	·0477	·307	·0421	·045	·0137	·069	·0160	·254	·0342	·074	·0164	·163	·0259	·107	·0212	·245	·0397
·063	·0162	·122	·0233	·544	·0590	·590	·0703	·091	·0198	·126	·0220	·447	·0506	·143	·0239	·256	·0335	·248	·0334	·385	·0544
·118	·0230	·211	·0310	·660	·0703	·765	·0938	·165	·0279	·191	·0280	·701	·0780	·241	·0334	·373	·0430	·379	·0436	·477	·0641
·206	·0315	·311	·0402	·755	·0816	·870	·1172	·275	·0380	·283	·0359	·856	·1056	·359	·0429	·486	·0525	·496	·0538	·584	·0761
·315	·0401	·402	·0463	·830	·0928	·935	·1405	·398	·0480	·399	·0460	·972	·1332	·463	·0522	·593	·0620	·607	·0639	·669	·0882
·418	·0485	·496	·0540	·883	·1040	·981	·1779	·504	·0583	·515	·0560	·977	·1679	·568	·0616	·715	·0773	·694	·0738	·748	·1004
·522	·0569	·582	·0618	·934	·1152	1·000	·2186	·624	·0726	·603	·0658	·993	·1947	·658	·0709	·796	·0905	·780	·0877	·830	·1195
·592	·0653	·653	·0694	·992	·1445			·753	·0884	·700	·0776			·724	·0803	·859	·1038	·849	·1038	·888	·1362
·676	·0736	·732	·0786	1·000	·1510	·939	·1706	·813	·0984	·788	·0915	·968	·1752	·781	·0892	·910	·1189	·909	·1236	·941	·1650
·753	·0819	·780	·0848			·826	·1243	·860	·1084	·851	·1052	·908	·1482	·834	·0983	·967	·1523	·987	·1884	·964	·1870
·806	·0901	·829	·0927			·534	·0728	·921	·1284	·895	·1169	·829	·1212	·872	·1079	·984	·1797	1·000	·2257	·981	·2139
·842	·0986	·896	·1086	C14		·117	·0288	·948	·1386	·930	·1344	·488	·0635	·918	·1272	·987	·1845			·994	·2336
·917	·1171	·954	·1302	(C13 Dried)		·077	·0251	·981	·1613	·958	·1585	·204	·0342	·953	·1500	1·000	·2064	·816	·1170	·998	·2596
·963	·1323	·982	·1431			·015	·0125	1·000	·1887	·978	·1817	·059	·0179	·977	·1656	1·000	·2416	·593	·0775		
·991	·1505	1·000	·1597	·002	·0031			1·000	·1998	·985	·1958			·985	·1771			·282	·0446	·968	·2284
1·000	·1638			·042	·0158					1·000	·2172			·989	·1945	·981	·2112	·036	·0168	·935	·1970
				·136	·0290	C15		·965	·1834							·938	·1740			·874	·1636
·895	·1405	C13		·244	·0396	(C9 Dyed		·946	·1731	·946	·1776	C18		·903	·1421	·879	·1415	C21		·792	·1348
·785	·1076	(C12 Soured)		·494	·0648	Diamine Sky		·869	·1315	·920	·1630	(C14 Dyed		·126	·0255	·563	·0733	(C9 Dyed		·669	·1063
·525	·0675			·608	·0777	Blue)		·650	·0874	·863	·1392	Brilliant		·051	·0155	·231	·0386	Methylene		·356	·0607
·210	·0362	·010	·0053	·702	·0906			·310	·0478	·806	·1197	Blue)						Blue)		·123	·0331
·097	·0270	·032	·0120	·779	·1032	·037	·0126	·048	·0188	·728	·1026									·048	·0221
·041	·0181	·094	·0231	·830	·1158	·192	·0296			·530	·0726	·006	·0048	C19		C20					
		·155	·0297	·872	·1287	·320	·0402			·448	·0632	·039	·0154	(C9 Dyed		(C14 Dyed		·008	·0044		
		·268	·0407	·925	·1540	·559	·0613	C16		·285	·0453	·109	·0259	Duranthrene		Duranthrene		·054	·0139	C22	
C12		·446	·0583	·962	·1793	·659	·0720	(C14 Dyed		·169	·0339	·276	·0436	Blue)		Blue)		·136	·0234	(C14 Dyed	
(C11		·587	·0738	·982	·2080	·774	·0870	Diamine		·115	·0283	·454	·0613					·287	·0361	Methylene	
Chemicked)		·700	·0893	·991	·2370	·840	·1040	Sky Blue)		·059	·0200	·606	·0788	·007	·0055	·015	·0105	·548	·0586	Blue)	
		·816	·1112	·998	·2614	·912	·1262					·729	·0964	·059	·0159	·109	·0257	·706	·0747		
·007	·0034	·917	·1461	1·000	·2836	·944	·1478	·007	·0045			·817	·1138	·187	·0268	·307	·0460	·795	·0874	·006	·0059
·034	·0143	·923	·1505			·962	·1623	·034	·0169			·876	·1312	·357	·0406	·503	·0664	·857	·1000	·043	·0157
·083	·0234	·941	·1605	·976	·2406	·974	·1774	·121	·0268	C17		·936	·1561	·547	·0543	·667	·0868	·919	·1191	·114	·0256
·189	·0361	·955	·1786	·923	·1878	·985	·1968	·237	·0395	(C9 Dyed		·984	·1964	·714	·0716	·796	·1124	·947	·1320	·235	·0386
·280	·0452	·976	·2097	·551	·0876	·997	·2204	·415	·0570	Thional		1·000	·2233	·823	·0880	·878	·1377	·975	·1511	·362	·0516
·371	·0544	·990	·2338	·347	·0627	1·000	·2428	·529	·0695	Brilliant				·886	·1063	·924	·1631	·987	·1639	·497	·0646
·466	·0634			·094	·0288			·694	·0893	Blue)		·967	·2097	·939	·1267	·957	·1890	1·000	·1860	·621	·0776
·608	·0795			·039	·0179	·920	·1675	·763	·1041			·936	·1838	·977	·1607	·973	·2150	•		·732	·0937
						·872	·0901	·849	·1264	·005	·0042	·825	·1388	1·000	·1938	·994	·2709	·935	·1603	·816	·1098
·952	·1996					·480	·0648	·911	·1510	·063	·0166	·619	·0935			·998	·2956	·825	·1175	·931	·1483
·912	·1840					·142	·0295	·944	·1756	·205	·0311	·360	·0604	·921	·1564	1·000	·3124	·629	·0798	·958	·1645
·848	·1495					·031	·0154	·969	·2027	·352	·0434	·136	·0348	·658	·0823			·333	·0466	·988	·1934
·769	·1281							·982	·2270	·548	·0619	·030	·0170	·425	·0550			·063	·0186	1·000	·2179
·667	·1057							·999	·2519	·663	·0740			·231	·0367						
·475	·0774							1·000	·2764	·762	·0882			·081	·0207					·943	·1898
·353	·0633									·841	·1043									·875	·1504
·225	·0489							·980	·2530	·930	·1327									·746	·1155
·149	·0393							·958	·2208	·966	·1474									·581	·0889
·058	·0245							·880	·1554	·976	·1629									·401	·0643
								·421	·0671	·990	·1756									·264	·0495
								·193	·0404	1·000	·1959									·126	·0341
								·089	·0266											·066	·0256

Relative Vapour Pressure p/P	Grams Water per Gram Dry Cotton, a													
	C1 (Grey)	C2 (C1 Dried)	C3 (C2 Singed)	C4 (C3 Malted)	C5 (C4 Soured)	C6 (C5 Kier-Boiled)	C7 (C6 Chemicked)	C8 (C7 Soured)	C9 (C8 Dried)	C10 (C6 Dried)	C11 (C10 Mercerised)	C12 (C11 Chemicked)	C13 (C12 Soured)	C14 (C13 Dried)
·05	·015	·015	·015	·016	·015	·013	·013	·013	·013	·015	·017	·018	·016	·017
·10	·021	·021	·021	·022	·021	·019	·020	·020	·020	·021	·024	·026	·024	·024
·15	·026	·026	·026	·028	·027	·025	·025	·025	·025	·025	·030	·032	·029	·029
·20	·031	·031	·031	·032	·031	·029	·030	·030	·029	·029	·036	·037	·034	·035
·25	·035	·035	·035	·037	·036	·034	·034	·034	·033	·034	·041	·043	·040	·040
·30	·039	·039	·039	·042	·040	·038	·038	·038	·037	·038	·046	·047	·044	·045
·35	·043	·043	·043	·046	·045	·042	·042	·042	·041	·042	·051	·052	·049	·050
·40	·047	·047	·047	·051	·049	·046	·046	·046	·045	·046	·056	·057	·054	·055
·45	·051	·050	·051	·056	·053	·050	·051	·051	·049	·050	·062	·062	·059	·060
·50	·056	·055	·056	·061	·058	·055	·056	·055	·054	·054	·067	·067	·064	·066
·55	·059	·059	·060	·066	·063	·060	·060	·059	·058	·058	·073	·073	·070	·071
·60	·064	·064	·064	·072	·069	·065	·065	·064	·062	·063	·078	·079	·075	·077
·65	·068	·069	·069	·078	·075	·071	·071	·070	·068	·068	·085	—	·082	·082
·70	·074	·075	·075	·084	·082	·078	·078	·076	·075	·075	·092	—	·089	·090
·75	·081	·081	·081	·091	·089	·085	·085	·084	·082	·082	·101	—	·098	·098
·80	·089	·088	·088	·100	·097	·094	·094	·092	·091	·091	·111	—	·108	·108
·85	·099	·097	·097	·111	·107	·105	·104	·104	·103	·104	·124	—	·121	·122
·90	·111	·110	·108	·126	·120	·123	·119	·120	·118	·120	·143	—	·138	·140
·95	·128	·127	·124	·150	·140	·153	·144	·145	·141	·148	·175	—	·171	·170
·95	—	—	—	·181	·176	·182	—	—	·183	—	·209	·203	—	·210
·90	·143	—	—	·148	·143	·153	·144	—	·149	—	·176	·172	—	·173
·85	·125	—	—	·130	·125	·134	·124	—	·128	·129	·154	·150	—	·150
·80	·112	—	—	·116	·113	·118	·111	—	·112	·113	·137	·135	—	·134
·75	·100	—	—	·105	·103	·106	·100	—	·100	·101	·123	·122	—	·121
·70	·090	—	—	·095	·094	·097	·091	—	·091	·092	·112	·112	—	·111
·65	·082	—	—	·088	·087	·090	·084	—	·084	·085	·102	·102	—	·102
·60	·076	—	—	·081	·080	·082	·077	—	·077	·078	·094	·094	—	·095
·55	·070	—	—	·075	·074	·076	·071	—	·072	·073	·087	·087	—	·088
·50	·065	—	—	·070	·068	·070	·065	—	·066	·067	·080	·081	—	·082
·45	·060	—	—	·064	·063	·064	·060	—	·061	·062	·074	·075	—	·076
·40	·054	—	—	·059	·058	·058	·055	—	·056	·058	·067	·069	—	·070
·35	·049	—	—	·054	·052	·053	·049	—	·051	·052	·060	·063	—	·063
·30	·045	—	—	·049	·047	·047	·044	—	·046	·047	·054	·058	—	·057
·25	·040	—	—	·044	·042	·042	·039	—	·041	·042	·048	·052	—	·051
·20	·035	—	—	·038	·037	·037	·034	—	·035	·036	·042	·046	—	·044
·15	·031	—	—	·033	·031	·031	·029	—	—	·031	·036	·039	—	·038
·10	·025	—	—	·027	·026	·026	·023	—	—	·025	·030	·032	—	·031
·05	·020	—	—	·020	·019	·019	·019	—	—	·018	·022	·023	—	·022

Table III

Relative Vapour Pressure p/P	Grams Water per Gram Dry Cotton, a									
	C9 (Bleached)	C15 (C9 Dyed Diamine Sky Blue)	C17 (C9 Dyed Thional Brilliant Blue)	C19 (C9 Dyed Duranthrene Blue)	C21 (C9 Dyed Methylene Blue)	C14 (Mercerised and Bleached)	C16 (C14 Dyed Diamine Sky Blue)	C18 (C14 Dyed Thional Brilliant Blue)	C20 (C14 Dyed Duranthrene Blue)	C22 (C14 Dyed Methylene Blue)
·05	·013	·014	·015	·015	·013	·017	·017	·017	·017	·017
·10	·020	·021	·021	·020	·020	·024	·024	·024	·024	·024
·15	·025	·026	·027	·024	·025	·029	·030	·030	·030	·030
·20	·029	·030	·031	·028	·029	·035	·036	·035	·036	·035
·25	·033	·034	·035	·032	·033	·040	·041	·041	·040	·040
·30	·037	·039	·040	·036	·038	·045	·046	·046	·045	·045
·35	·041	·043	·044	·040	·042	·050	·050	·051	·050	·051
·40	·045	·047	·048	·044	·046	·055	·056	·056	·055	·055
·45	·049	·052	·053	·047	·050	·060	·061	·061	·060	·060
·50	·054	·056	·057	·051	·054	·066	·066	·067	·066	·065
·55	·058	·061	·062	·055	·059	·071	·073	·073	·072	·070
·60	·062	·066	·067	·059	·063	·077	·078	·078	·078	·075
·65	·068	·071	·073	·064	·068	·082	·084	·084	·085	·081
·70	·075	·077	·079	·070	·074	·090	·092	·092	·092	·088
·75	·082	·085	·086	·077	·080	·098	·101	·100	·102	·096
·80	·091	·094	·095	·085	·088	·108	·112	·110	·113	·106
·85	·103	·106	·106	·096	·098	·122	·127	·122	·128	·119
·90	·118	·123	·121	·112	·113	·140	·148	·140	·149	·134
·95	·141	·152	·144	·137	·135	·170	·182	·166	·184	·159
·95	·183	·195	—	—	·171	·210	·212	·194	—	·197
·90	·149	·154	—	·142	·142	·173	·174	·166	—	·161
·85	·128	·130	—	·122	·124	·150	·153	·146	—	·142
·80	·112	·115	—	·107	·110	·134	·137	·131	—	·128
·75	·100	·104	—	·097	·099	·121	·124	·118	—	·116
·70	·091	·094	—	·088	·090	·111	·114	·108	—	·106
·65	·084	·087	—	·080	·083	·102	·104	·099	—	·098
·60	·077	·080	—	·074	·076	·095	·095	·091	—	·090
·55	·072	·074	—	·067	·070	·088	·086	·085	—	·083
·50	·066	·068	—	·062	·064	·082	·078	·078	—	·077
·45	·061	·062	—	·057	·059	·076	·071	·071	—	·071
·40	·056	·056	—	·052	·054	·070	·065	·065	—	·065
·35	·051	·051	—	·048	·049	·063	·059	·059	—	·059
·30	·046	·046	—	·044	·044	·057	·053	·054	—	·054
·25	·041	·041	—	·039	·038	·051	·047	·048	—	·048
·20	·035	·035	—	·034	·033	·044	·041	·042	—	·043
·15	—	·030	—	·029	·028	·038	·036	·037	—	·037
·10	—	·025	—	·024	·023	·031	·029	·030	—	·030
·05	—	·017	—	·018	·017	·022	·021	·022	—	·022

submitted to any wet processing, and consequently retained all the non-cellulosic impurities associated with raw cotton. On this account alone one would expect them to be more hygroscopic than the wet processed samples, but they contain in addition a small amount of starch as size on the warp, and as starch is more hygroscopic than cotton still higher values might have been looked for. Actually, however, they are less hygroscopic throughout the whole humidity range than the malted sample C4, and at high humidities are less hygroscopic than any of the wet-processed samples. The total amount of size present is about 3 per cent. of the weight of the cloth; China Clay is absent, and hence the lower hygroscopicity cannot be attributed to the weighting of the cotton with a non-hygroscopic substance. The fact that these samples are at ordinary humidities less hygroscopic than the malted sample may possibly be due to the increase of hygroscopicity caused by treatment with a warm solution[4] being greater than the decrease caused by the removal of a small amount of starch; the cause of the low hygroscopicity at high humidities, however, is unknown.

The effects of the various dyeing processes are evident from Table III. The direct dyed fabrics are more hygroscopic, and the basic dyed fabrics less hygroscopic, than the undyed materials, whether bleached or mercerised and bleached. The extent of the changes, however, seems to be less for the mercerised samples. The absorption figures for the sulphur dyed fabrics are greater than those for the undyed materials but the one set of desorption figures available shows the reverse effect. The hygroscopicity of the unmercerised sample is decreased as a result of vat-dyeing, whereas that of the mercerised material is, if anything, slightly increased; the absolute differences are, however, small, and the reality of this apparent difference in behaviour must remain in doubt. The differences occasioned by these different dyeing processes are small relative to the differences that may be caused in any one sample as a result of differences in pre-history, and hence for practical purposes the hygroscopicity of a bleached and dyed cloth may be regarded as identical with that of the undyed material. This conclusion may not, of course, be applicable to material dyed on a lightly prepared ground, since the dyeing process may itself cause a partial purification of such material.

Effect of Time and Temperature of Drying

The effect of high temperature drying in reducing the amount of water subsequently adsorbed by cotton was noted in the first paper of this series[6]. The results of a more detailed investigation of this effect are given in Tables IV and V. Table IV gives the results of the first series of experiments, and illustrates the effect of the time of drying at 110° C. on the hygroscopicity of a soda-boiled cotton and two cottons prepared from it by mercerisation without tension. The hygroscopicity decreases as the time of heating is increased within the range examined, though there may be a slight increase after short times of heating for one of the mercerised samples. The decrease appears to be less for the soda-boiled than for the mercerised samples, though this may be partly due to the fact that the original (technical) drying of this soda-boiled material was accomplished at 80° C.

The samples to which Table IV refers were air-dry when placed in the oven; on the other hand, the results given in Table V refer to mercerised yarns that were put in the oven while still damp from the wash-off after mercerising, and are consequently more closely related to technical practice.

Table IV

Relative Vapour Pressure p/P	Grams Water per gram Dry Cotton, a								
	Not Heated	Heated at 110° C. for							
		5 mins.	10 mins.	20 mins.	30 mins.	1 hr.	2 hrs.	4 hrs.	6 hrs.
Soda-boiled Cotton 85R									
·400	·047	·046	·046	·046	·045	·045	·044	·044	·044
·560	·062	·061	·061	·061	·061	·061	·060	·060	·060
·797	·097	·096	·096	·097	·096	·095	·095	·095	·096
Soda-boiled Cotton 85R Mercerised Without Tension in 15 per cent. Caustic Soda Solution									
·397	·069	·068	·068	·067	·066	·065	·064	·065	·064
·569	·091	·091	·091	·090	·089	·088	·087	·088	·086
·794	·142	·142	·142	·142	·140	·139	·137	·139	·136
Soda-boiled Cotton 85R Mercerised Without Tension in 25 per cent. Caustic Soda Solution									
·395	·074	·075	·075	·074	·073	·070	·071	·071	·070
·557	·098	·099	·099	·097	·098	·095	·096	·095	·095
·789	·150	·152	·152	·151	·152	·150	·150	·148	·148

It was necessary to examine these yarns in four separate series; the actual experimental results are therefore not directly comparable, and the figures of Table V were interpolated from curves drawn separately for each sample. These results show that the hygroscopicity of cotton decreases with both time and temperature of drying, but it is evident that many of the samples that were heated have higher regains than the yarn dried at room temperature only. This is not an ordinary hysteresis effect, for the figures of Table V were taken from the absorption curves determined after all the samples had been dried out over phosphorus pentoxide at room temperature. The results of Tables II and IV have already given some slight evidence of such behaviour, and in considering the possible cause of this effect one has to remember that the majority of the yarns were by no means dry after the heat treatment to which they were subjected. Many of the samples, in fact, remained damp throughout the whole of the treatment, and this has previously been shown to result in an increased hygroscopicity.[4] In this connection the figures of Table VI are of interest. This Table shows the amounts of water remaining in the yarn samples after the heat treatments to which they were subjected, the regains before the treatments being 60 to 80 per cent. A comparison of this Table with Table V makes it plain that only those samples that had their moisture contents reduced to small values by the heat treatment have suffered an appreciable decrease of hygroscopicity as a result of it. The increase of hygroscopicity resulting from the heat treatment of damp yarn might be expected to be greater the

Table V

Relative Vapour Pressure p/P	Time in Oven	Grams Water per Gram Dry Cotton, a							
		Not Heated	Temperature of Oven °C.						
			40	60	70	82	90	100	111	119
		·040								
	40 mins.		·041	·041	·041	—	—	·041	·041	·040
	60 mins.		·041	·041	—	—	—	·041	·040	·040
·20	80 mins.		·041	—	—	·041	·041	·040	·040	·039
	24 hrs.		·041	·041	·040	·040	·040	·039	·039	·039
		·051								
	40 mins.		·053	·052	·052	·050	·050	·051	·051	·051
	60 mins.		·053	·052	·051	—	·050	·051	·051	·051
·30	80 mins.		·053	·050	·050	·049	·051	·051	·051	·050
	24 hrs.		·052	·052	·051	·051	·051	·050	·051	·050
		·061								
	40 mins.		·064	·063	·063	·062	·060	·061	·061	·061
	60 mins.		·064	·063	·062	—	·061	·061	·061	·061
·40	80 mins		·064	·062	·061	·061	·061	·061	·061	·061
	24 hrs.		·062	·061	·061	·061	·061	·061	·061	·060
		·073								
	40 mins.		·076	·075	·075	·074	·072	·072	·072	·072
	60 mins.		·076	·075	·074	—	·073	·072	·072	·072
·50	80 mins.		·075	·075	·073	·073	·073	·073	·073	·072
	24 hrs.		·074	·073	·073	·072	·072	·072	·072	·071
		·086								
	40 mins.		·088	·088	·088	·087	·086	·086	·086	·086
	60 mins.		·088	·088	·087	—	·087	·085	·085	·085
·60	80 mins.		088	·088	·087	·086	·087	·085	·085	·084
	24 hrs.		·087	·086	·086	·085	·085	·085	·085	·083
		·104								
	40 mins.		·105	·104	·104	·103	·103	·103	·103	·103
	60 mins.		·105	·104	·103	—	·103	·102	·102	·100
·07	80 mins.		·105	·104	·103	·103	·103	·102	·101	·100
	24 hrs.		·103	·102	·102	·101	·102	·101	·100	·098
		·122								
	40 mins.		·130	·128	·129	·125	·125	·126	·125	·125
	60 mins.		·130	·128	·126	—	·124	·124	·124	·121
·80	80 mins.		·128	·127	·125	·127	·126	·125	·122	·120
	24 hrs.		·127	·126	·126	·124	·125	·122	·121	·119

higher the temperature, so long as the yarn was damp at the end of the treatment. The figures of Table V provide no evidence of any such increase, though it may be noted that the experimental method was not suited to the measurement of such small differences as might have been expected.

Table VI

Time in Oven	Per Cent. Water in Yarn after Heating							
	Temperature of Oven °C.							
	40	60	70	82	90	100	111	119
40 mins.	>40	>40	>40	—	>40	25	14	10
60 mins.	>40	>40	38	—	35	6	2	0·6
80 mins.	>40	—	31	29	12	2	1	0·3
24 hrs.	4	1	1	1	0·6	0·4	0·6	0·1

The results of Table V are absorption results determined after the samples were dried out at room temperature; a few measurements were made, however, prior to this complete drying of the material. These exhibit the usual features common to intermediate absorption and desorption curves,[5] and the samples that were not dried down too far show an irreproducible primary desorption curve. The results thus confirm previous observations, but add nothing new to them, and as the intermediate curves investigated were necessarily different for the different series of samples the results afford no information with regard to the effect of time and temperature of drying; they are therefore not given here.

Visual examination of the dyed knitted fabric prepared from samples of yarn that had been submitted to the same heat treatments showed beyond all doubt a gradation of shade from dark to light corresponding to the change from high to low hygroscopicity. The untreated samples, however, were all darker in shade than those that had been heated, but this does not necessarily mean that the correspondence between hygroscopicity and dyed shade breaks down. The hygroscopicity figures for the untreated samples refer to material that had been dried out over phosphorus pentoxide at room temperature, while the corresponding dyed samples were air-dried only, and it is very probable that the latter were not sufficiently dried to impair entirely the high adsorptive capacity possessed immediately after mercerising.[5]

Effect of Drying to Different Extents at Room Temperature

This abnormally high adsorptive capacity possessed by samples immediately after the mercerisation process[5] is important both theoretically and practically; to investigate it further the effect of drying mercerised yarn to different extents at room temperature has been examined. The results of this investigation are given in Table VII and illustrated in Fig. 1.

The continuous curves of this Figure are the standard absorption and desorption curves, determined on yarn that had been dried out at room temperature, and the uppermost dotted curve is the primary desorption curve, determined on yarn taken directly from the wash-off after mercerisation. The other curves were determined on samples that had been dried (at room temperature) to various extents intermediate between these extremes. Thus the points B and C represent the starting points of experiments B and C, in which the yarns were initially dried to a = ·0384 and ·0609 respectively. These starting points are on the standard desorption curve, and the absorption curves determined from them run into the standard absorption curve before the saturation point is reached; the subsequent desorption curves are therefore identical with the standard desorption curve. The curves obtained from these samples are thus quite normal for a limited cycle of this kind. The starting points of experiments D, E, and F, on the other hand, lie on the primary desorption curve before it runs into the standard desorption curve. The absorption curves from these points do not run into the standard absorption curve, their saturation values are higher, and the desorption curves lie above the standard desorption curve but below the primary desorption curve, running into the latter at the starting point. These results fully confirm the suggestion put forward in the previous paper of this series,[5] *viz.*: " It is probable that the area between the two desorption curves (standard and primary) may also be regarded

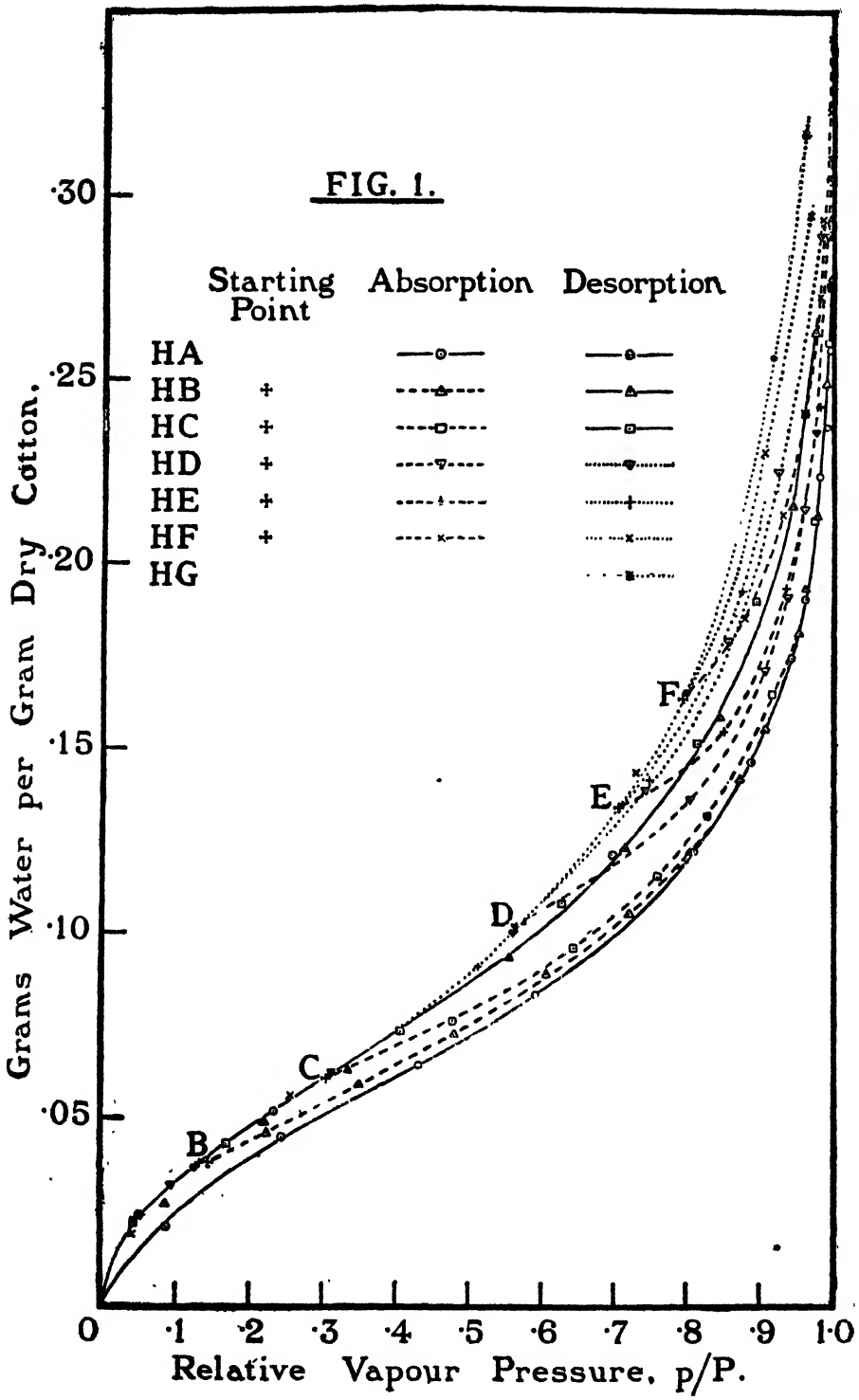


FIG. 1.
Starting Point
Absorption
Desorption
HA
HB
HC
HD
HE
HF
HG
B
C
D
E
F
·30
·25
·20
·15
·10
·05
0
·1
·2
·3
·4
·5
·6
·7
·8
·9
1·0
Grams Water per Gram Dry Cotton.
Relative Vapour Pressure, p/P.

Table VII

Adsorption of Water by Mercerised Yarns Dried to Various Extents at Room Temperature

p/P	a	p/P	a	p/P	a	p/P	a	p/P	a
HA		HB		HC		HD		HF	
·087	·0210	·144	·0384	·306	·0609	·566	·1024	·795	·1635
·244	·0453	·224	·0463	·479	·0763	·805	·1364	·881	·1856
·432	·0645	·351	·0597	·645	·0960	·908	·1712	·932	·2134
·593	·0836	·480	·0729	·761	·1156	·939	·1911	·962	·2411
·810	·1222	·608	·0893	·828	·1321	·963	·2150	·984	·2728
·889	·1463	·721	·1057	·917	·1650	·978	·2358	·988	·2938
·944	·1749	·806	·1221	·975	·2120	·996	·2892	·998	·3234
·963	·1907	·872	·1422	·995	·2600	1·000	·3105	1·000	·3432
·983	·2240	·908	·1557	·999	·2757				
·993	·2374	·954	·1814	1·000	·2913	·985	·2893	·971	·2948
·997	·2582	·964	·1936			·926	·2250	·908	·2304
1·000	·2774	·980	·2134	·895	·1899	·858	·1793	·731	·1436
		·992	·2494	·815	·1515	·744	·1387	·565	·1029
·963	·2406	·999	·2758	·629	·1082	·563	·1002	·258	·0562
·698	·1215	1·000	·2944	·406	·0737	·312	·0623	·040	·0186
·234	·0519			·169	·0433	·094	·0320		
·050	·0241	·977	·2632	·043	·0221			HG	
		·946	·2160			HE		·963	·3169
		·845	·1588			·707	·1342	·919	·2559
		·716	·1231			·851	·1548	·799	·1654
		·557	·0936			·936	·1935	·576	·1030
		·336	·0631			·982	·2430	·126	·0369
		·221	·0492			·998	·2890	·043	·0224
		·086	·0272			1·000	·3034		
						·876	·1929		
						·749	·1417		
						·514	·0910		
						·133	·0379		
						·053	·0239		

as an equilibrium area, but of a different kind from that between the standard absorption and desorption curves. The impairment of the adsorptive capacity brought about by drying probably occurs continuously down the primary desorption curve, so that after a sample has been dried down to a given point on it a certain part of the area above that point is no longer capable of representing the condition of the material, until when the standard desorption curve is reached at about 50 per cent. relative humidity the whole of the upper area is excluded." The additional and more accurate data now available, however, would indicate that the meeting of the primary and standard desorption curves occurs nearer 40 per cent. than 50 per cent. relative humidity, though there is no evident reason for supposing that the meeting must occur at the same humidity for different materials.

Effect of Chemical Attack

The effects of normal souring and chemicking treatments are shown in Table II ; it may be of interest, however, to place on record some figures for the hygroscopicity of cottons that have been attacked by acids and oxidising agents. Tables VIII to X give the results of an examination of some of the oxy- and hydro-celluloses prepared and examined by Birtwell, Clibbens, and Ridge[1], and Birtwell, Clibbens, and Geake[2]. It is evident that such chemical attack generally causes a decrease of hygroscopicity,

Table VIII

Relative Vapour Pressure p/P	Grams Water per Gram Dry Cotton, a					
	Roving 93	Hypobromite Oxycelluloses				
		RB4	RB3	RB1	RB2	RB5
·186	·029	·029	·029	·029	·029	·029
·387	·046	·046	·046	·046	·045	·045
·570	·064	·064	·063	·063	·061	·062
·785	·092	·092	·091	·091	·089	·089
·899	·130	·130	·128	·130	·126	·124
·961	·167	·166	·164	·163	·160	·158
·903	·148	·148	·146	·146	·142	·140
·796	·115	·115	·113	·114	·110	·109
·778	·110	·110	·109	·107	·106	·104
·596	·081	·079	·080	·078	·078	·076
·398	·054	·055	·054	·054	·053	·052
·204	·034	·035	·034	·034	·034	·034
Adsorption Ratio ...	1·000	1·001	0·988	0·989	0·969	0·960
% Oxygen[1] Consumed...	0·0	0·064	0·096	0·16	0·32	0·48
Log-Viscosity[1]	3·2	1·78	0·68	$\bar{1}$·96	$\bar{1}$·37	$\bar{1}$·09

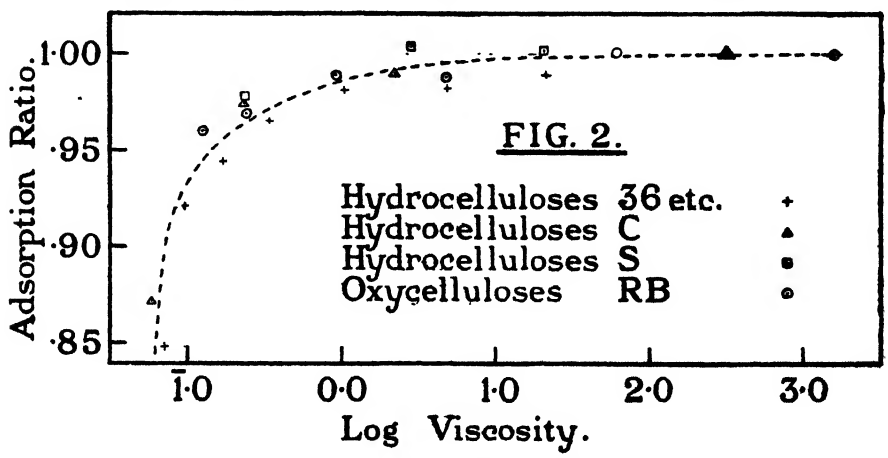
Table IX

Relative Vapour Pressure p/P	Grams Water per Gram Dry Cotton, a							
	Yarn 70C	Hydrocelluloses						
		36	37	38	39	40	41	42
·209	·030	·029	·029	·029	·028	·028	·028	·026
·390	·046	·045	·045	·046	·045	·044	·043	·040
·605	·065	·065	·065	·065	·064	·062	·060	·057
·790	·091	·091	·090	·090	·088	·086	·084	·079
·899	·123	·121	·120	·121	·118	·117	·111	·102
·959	·160	·158	·157	·157	·154	·150	·146	·128
·957	·189	·188	·186	·184	·180	·177	·174	·153
·900	·150	·148	·148	·147	·144	·142	·139	·124
·796	·115	·113	·113	·112	·110	·108	·106	·095
·606	·080	·079	·079	·078	·078	·075	·074	·067
·415	·056	·055	·055	·055	·054	·052	·051	·047
·217	·036	·035	·035	·035	·034	·033	·033	·032
Adsorption Ratio	1·000	0·989	0·982	0·981	0·965	0·944	0·921	0·848
Treatment[2] ...		Steeped in Sulphuric Acid Solution for 48 hrs. at 20° C.						
		Concentration of Acid (Grams per Litre)						
		100	200	300	400	500	600	700
Log-Viscosity[2] ...	2·5	1·33	0·69	0·02	1·53	1·23	$\bar{2}$·98	$\bar{2}$·85

Table X

Relative Vapour Pressure p/P	Grams Water per Gram Dry Cotton, a						
	Yarn 70C	Hydrocelluloses					
		S11	S12	S14	C3	C2	C1
·204	·030	·029	·030	·028	·029	·028	·026
·388	·046	·045	·046	·044	·045	·045	·040
·600	·066	·065	·065	·063	·065	·064	·057
·791	·091	·092	·092	·089	·091	·089	·079
·893	·120	·121	·121	·117	·120	·117	·102
·972	·171	·174	·173	·168	·169	·168	·144
·957	·190	·190	·192	·186	·189	·185	·166
·887	·143	·143	·143	·140	·141	·139	·126
·692	·092	·093	·092	·091	·091	·090	·081
·590	·077	·077	·077	·076	·076	·075	·067
·429	·057	·058	·057	·056	·056	·056	·049
·228	·036	·037	·037	·036	·036	·036	·032
Adsorption Ratio	1·000	1·002	1·004	0·978	0·990	0·975	0·872
Treatment[2] ...		Steeped in Sulphuric Acid Solution for 1 hr. at 100° C.			Steeped in Hydrochloric Acid Solution for 48 hrs. at 20° C.		
		Concentration of Acid					
		N/1000	N/100	N/10	100	200	300
					Grams per Litre		
Log-Viscosity[2] ...	2·5	1·31	0·45	$\bar{1}$·37	0·34	$\bar{1}$·36	$\bar{2}$·76

though there may be an initial slight increase in the " S " series of hydrocelluloses, which were treated with dilute acids at 100° C. The ratio of the amount of water adsorbed by the treated material to that adsorbed by the



untreated material shows no definite trend with humidity, and is sufficiently constant to permit of the use of its mean value as a measure of the change of hygroscopicity brought about by the treatment. This " adsorption

ratio " is in Fig. 2 plotted against the log-viscosity of the material in 2 per cent. cuprammonium solution. It appears from this Figure that there is no specific effect of either oxidising or acid attack, and as the log-viscosity of a technically bleached cotton should not be less than 1·0, while 0·0 represents considerable chemical attack, it is evident that the hygroscopicity change is inappreciable over the range to be expected in technical processing, and that it becomes large only when the attack is so serious as to cause almost complete loss of strength.

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11—INVESTIGATION OF DEFECTS: A MACHINE FOR TWISTING AND UNTWISTING SINGLE AND FOLDED YARNS

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(Wool Industries Research Association, Leeds)

The machine or apparatus, which is a compound differential mechanism, has been designed with the intention of producing a means whereby any folded yarn may be divided into its component singles. It had long since been found desirable to have such a machine in order to obtain more reliable data with respect to the single yarns which are of more particular concern in certain technical investigations than the folded yarn.

The usual procedure has been to untwist as long a length of yarn as possible by means of two twist testers and wind the singles on to bobbins. This method is far from being satisfactory although with exceptional care a fairly reliable result may be obtained, yet the whole is subject to personal error. By such a mechanical contrivance, as is hereinafter illustrated and described, it is possible to obtain the component singles from practically any length of folded yarn and submit the same to any test so desired.

THE DESIGN AND PRINCIPLE OF THE MACHINE

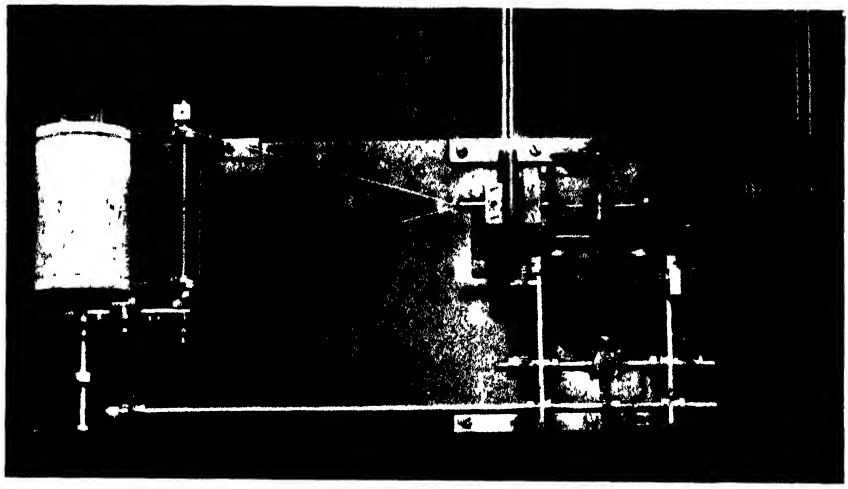
The twisting and untwisting part of the machine consists of three bevel gears, A referred to as the adjustable or regulating bevel, and B and B^1, referred to as the crown bevels, and a pair of nip rollers R and R^1, the speed and direction of which are controlled by bevel A, by means of a cone drive.

The nip rollers are carried by arms a and a^1, as also are the crown bevels, the latter transmitting motion to the former by means of centrally disposed spindles S and S^1, and a gear g and g^1, fixed on the spindle of the respective roller of each bevel B and B^1. The arms a and a^1 are fixed to a metal plate P, which is rotatably mounted on shaft XX^1 so that the crown bevels make a right-angle drive with the vertical bevel A, which is also carried by a horizontal shaft YY^1, which is situated in the same straight line as XX^1. Shaft YY^1 also carries a steep angled cone which is driven from a similar cone on the main shaft MN. Each shaft XX^1 and YY^1 contains a fine central bore through which the yarn passes.

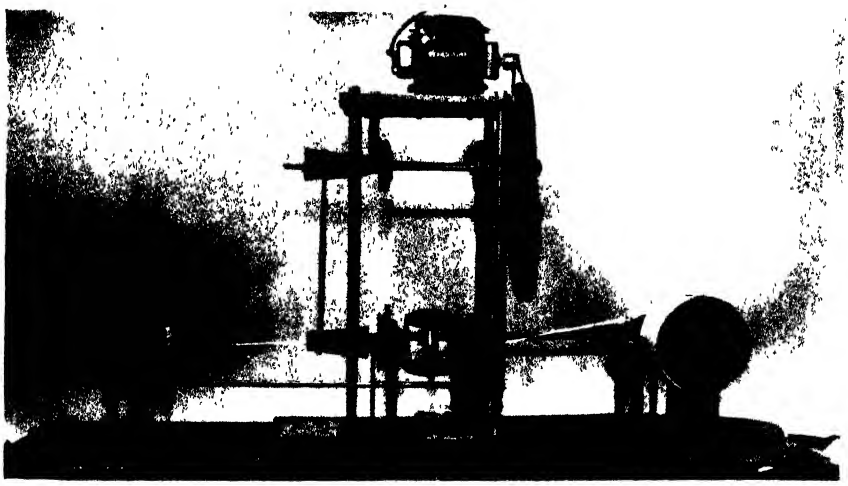
The drawing-off roller G is centred in the same plane as shafts XX^1 and YY^1 but at right-angles and receives the yarn from the delivery rollers RR^1, the yarn being evenly spaced over the roller G by means of travelling nuts and a feed-screw.

The take-up of roller G is kept in a constant ratio with the delivery of rollers RR^1 by means of a simple differential Z on the shaft CD, which communicates its motion to the transmitting shaft EF by means of its crown wheel as shown, which shaft EF revolves the roller G by means of bevel gears. A low shaft HK transmits motion to the yarn holder N, turning it in the same direction and at the same speed at which the crown bevels are rotated.

The transmitting shaft EF also communicates motion to a drum, moving it at a rate which varies in a constant ratio according to the variations of the rate of delivery of the nip rollers RR^1.



Untwisting a Left Twist Yarn (Yarn winding on under-side of drum)



Untwisting a Right Twist Yarn (Yarn winding on upper side of drum)

A scriber carried by the belt guide will record on a drum the movement of the belt along the cones and thus indicate the variations in delivery of the nip rollers RR^1 through the medium of bevel A necessitated by the variations in twist of the folded yarn.

From such a record a general impression of the distribution of the twist over an unlimited length of a yarn may be obtained.

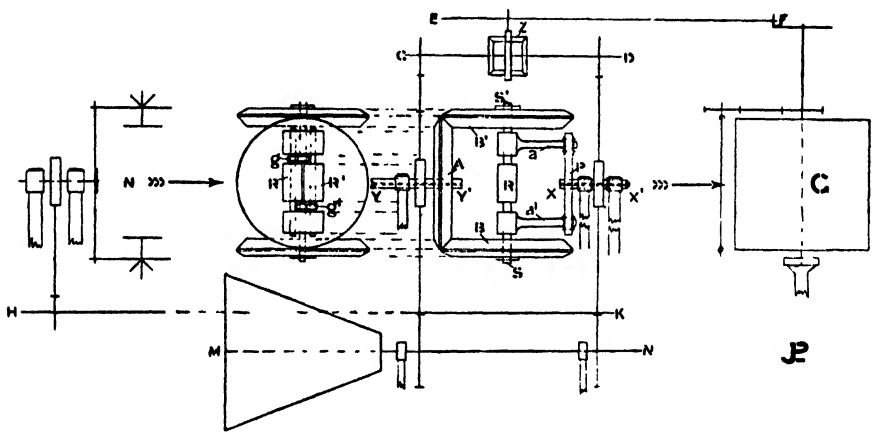
The whole mechanism is driven by two independent drives from shaft MN through shafts XX^1 and YY^1. The speed of shaft XX^1, or the rate at which the crown bevels B and B^1 are rotated, is constant.

THEORY OF THE MACHINE

It is desirable that the fundamentals of construction be as follows :—

(1) The effective gearing A, B, and B^1, R and R^1, the crown wheel of the simple differential have a fixed ratio of unity.

(2) The diameter D of rollers R and R^1 be one inch.



(3) The rate of rotation of the crown bevels be constant.

(4) The revolution of shafts XX^1 be for the purpose of inserting or extracting twist.

(5) The revolutions of shaft YY^1 be for the purpose of controlling the delivery of rollers R and R^1 through the medium of bevel A.

Let L = delivery of nip rollers in either (+) positive direction or (−) negative direction.

Let (±)N = the constant number of rotations of the crown bevels about bevel A or revolutions of shaft XX^1 in the positive or negative directions respectively.

Let ±x = the increase or decrease respectively in speed of bevel A from the constant speed N.

Let D = the diameter of each nip roller R and R^1.

When the signs plus or minus are enclosed in brackets thus (+) or (−) or (±x) they indicate respectively the positive or negative direction of revolution, i.e. looking in the direction of the arrow in the above diagram, a positive direction of revolution is clockwise, and a negative direction of revolution anticlockwise. Similarly, a positive delivery means that the

yarn is delivered by the nip rollers R and R^1 in the direction indicated by the arrows.

e.g. L = (−) (NπD) is read, L = NπD ins. in the negative direction and so on.

When shaft XX^1 makes (+)N turns

$$L = (\overset{\text{or}}{-}) (N\pi D) \text{ ins.} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

When shaft XX^1 makes (−)N turns

$$L = (+) (N\pi D) \text{ ins.} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

When shaft YY^1 makes (+)N turns

$$L = (+) (N\pi D) \text{ ins.} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

When shaft YY^1 makes (−)N turns

$$L = (-) (N\pi D) \text{ ins.} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

hence when shafts XX^1 and YY^1 make (+) N turns simultaneously, from (1) and (3)

$$L = O \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

and similarly when both shafts make (−)N turns simultaneously from (2) and (4)

$$L = O \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

Therefore to obtain a positive delivery with shaft XX^1 making (+)N turns from (1) and (3) shaft YY^1 must make

$$(+) (N + x) \text{ turns...} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

and similarly when shaft XX^1 makes (−)N turns from (2) and (4) shaft YY^1 will make

$$(-) (N - x) \text{ turns...} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

therefore generally from (7) and (8) to untwist left or crossband twist, bevel A must revolve at a greater speed than N ; and to untwist right or open band twist, bevel A must revolve at a speed less than N.

Therefore to untwist,

(*a*) *Left* twist, the direction of revolution must be positive (+) and bevel A = (N + x) revolutions.

(*b*) *Right* twist, the direction of revolutions must be negative (−) and bevel A = (N − x) revolutions.

Generally speed of A = N ± x according to the direction and amount of twist.

Let T_l = left twist, and T_r = right twist, from (1), (3), (5) and (7).

$$T_l = \frac{N}{(+x)\pi D} \text{ (when A makes + (N + x) revs.) ...} \quad (9)$$

from (2), (4), (6) and (8).

$$T_r = \frac{N}{(-x)\pi D} \text{ (when A makes − (N − x) revs.) ...} \quad (10)$$

Generally,

$$T = \frac{N}{(\pm x)\pi D} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

or when A makes (N + x) revs.

$$(+x) = \frac{N}{T\pi D} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (9a)$$

when A makes (N − x) revs.

$$(-x) = \frac{N}{T\ \pi\ D} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (10a)$$

Generally again

$$(\pm x) = \frac{K}{T} \text{ where } K = \frac{N}{\pi D} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (11a)$$

When the value of (x) has been obtained, by estimating the twist in the yarn in the usual manner and substituting for (T) in the formula, the constant value (N) is increased by (x) for left twist yarns and decreased by (x) for right twist yarns.

The reason for this is because of the change in the direction of the delivery of the nip rollers, with the change in the direction of rotation of the crown bevels.

When the crown bevels are rotated about bevel A in the positive direction, the delivery of the nip rollers is in the negative direction, hence, bevel A must revolve at a speed greater than that at which the crown bevels are rotated in order to effect a delivery in the positive direction, and similarly, when the crown bevels are rotated in the negative direction, the delivery of the nip rollers is positive, and bevel A must revolve at a speed less than that at which the crown bevels are rotated in order still to effect a positive delivery at a rate in accordance with the amount of twist to be extracted.

For twisting yarns, the general formula used for untwisting, i.e. (11a), $x(\pm) = \frac{K}{T}$ is applicable, the direction and amount of twist being noted and (x) calculated accordingly.

It will be conceivable from the foregoing that the machine, apart from untwisting or twisting yarns, is capable of indicating,

(1) an average folding twist for the yarn being untwisted ;
(2) any serious variations in take-up due to folding ;
(3) distribution of twist.

It will also provide an accurate means of reeling single yarns to permit of tests for count.

The importance of correct information, wherever possible, with respect to defective pieces, will be appreciated and it is with the intention of meeting industrial requirements that this machine has been designed.

ACKNOWLEDGMENTS

The author's thanks are due to Mr. Amos, Foreman of the Association's workshops, for the making and assembly of the parts of the machine. He is also indebted to Mr. F. Briggs for the preparation of the photographs.

REFERENCE

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12—THE EMULSION OILING OF WOOL

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During recent years, considerable advantages have been claimed for the use of emulsions of oil in water in preference to ordinary " dry " oils for the oiling of wool in woollen yarn manufacture in particular. These claims may have the merit of being based on trade opinion, but experimental evidence is not usually available for publication, and their validity has been thought worthy of independent investigation.

The reasons governing the use of oil in manipulating wool need not now be discussed—they have received repeated attention in the literature of the subject and it will be sufficient to state that the most successful results in yarn manufacture are obtained when the oil is uniformly distributed over the surface of the wool. This object is difficult of attainment because the surface exposed by the wool is enormous for its weight and only limited amounts of oil are used. A particular instance may serve to emphasise the difficulty : the external surface area of one pound of 64's merino wool is of the order of 80 square yards, and if this is to be oiled with, say, 12·5 per cent. of oil, 2 ounces of oil have to be distributed over this enormous area. In order to ensure that all fibres are oiled to some extent at least, the woollen industry is therefore compelled to use far greater amounts of oil than would be necessary if uniform distribution were easily attainable. In earlier times, difficulties of this kind were overcome by applying oil from a watering can to successive layers of wool, the resulting stack of material being allowed to stand, with frequent disturbance, for a considerable time before carding was attempted. Under such conditions, uniform distribution of oil was realised by its natural tendency to spread. It must not, however, be assumed that where such a method of applying oil is practicable, emulsions of oil in water—wool creams—can serve no useful purpose, for reasons to be discussed later in the paper. Modern conditions of manufacture, however, demand rapid manipulation, and every endeavour has been made to devise improved methods of oiling wool so as to achieve the desired uniformity of oil distribution rapidly. Among these may be noted the displacement of the primitive watering can by the atomiser, and the suggested use of wool creams in place of wool oils. As has already been indicated, the difficulty of ensuring uniform oiling is due to the fact that only limited quantities of oil are used on the wool. If, however, the oil is emulsified with an equal quantity of water the total bulk of liquid is increased without significant increase in cost, and the likelihood of uniform distribution of oil is correspondingly increased. Indeed, where oil emulsions are used, the improvement in the distribution of oil may be so great as to allow the actual amount of oil employed to be reduced below that normally possible when ordinary oils are used.

Such, then, is the main reason for the introduction of wool creams into the woollen industry, but following their successful application, numerous other claims have been made in their favour. Chief among these are the following : that their use gives a stronger yarn, more uniform in count and

twist, than is possible with ordinary oils. The purpose of the present investigation is to examine the validity of these claims.

EXPERIMENTAL

Two series of experiments were carried out. In the first, a 99/100 per cent. oleine was compared with an oleine-emulsion on a 56's New Zealand Corriedale wool. Although positive results were realised from the tests carried out on the resulting yarn, the work must be regarded as being simply preliminary to the second series of experiments, because the Corriedale wool used was too long in the staple for ideal working on the woollen card available. The second set of experiments was carried out on a 56's Down wool, olive oil being compared with olive oil-emulsions under improved conditions with the benefit of the earlier experience on oleine emulsions. It should perhaps be stated that olive oil was chosen for use, not because it normally finds application to woollens, which is far from being the case, but simply in order to obtain results for wool creams made from neutral oils as well as from oleine. Should both types of cream give the same general results, the latter can then be regarded as true for all kinds of oil.

It was clear from the outset that any difference between wool oils and wool creams would best be realised by carding immediately after oiling. If any considerable period should elapse between oiling and carding, the superior uniformity of oiling brought about in the case of wool creams by virtue of the greater bulk of liquid used, would be masked by the tendency of the oil to spread in the case of the material oiled with oil alone. Similarly the test would be invalidated by evaporation of water from the wool cream blend during the period of storage, since this water may have an important part to play in the subsequent behaviour of the wool. For both these reasons, the experiments to be described were carried out as rapidly as possible, carding being commenced immediately after the application of oil. In all cases, the oil or emulsion was applied by hand to the scoured wool before the latter was fed to the carding machine, every endeavour being made to realise uniform oiling, but without the aid of any mechanical device such as an atomiser.

Oleine Experiments

For the oleine experiments, the scoured wool was divided into two lots. One of these was oiled with 15 per cent. by weight of oleine and carded. The six condenser bobbins of roving obtained were then spun on the Whiteley mule to 11's (Y.S.) woollen yarn having 7 turns per inch twist. Two cops were taken from each condenser bobbin, making twelve in all, and the spindles on which the yarn was spun were marked. The second lot of wool was oiled with 30 per cent. by weight of a wool cream consisting of equal parts of oil and water. The composition of the oil was approximately as follows :—

Free fatty acids	...	...	28 per cent.
Glycerides	...	...	52 per cent.
Unsaponifiable matter		...	20 per cent.

and it was emulsified with the aid of a small quantity of ammonia in the water used to make the cream. This lot of wool was passed through the card immediately after the wool oiled with oleine and then spun on the same mule, the setting of both card and mule being left unaltered from one lot of

wool to the other. Two cops were again taken from each condenser bobbin, from the same marked spindles as before, in order to eliminate variations of spindle speed from the comparison of the two lots of yarn.

Olive Oil Experiments

In view of the experience gained in the preceding experiments, the work with olive oil was made still more precise. As already stated, a Down wool was chosen for experiment and the 50 lbs. of scoured wool available was divided into five lots. The first of these was oiled with 15 per cent. of olive oil, and while the material was being carded and spun, all the necessary adjustments were made to the card and mule, both machines being then left unaltered in subsequent experiments. The yarn produced from this lot of wool was discarded. In the second experiment, the wool was again oiled with 15 per cent. of olive oil, six condenser bobbins of roving being produced and converted into 11's (Y.S.) woollen yarn having 9 turns per inch twist. Two sample cops of yarn were taken from each condenser bobbin and the spindles marked as before, twelve cops being thus available for subsequent examination. The third lot of wool was oiled with 30 per cent. by weight of an olive oil cream prepared by emulsifying olive oil with an equal weight of water containing sufficient ammonia to neutralise an amount of free fatty acid in the oil equal to 1 per cent. of its weight. This was also converted into yarn and twelve sample cops taken from the same marked spindles as before. The fourth and fifth lots of wool were oiled with 22 per cent. of the same wool cream and 15 per cent. of olive oil, respectively, twelve sample cops being taken in each case for purposes of experiment from the same marked spindles. In these experiments, therefore, the wools oiled with emulsions were sandwiched between wools oiled with olive oil, and from the tests on the various yarns it should be possible to detect any progressive change in carding manipulation, as well as to test the reproducibility and reliability of the results by comparing the yarns produced on two separate occasions from the same wool oiled with the same amount of olive oil. As will be seen later, the results are surprisingly precise, and the precautions taken in yarn sampling appear to be definitely efficient.

Testing

In view of the purpose of these experiments, the yarns produced in the several ways described above were tested for strength, count and twist.

(a) Strength

For each method of oiling, twelve cops of yarn were available for test. These were conditioned for 14 days in a room maintained at 65 per cent. relative humidity and 72° F. before being used. The strength of the yarn was then determined in the same room by means of a Baer single thread tester. 50 observations were made on each cop, using 18-inch lengths of yarn, but in order to obtain a true mean value for the breaking load, the yarn tested was chosen from different parts of the several cops. With the first cop, tests were made from the outside inwards, but in the second case about one-third of the total length of yarn was reeled off before testing was commenced, the third cop being tested like the first, the fourth like the second, and so on. In all, 600 determinations of breaking load were made for each kind of yarn.

In order to obtain a measure of the uniformity of strength of the various yarns, the mean strength of each cop was calculated from the 50 determinations. The average deviation of the several results from the mean was then calculated. For each kind of yarn, twelve values for the average variation in yarn strength were thus obtained, one from each cop, and a final average of the twelve values was taken to obtain a mean value for the average variation in yarn strength. The results were also treated in a second way: the mean strength of each type of yarn was calculated from the 600 observations, and the average deviation of the results from this mean calculated. The second method gives higher values than the first because it includes variations in average yarn strength from cop to cop, but the data obtained in this way have their special uses.

The results obtained for the various yarns are summarised in the following table.

Table I

Oil	Mean Breaking Load of Yarn (ozs.)	Average Variation in Yarn Strength (1)	Average Variation in Yarn Strength (2)
Oleine. 15%	27·3	8·7%	13·8%
Oleine Cream. 30%	30·1	8·5%	10·6%
Olive oil. 15%	19·5	10·2%	12·8%
Olive oil cream. 30%	23·8	9·3%	10·5%
Olive oil cream. 22%	26·0	9·2%	11·1%
Olive oil. 15%	19·8	9·5%	12·5%

There can be no doubt that the preceding results serve to substantiate two of the claims made in favour of wool creams for use on woollens. Both with oleine and olive oil, the use of an emulsion of either oil gives a far stronger yarn than the corresponding " dry " oil. The increase in strength with oleine emulsions is not so well marked as with olive oil emulsions, but as previously pointed out, this is probably due to the unsuitability of the wool for the carding machine available. The results for olive oil are particularly interesting. In the first place, the mean strengths of the two lots of yarn produced with olive oil agree remarkably closely in spite of the fact that they were separated in their working by two lots of wool oiled with emulsions of olive oil. Secondly, the increase in strength produced by using 22 per cent. of the wool cream is greater than with 30 per cent., and both increases are remarkably high.

In regard to variations in yarn strength, it is apparent that the variation is in all cases less for wool creams than the corresponding oils. Although real, the difference is not unusually great, and it appears to be insufficient to account for the great increase in yarn strength given by wool creams. This is a fact of some importance in regard to the origin of the increased strength, a matter which will receive discussion later in the paper.

(b) Twist

Testing was carried out on Barker's twist testing machine using 10-inch lengths of yarn. Ten tests were made on each cop, 120 tests in all for each

kind of yarn, and the general average taken. The average variation in twist was calculated from this mean value.

Table II

Oil	Average Twist (turns per inch)	Average Variation in Twist %
Oleine. 15%	7·12	8·62
Oleine cream. 30%	7·29	9·31
Olive oil. 15%	9·22	9·48
Olive oil cream. 30%	9·48	9·58
Olive oil cream. 22%	9·33	8·12
Olive oil. 15%	9·52	10·4

In both sets of experiments, the amount of twist in the various yarns is independent of the method of oiling and is fairly constant, so that no correction of the observed yarn strengths need be made on this account. No discrimination can be made between wool oils and wool creams in respect of uniformity of twist, except perhaps in the case of the yarn oiled with 22 per cent. of olive oil cream which is definitely the best of the series.

(c) Counts

The usual procedure was followed in determining yarn counts, 30 yards being reeled from each cop and weighed. Thus 12 determinations were made for each lot of wool and the mean value calculated. The average count was further corrected for the amount of oil on the wool, the figures quoted below being based simply on the weight of wool, conditioned at 65 per cent. relative humidity and 72° F., in the yarn.

Regularity of count was determined by cutting 25 successive 9-inch lengths of yarn from each cop by means of the apparatus used by Goodings[1] in his studies of drafting. These 9-inch strips were weighed in the humidity room, 300 results being obtained for each type of yarn (12 cops). The average deviation of the several results from the mean gives a measure of the regularity of count of the various yarns.

Table III

Oil	Average Count (Y.S.)	Average Variation in Count %
Oleine. 15%	12·6	8·1
Oleine Cream. 30%	12·2	8·1
Olive oil. 15%	12·1	8·0
Olive oil cream. 30%	11·6	8·1
Olive oil cream. 22%	11·0	7·5
Olive oil. 15%	12.0	8·2

Within the limits of experimental error, all the yarns appear to be equally uniform in count, except perhaps the yarn oiled with 22 per cent. of olive oil cream, which is again the best of the series. A surprising feature of the

results is that the yarns produced with wool creams are in all cases smaller in count than the yarns oiled with the corresponding oils.* In the case of olive oil, these differences in count are too great to be ignored when comparing the strengths of the several yarns. The observed strengths have therefore been reduced to a standard count of 11·5 (Y.S. woollen) on the assumption that the strength is in each case inversely proportional to the observed count. Values for the corrected strengths of the various yarns are given in the following table.

Table IV

Oil	Corrected Strength (ozs).
Olive oil. 15%	20·5
Olive oil cream. 30%	24·0
Olive oil cream. 22%	24·9
Olive oil. 15%	20·7

DISCUSSION OF RESULTS

The preceding data indicate beyond doubt that the use of wool creams gives a far stronger yarn than the normal practice of using oil, especially under conditions of rapid working. The results for wool oiled with 22 per cent. by weight of the olive oil cream are particularly remarkable, this yarn being the strongest and most regular in count and twist of the series, An attempt was first made to refer the increased strength to the part played by the water added with the oil to the wool before carding. In the case of the wool oiled with 22 per cent. of olive oil cream, 11 per cent. of water was added to wool which already contained 18 per cent. of water. Thus the wool was almost saturated with water when carding was commenced, and under the action of the card wires, the individual fibres would be readily straightened and perhaps stretched. It is, however, well known that the majority of the added water evaporates from the wool before it reaches the condenser, so that the fibres are drawn taut in the wet condition and dried before they have the opportunity to recover their original form. Their new configuration will therefore be semi-permanent and the resulting roving and yarn, being composed of straightened fibres, will be more compact in structure than corresponding roving and yarn made from " dry-oiled " wool. The preceding deduction finds confirmation in the fact that roving produced from wool oiled with wool creams packs more compactly on the condenser bobbin than roving prepared from wool oiled with oil alone. In the above experiments with olive oil creams, the increase in compactness amounted to 7·2 per cent. The use of wool creams on woollens suggests many analogies with the " wet " carding of worsteds, and it is therefore interesting to note that wool creams

*This result is sufficiently anomalous to deserve comment. Since the carding machine was set for wool oiled with olive oil and then left unaltered in subsequent experiments, the count of the yarn oiled with cream should have been greater than that for the olive oil yarn. Nevertheless, the facts are as stated. A possible explanation is that the concentration of wool on the card is always greater when creams are used. In view of the more efficient lubrication given by wool creams (*vide infra*), and the tendency they have to promote the removal of crimp, there is nothing improbable in the experimental result.

are stated to have a *tendency* to impart a worsted appearance to a woollen yarn. This observation is again in keeping with the hypothesis of straightened fibres. If the preceding were the only explanation of the increased yarn strength given by wool creams, the increased strength should be counterbalanced by a reduced extension at break. This is far from being the case, as shown by the following data, which were obtained simultaneously with the strength tests recorded previously.

Table V

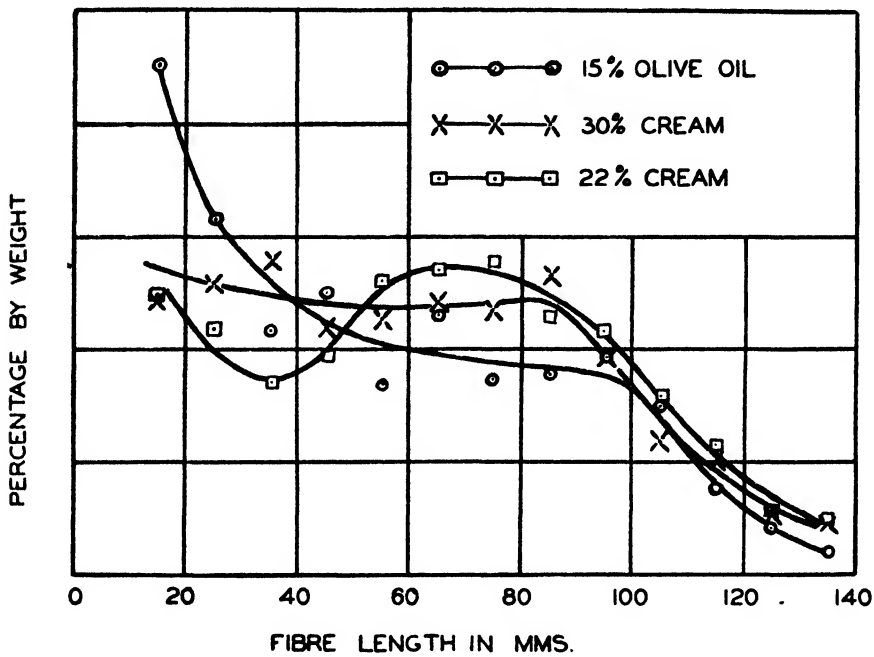
Oil	Average Percentage Extension at Break (600 Observations)
Olive oil. 15%	21·1
Olive oil cream. 30%	23·8
Olive oil cream. 22%	25·1
Olive oil. 15%	22·3

Obviously only a very minor part can be played by the straightening and stretching of fibres in determining the increased strength of yarn given by wool creams. The above hypothesis must therefore be supplemented by assuming what is inherently probable, that the greater bulk of liquid applied to wool in emulsion oiling leads to a better distribution of oil, which is remarkably efficient in minimising fibre breakage. In order to test this assumption, Mr. W. Sever, M.Sc., has kindly determined for us the percentage by weight of fibres of different lengths in the three types of roving under consideration—those oiled with 15 per cent. of olive oil, 30 per cent. olive oil cream and 22 per cent. olive oil cream—using the instrument[3] he has recently devised in this laboratory. Three tufts, each containing approximately 120 fibres, were prepared from each roving in the manner described for top by Wilkinson[3]. In view of the way in which the samples are prepared for analysis, the percentage by weight of fibres of various lengths in the roving is obtained directly from the length measurements. The results are given in Table VI.

Table VI

Fibre Length mm.	Percentage by Weight in Roving oiled with 15% olive oil	30% cream	22% cream
10— 20	18·1	9·7	9·9
20— 30	12·6	10·4	8·7
30— 40	8·6	11·1	6·8
40— 50	10·0	8·7	7·8
50— 60	6·7	9·1	10·4
60— 70	9·2	9·6	10·8
70— 80	6·9	9·3	11·1
80— 90	7·1	10·6	9·1
90—100	7·7	7·6	8·6
100—110	6·0	4·7	6·3
110—120	3·0	4·0	4·5
120—130	1·6	2·1	2·2
130—140	0·8	1·8	1·9
over 140	1·5	1·4	2·0

It is at once evident from these figures and the accompanying graph, that the wool oiled with 15 per cent. of olive oil contains the greatest number of short fibres, while that oiled with 22 per cent. of olive oil cream contains relatively few short fibres and the greatest proportion of long ones. Perhaps the most effective summary of the data is given by stating that the percentage by weight of fibres greater than 50 mm. in length is 50·5 per cent. for 15 per cent. olive oil, 60·2 per cent. for 30 per cent. olive oil cream and 66·9 per cent. for 22 per cent. olive oil cream. These values are in precisely the same order as those for yarn strength given previously, and the marked superiority of wool creams must be referred definitely to reduced fibre



breakage. Of particular interest in this connection is the fact that breakage is less in the case of wool oiled with 22 per cent. of olive oil cream than with 30 per cent., although the amount of oil used is greater in the latter instance. The improved distribution of oil given by using 30 per cent. of the cream must be counterbalanced by the effect of the large amount of added water in weakening the fibres and facilitating breakage. Hence in order to obtain the best results with wool creams, it is clearly necessary to adjust the proportions of oil and water to suit the water content of the wool in use. Although 22 per cent. by weight of the olive oil cream used in these experiments is so much superior to 15 per cent. of olive oil, there is no reason to assume that this composition and amount of cream represent the optimum conditions attainable.

In conclusion, there can be no doubt that wool creams give a far stronger yarn than ordinary " dry " oils under conditions of rapid working. They appear to function mainly by promoting uniform oil distribution, which in turn minimises fibre breakage. It has to be admitted that the conditions under which oils and emulsions have been compared, although strictly

impartial, are such as to reveal the maximum possible advantage to be derived from the adoption of emulsion oiling. This is because carding was carried out immediately after oiling, but even when prolonged storage of oiled wool is customary, wool creams can give no worse results than ordinary oils; while under normal conditions of storage for a limited time, they will undoubtedly be superior.

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13—THE ADSORPTION OF WATER BY RAYON

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INTRODUCTION AND SUMMARY

A considerable amount of work has already been done with a view to determining the relation between the regain of rayon and the relative humidity of the atmosphere to which it is exposed. Whilst many of the investigations are of little value as contributions to a serious study of the subject, being concerned merely with the determination of average regain values in atmospheres of uncontrolled humidity and temperature, others compare the regains in adequately controlled atmospheres, over a sufficiently wide range to permit the construction of the adsorption isotherms. [1, 2, 3, 5, 6, 15]

As a result of these investigations it is known that the regenerated cellulose rayons give curves similar to those given by cotton and mercerised cotton, with a like hysteresis. The absolute values of the regain, however, are higher even than those of mercerised cotton, and there appears to be agreement that the highest hygroscopicity is exhibited by cellulose regenerated from cellulose nitrate. It is also known that esterification greatly reduces the hygroscopicity of cellulose. The difference between a regenerated cellulose and a cellulose ester, however, lies not only in the absolute values of the regains, but also in the form of the curves; cellulose acetate, for example, does not give a sigmoid curve like those of cotton and the regenerated celluloses.

The present paper describes the application of the methods previously developed for cotton[7-14] to the determination of the regain-relative humidity curves for a series of rayons, most of them being in the form in which they are, or were, commercially obtainable. The results are of interest principally as data for reference purposes, and the general conclusions are for the most part in agreement with those of the earlier workers referred to above.

RESULTS AND DISCUSSION

The materials examined are enumerated below under the names by which they are designated in the Tables and text:

Viscose rayons.			
" A Quality "	150 den.	Courtaulds Ltd.;	1928
" Escorto "	150 den.	Courtaulds Ltd.;	1928
" Dulesco."	150 den.	Courtaulds Ltd.;	1928
" Tudenza."	150 den.	Courtaulds Ltd.;	1928
" Dulenza."	150 den.	Courtaulds Ltd.;	1928
" Snia."	150 den.	Snia Viscosa (Italy);	1929
" Celta " (Hollow Viscose).	150 den.;	Kemil Ltd.;	1928
" Fibro " (Staple Fibre).		Courtaulds Ltd.;	1929
" Vistra " (Staple Fibre).		I. G. Farbenindustrie Aktiengesellschaft (Germany);	1929

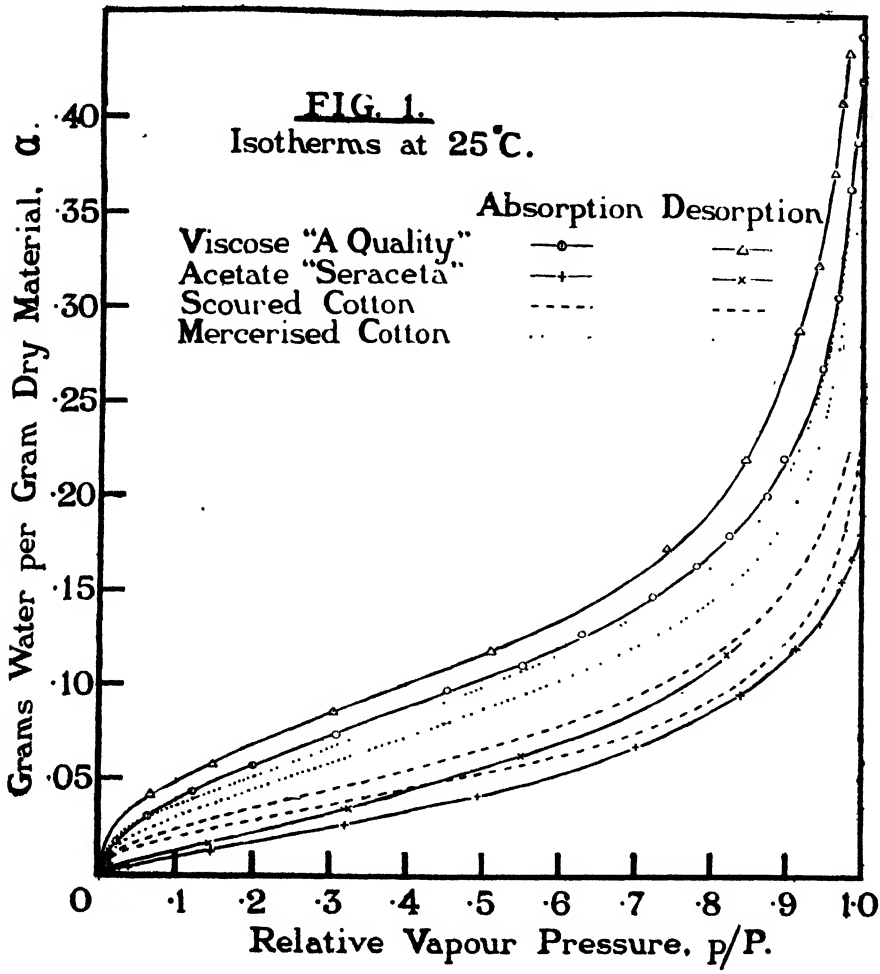
Viscose sheet.			
" Cellophane "	·04 mm. thick;	The Cellophane Co. Ltd.;	1928
Washed with distilled water to remove glycerol.			
Lilienfeld viscose rayons.			
" Sample A."	80 den.;	Courtaulds Ltd.;	1929
This was an experimental material, and is not on the market.			
" Durafil."	160 den.;	Courtaulds Ltd.;	1929
" Tenasco."	150 den.;	Nuera Art Silk Co. Ltd.;	1929
Cuprammonium rayons.			
" Brysilka Unbleached."	150 den.;	Brysilka Ltd.;	1928
" Brysilka Unbleached Desoaped."	150 den.;	Brysilka Ltd.;	1928
Acid washed and extracted with ether.			
" Brysilka Bleached."	150 den.;	Brysilka Ltd.;	1928
" Bemberg Oiled."	150 den.;	J. P. Bemberg A. G. (Germany);	1929
" Bemberg Desoaped."	150 den.;	J. P. Bemberg A. G. (Germany);	1929
Acid washed and extracted with ether.			
Nitrocellulose rayons.			
" Obourg."	90 den.;	Fabrique de Soie artificielle d'Obourg S.A. (Belgium);	1928
Cellulose acetate rayons.			
" Celanese."		British Celanese Ltd.;	1928
" Seraceta."	75 den.;	Courtaulds Ltd.;	1928
" Seraceta Desoaped."	75 den.;	Courtaulds Ltd.;	1928
Acid washed and extracted with ether.			

The experimental results given in this paper were all obtained by the vacuum method, which has already been described.[12] The method was perfectly satisfactory for the majority of these materials, but a few of them caused a blackening of the surface of the mercury in the manometer, probably owing to the distillation of free sulphur present in the rayon. This was very pronounced with " Tudenza," which by the end of the experiment was quite black owing to the concurrent distillation of mercury; it was slightly noticeable with " Dulenza " and " Fibro", but none of the others showed any sign of it. Except for the increased difficulty of reading the mercury level, whereby the pressure readings may be slightly less accurate, it is improbable that this complication has appreciably affected the results given by these materials.

The experimental results are presented in Table I, and figures interpolated from separately drawn curves are given in Table II, in order to facilitate comparison of the different rayons. As has been customary in this work,[7-14] the results are expressed in terms of the relative vapour pressure of water in the rayon, denoted by p/P, and the weight of water in grams per gram of dry rayon, denoted by a. Multiplied by 100, these figures become per cent. relative humidity and per cent. moisture regain respectively. It should perhaps be mentioned that the figures apply only to the samples examined; it is not known what variation is to be expected in different batches of the same brand.

The regain-relative humidity curves for the regenerated celluloses, i.e., the viscose, Lilienfeld viscose, cuprammonium and nitro rayons, are all of the same form as those for cotton and mercerised cotton, but the actual

values of the regain at any particular humidity are all appreciably higher. This is illustrated in Fig. 1, where the isotherm for " A Quality " viscose rayon is shown together with those for a scoured cotton and a mercerised cotton. The mercerised cotton represented in Fig. 1, was the scoured cotton 85R mercerised without tension in 15 per cent. caustic soda solution and dried at room temperature; the increase of hygroscopicity occasioned by this process is slightly less than the maximum increase that can be obtained by laboratory experiments, but is much greater than that ever shown by a



technically mercerised cotton.[7, 13] From the standpoint of moisture adsorption, therefore, the regenerated celluloses behave as mercerised cottons with abnormally great affinities for water; it has already been shown[7, 13] that the ratio a mercerised cotton/a scoured cotton is practically constant at all values of the relative vapour pressure, and it appeared of interest to enquire if a similar effect could be observed with the rayons. Accordingly in Table III the ratios of the regains of the regenerated cellulose rayons to the corresponding regain of the scoured cotton 85R are given. It is apparent from the Table that these ratios, instead of being independent of the humidity, change with the humidity in a similar way for all these materials. The absorption

figures increase fairly rapidly with p/P to a maximum somewhere about $p/P = 0{\cdot}25$, after which further increase of p/P causes a steady decrease of the ratio. Most of the desorption ratios decrease slightly as p/P is lowered from 0·95 to 0·80, after which further lowering causes a steady increase. It is perhaps not surprising that the adsorption ratios of the rayons do not exhibit the constancy of those of the mercerised cottons, for the selection of a standard cellulose for comparison with the rayons must of necessity be arbitrary, and many of the rayons contain appreciable amounts of non-cellulosic substances, either produced during manufacture or deliberately added for particular purposes.

Owing to this variation of the ratio with p/P the mean values given in Table III have little intrinsic significance; they may, however, be used as rough measures for comparing the hygroscopicities of the regenerated cellulose rayons.

The rayons exhibit the phenomenon of hysteresis already observed for cotton and mercerised cotton,[7,14] and a few desiccator experiments have shown beyond doubt that for them also the absorption and desorption curves are merely the limits of an equilibrium area, any point of which is capable of representing the state of the material under suitable conditions of humidity and prehistory.[10] The "adsorption ratios" of the regenerated celluloses are, except for the two staple fibre rayons "Fibro" and "Vistra," less in desorption than in absorption, an effect that has already been observed for mercerised cotton.

An examination of the mean ratios is sufficient to show that the hygroscopicities of these regenerated cellulose rayons cover a fairly wide range, the absorption ratios of the commercial materials varying between 2·12 and 1·75. In the absence of any very definite information with regard to the method of manufacture or the non-cellulosic matters present in them there is little to be gained by any extended discussion of the differences here made manifest; a few points, however, may be noted.

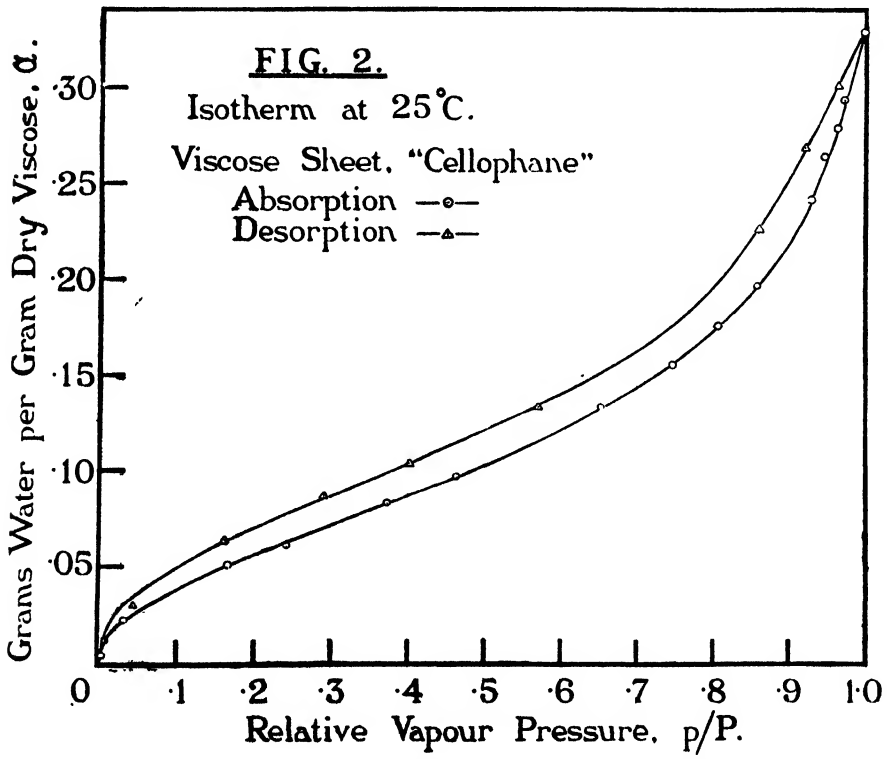
If the data given by the one nitro rayon examined may be taken as typical of nitro rayons in general, it is plain that the processes involved in the manufacture of this material result in more extensive dispersion of the cellulose than either the viscose or the cuprammonium process. (It may be noted that the production of nitro rayon also results in greater chemical modification of the cellulose).[4]

Another interesting feature is an apparent inverse connection between hygroscopicity and the amount of oily matter in the material. The five rayons "A Quality," "Escorto," "Dulesco," "Tudenza," and "Dulenza" are the products of one manufacturer, and are probably fairly similar in basic constitution, so that their different hygroscopicities may be attributable to a considerable extent to the presence of non-cellulosic substances. The results of a large number of isolated measurements on different textile materials have indicated that the presence of fat or oil may reduce the hygroscopicity more than would be expected if it acted merely as a non-hygroscopic loading material, and in this connection the following figures for these rayons are of interest:

	Escorto	A Quality	Dulenza	Dulesco	Tudenza
% Extractable Matter[4]	0·21	0·57	0·56	0·80	1·36
Mean Ratio	2·04	1·90	1·89	1·77	2·04

If the figures for " Tudenza " are neglected there is evidently a decrease of hygroscopicity with increase of the amount of extractable matter. " Tudenza " is far out of place in this series; but " Tudenza " is in other respects abnormal. It contains a relatively large proportion of free sulphur, much of which is removed mechanically in the ether extraction, but even when this is allowed for, the ether extract remains abnormally large for a rayon that has not been delustred with oil, as have " Dulesco " and " Dulenza."

The regains of the three acetate rayons examined are all very similar, but as will be evident from Fig. 1 the curves they yield are quite different in form from those of cotton and the regenerated celluloses, the rapid rise at low humidities being absent. This behaviour is obviously connected with the diminution of the number of free hydroxyl groups caused by the esterification; it is undesirable, however, to discuss the theoretical aspect of the work until the rather scanty experimental data so far available have been supplemented by measurements of the adsorption of a series of vapours by regenerated cellulose and cellulose ester rayons.



In previous work with cotton and mercerised cotton it was found that there was never any tendency for the hysteresis loop to close at the saturation point,[7-14] and it was suggested that this might be due to the filling with water of the small capillary spaces that must exist *between* the cotton hairs.[10,12] All the rayon yarns examined show the same effect, and of course the same explanation is applicable. In this connection the results obtained from the sheet viscose " Cellophane " are interesting, for with it there cannot be such a system of capillary spaces. Fig. 2 showns the isotherm for this material,

and as far as one may judge the hysteresis loop does in fact close at the saturation point. The evidence can hardly be regarded as conclusive, since the displacement of only one point on the desorption curve would be sufficient to keep the curves apart, but at least it provides additional support for an explanation that has already a fair amount of evidence in its favour.

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Table I

Adsorption of Water by Rayons at 25° C.

Experimental Data.

Each determination consists of two values separated by a comma, the first being p/P, the second the corresponding value of a. Distinct determinations are separated by a semi-colon.

Viscose, "A Quality." Absorption, ·010, ·0067; ·023, ·0168; ·063, ·0302; ·121, ·0436; ·200, ·0571; ·309, ·0739; ·454, ·0972; ·552, ·1106; ·630, ·1271; ·722, ·1470; ·781, ·1636; ·825, ·1802; ·875, ·2011; ·898, ·2216; ·949, ·2695; ·970, ·3072; ·985, ·3650; ·994, ·3898; 1·000, ·4226; 1·000, ·4454. Desorption, ·982, ·4371; ·972, ·4102; ·964, ·3733; ·943, ·3240; ·916, ·2891; ·847, ·2208; ·742, ·1728; ·511, ·1179; ·305, ·0861; ·148, ·0579; ·067, ·0420.

Viscose, "Escorto." Absorption, ·060, ·0342; ·203, ·0618; ·462, ·1032; ·676, ·1439; ·805, ·1815; ·873, ·2117; ·931, ·2526; ·959, ·2809; ·978, ·3144; ·993, ·3562; ·994, ·3908; 1·000, ·4165; 1·000, ·4529. Desorption, ·978, ·4392; ·951, ·3556; ·914, ·2934; ·860, ·2426; ·780, ·2003; ·668, ·1650.

Viscose, "Dulesco." Absorption, ·008, ·0100; ·057, ·0261; ·140, ·0422; ·294, ·0663; ·512, ·0987; ·687, ·1311; ·829, ·1716; ·882, ·1990; ·934, ·2410; ·967, ·2795; ·981, ·3116; ·994, ·3406; 1·000, ·3884; 1·000, ·4053. Desorption, ·975, ·3852; ·962, ·3390; ·920, ·2630; ·875, ·2266; ·808, ·1914; ·696, ·1518; ·525, ·1181; ·371, ·0947; ·258, ·0782; ·124, ·0536; ·032, ·0276.

Viscose, "Tudenza." Absorption, ·012, ·0120; ·049, ·0283; ·115, ·0446; ·211, ·0610; ·375, ·0885; ·539, ·1159; ·643, ·1376; ·743, ·1648; ·831, ·1978; ·889, ·2296; ·960, ·3154; ·983, ·3540; ·996, ·4160; 1·000, ·4576. Desorption, ·981, ·4183; ·967, ·3652; ·945, ·3232; ·913, ·2760; ·838, ·2184; ·687, ·1616; ·537, ·1297; ·310, ·0887; ·118, ·0565.

Viscose, "Dulenza." Absorption, ·003, ·0043; ·016, ·0140; ·060, ·0285; ·124, ·0430; ·242, ·0622; ·362, ·0815; ·526, ·1057; ·657, ·1298; ·771, ·1588; ·822, ·1782; ·919, ·2338; ·944, ·2590; ·963, ·2924; ·980, ·3258; ·986, ·3648; 1·000, ·4072; 1·000, ·4133. Desorption, ·970, ·3642; ·963, ·3456; ·952, ·3225; ·926, ·2841; ·899, ·2552; ·817, ·1980; ·716, ·1629; ·587, ·1332; ·307, ·0845; ·109, ·0516; ·033, ·0282.

Viscose "Snia." Absorption, ·004, ·0092; ·035, ·0250; ·118, ·0461; ·208, ·0619; ·408, ·0935; ·568, ·1198; ·707, ·1462; ·830, ·1832; ·908, ·2222; ·948, ·2508; ·987, ·3046; 1·000, ·3462; 1·000, ·3722. Desorption, ·948, ·3338; ·918, ·2864; ·884, ·2545; ·821, ·2115; ·774, ·1920; ·716, ·1751; ·624, ·1498; ·308, ·0908; ·212, ·0764; ·157, ·0663; ·120, ·0577; ·086, ·0495; ·056, ·0404.

Viscose, "Celta." Absorption, ·009, ·0070; ·040, ·0244; ·113, ·0419; ·253, ·0682, ·467, ·1032; ·610, ·1296; ·720, ·1555; ·825, ·1914; ·884, ·2276; ·931, ·2637; ·973, ·3261; ·986, ·3645; ·997, ·4026; 1·000, ·4482; 1·000, ·4762. Desorption, ·983, ·4523; ·974, ·4040; ·957, ·3496; ·935, ·3073; ·889, ·2622; ·829, ·2292; ·742, ·1884; ·617, ·1575; ·472, ·1269; ·269, ·0890; ·174, ·0727; ·085, ·0485.

Staple Fibre Viscose, "Fibro," Absorption, ·004, ·0083; ·061, ·0298; ·166, ·0516; ·268, ·0680; ·442, ·0954; ·574, ·1169; ·713, ·1439; ·808, ·1714; ·905, ·2152; ·950, ·2533; ·985, ·2972; 1·000, ·3432; 1·000, ·3622. Desorption, ·956, ·3350; ·925, ·2923; ·880, ·2431; ·808, ·2022; ·679, ·1588; ·518, ·1266; ·362, ·0994; ·238, ·0794; ·150, ·0648; ·102, ·0540; ·069, ·0453.

Staple Fibre Viscose, "Vistra." Absorption, ·015, ·0090; ·069, ·0270; ·160, ·0451; ·278, ·0631; ·444, ·0883; ·567, ·1064; ·680, ·1278; ·782, ·1493; ·879, ·1859; ·951, ·2418; ·976, ·2737; ·993, ·3100; 1·000, ·3263. Desorption, ·933, ·3091; ·887, ·2538; ·813, ·2006; ·717, ·1629; ·582, ·1296; ·437, ·1037; ·300, ·0821; ·203, ·0668; ·136, ·0555; ·097, ·0468; ·056, ·0362.

Lilienfeld Viscose, Sample "A." Absorption, ·009, ·0046; ·028, ·0149; ·080, ·0288; ·158, ·0426; ·266, ·0600; ·368, ·0738; ·473, ·0876; ·585, ·1013; ·712, ·1286; ·767, ·1422; ·830, ·1590; ·886, ·1792; ·925, ·1980; ·957, ·2306; ·978, ·2541; ·981, ·2747; ·986, ·2921; ·989, ·3068; ·999, ·3632; 1·000, ·3695; 1·000, ·3961. Desorption, ·988, ·3596; ·954, ·2826; ·909, ·2282; ·786, ·1628; ·674, ·1332; ·549, ·1119; ·055, ·0288.

Lilienfeld Viscose, "Durafil." Absorption, ·002, ·0044; ·030, ·0191; ·089, ·0339; ·181, ·0527; ·294, ·0715; ·425, ·0903; ·538, ·1092; ·644, ·1276; ·745, ·1535; ·840, ·1832; ·906, ·2163; ·964, ·2795; ·977, ·3144; ·985, ·3452; ·993, ·3682; ·998, ·3871. Desorption, ·974, ·3760; ·964, ·3464; ·944, ·3029; ·905, ·2564; ·852, ·2208; ·774, ·1866; ·635, ·1470; ·431, ·1080; ·196, ·0690; ·112, ·0538; ·045, ·0351.

Table I—Continued.

Adsorption of Water by Rayons at 25° C.

Experimental Data.

Each determination consists of two values separated by a comma, the first being p/P, the second the corresponding value of a. Distinct determinations are separated by a semi-colon.

Lilienfeld Viscose, "Tenasco." Absorption, ·005, ·0068; ·047, ·0252; ·132, ·0436; ·273, ·0690; ·395, ·0906; ·493, ·1122; ·588, ·1339; ·777, ·1807; ·869, ·2126; ·937, ·2481; ·983, ·2984; ·992, ·3316; ·996, ·3534. Desorption, ·942, ·3121; ·916, ·2674; ·793, ·2086; ·661, ·1696; ·480, ·1315; ·329, ·1066; ·235, ·0883; ·139, ·0682; ·078, ·0510; ·033, ·0322.

Sheet Viscose, "Cellophane." Absorption, ·002, ·0046; ·007, ·0120; ·032, ·0226; ·165, ·0511; ·242, ·0617; ·373, ·0830; ·464, ·0972; ·652, ·1327; ·747, ·1555; ·807, ·1755; ·859, ·1966; ·929, ·2418; ·947, ·2644; ·964, ·2792; ·974, ·2939; 1·000, ·3295. Desorption, ·965, ·3016; ·921, ·2688; ·861, ·2266; ·570, ·1335; ·402, ·1038; ·290, ·0870; ·162, ·0640; ·043, ·0304.

Cuprammonium, Brysilka, Unbleached. Absorption, ·009, ·0084; ·036, ·0194; ·111, ·0358; ·204, ·0522; ·337, ·0742; ·550, ·1066; ·724, ·1386; ·857, ·1816; ·912, ·2115; ·940, ·2354; ·956, ·2542; ·971, ·2694; ·983, ·2936; ·995, ·3383; 1·000, ·3729; 1·000, ·3868. Desorption, ·979, ·3695; ·949, ·3099; ·852, ·2098; ·652, ·1409; ·522, ·1175; ·367, ·0922; ·189, ·0647; ·071, ·0394.

Cuprammonium, Brysilka, Unbleached, Desoaped. Absorption, ·004, ·0099; 070, ·0324; ·191, ·0548; ·334, ·0771; ·453, ·0994; ·673, ·1329; ·765, ·1553; ·859, ·1886; ·938, ·2388; ·977, ·2947; 1·000, ·3503. Desorption, ·947, ·3162; ·931, ·2896; ·913, ·2648; ·851, ·2168; ·751, ·1746; ·623, ·1400; ·473, ·1136; ·317, ·0886; ·183, ·0671; ·081, ·0465; ·021, ·0261.

Cuprammonium, Brysilka, Bleached. Absorption, ·012, ·0113; ·069, ·0320; ·182, ·0528; ·311, ·0734; ·525, ·1044; ·643, ·1250; ·763, ·1559; ·839, ·1816; ·891, ·2074; ·937, ·2485; ·988, ·3618; ·998, ·3982; 1·000, ·4182. Desorption, ·979, ·3728; ·952, ·3192; ·911, ·2553; ·841, ·2050; ·718, ·1576; ·481, ·1136; ·351, ·0856; ·217, ·0694; ·123, ·0539; ·075, ·0437; ·048, ·0371.

Cuprammonium, Bemberg, Oiled. Absorption, ·008, ·0125; ·080, ·0328; ·144, ·0479; ·314, ·0729; ·486, ·0978; ·634, ·1230; ·750, ·1480; ·848, ·1775; ·922, ·2174; ·981, ·3032; ·995, ·3358; 1·000, ·3628; 1·000, ·3735. Desorption, ·957, ·3261; ·907, ·2551; ·767, ·1748; ·638, ·1445; ·408, ·1008; ·114, ·0544; ·026, ·0285.

Cuprammonium, Bemberg, Desoaped. Absorption, ·012, ·0097; ·036, ·0209; ·105, ·0378; ·272, ·0658; ·421, ·0883; ·564, ·1109; ·729, ·1444; ·821, ·1724; ·888, ·2008; ·932, ·2293; ·981, ·2880; ·993, ·3192; ·996, ·3418; 1·000, ·3688. Desorption, ·952, ·3154; ·936, ·2938; ·895, ·2452; ·829, ·2016; ·643, ·1463; ·495, ·1151; ·364, ·0936; ·247, ·0751; ·158, ·0585; ·074, ·0380.

Nitro, Obourg. Absorption, ·011, ·0117; ·032, ·0233; ·097, ·0408; ·176, ·0583; ·302, ·0817; ·474, ·1113; ·695, ·1569; ·763, ·1761; ·856, ·2112; ·899, ·2377; ·970, ·3202; ·983, ·3582; 1·000, ·4234. Desorption, ·973, ·4042; ·960, ·3751; ·934, ·3243; ·895, ·2750; ·810, ·2196; ·612, ·1574; ·334, ·1042; ·147, ·0670; ·067, ·0472.

Acetate "Celanese." Absorption, ·023, ·0033; ·135, ·0113; ·243, ·0197; ·343, ·0282; ·437, ·0366; ·524, ·0451; ·650, ·0600; ·718, ·0701; ·752, ·0784; ·809, ·0851; ·845, ·0968; ·900, ·1083; ·920, ·1173; ·967, ·1405; ·980, ·1573; ·990, ·1648; 1·000, ·1769. Desorption, ·957, ·1602; ·907, ·1463; ·868, ·1302; ·830, ·1196; ·782, ·1089; ·688, ·0831; ·586, ·0644; ·510, ·0546; ·357, ·0351; ·349, ·0342; ·152, ·0160; ·015, ·0027.

Acetate, "Seraceta." Absorption, ·038, ·0037; ·145, ·0119; ·320, ·0264; ·494, ·0416; ·701, ·0678; ·841, ·0962; ·914, ·1206; ·947, ·1339; ·975, ·1560; ·988, ·1681; 1·000, ·1812. Desorption, ·822, ·1178; ·551, ·0628; ·326, ·0350; ·144, ·0164; ·014, ·0045.

Acetate, "Seraceta," Desoaped. Absorption, ·032, ·0030; ·128, ·0106; ·225, ·0182; ·342, ·0283; ·448, ·0384; ·577, ·0534; ·653, ·0635; ·728, ·0761; ·815, ·0959; ·993, ·1817; 1·000, ·1901. Desorption, ·922, ·1680; ·873, ·1488; ·825, ·1305; ·723, ·1024; ·592, ·0770; ·462, ·0567; ·335, ·0414; ·210, ·0263; ·119, ·0175; ·041, ·0062.

All values of a corresponding to p/P = 1·000 are higher than the true saturation value by a greater or less amount, depending on the quantity of dew inside the bulb.

Table III

Adsorption Ratios

Relative Vapour Pressure p/P	Viscose Rayons										Lilienfeld Viscose Rayons			Cuprammonium Rayons					Nitro Rayon
	"A Quality"	"Escorto"	"Dulesco"	"Tudenza"	"Dulenza"	"Celta"	"Snia"	"Fibro"	"Vistra"	"Cellophane"	"Sample A"	"Durafil"	"Tenasco"	"Brysilka" Unbleached	"Brysilka" Unbleached, Desoaped	"Brysilka" Bleached	"Bemberg"	"Bemberg" Desoaped	"Obourg"
ABSORPTION.																			
·05	1·84	2·20	1·70	1·99	1·84	1·92	2·06	1·92	1·49	1·58	1·49	1·77	1·64	1·92	1·92	1·92	2·13	1·77	2·13
·10	1·99	2·17	1·77	2·12	1·87	1·97	2·12	1·92	1·72	1·92	1·67	1·87	1·67	1·72	1·97	1·97	2·02	1·87	2·12
·15	1·95	2·15	1·79	2·07	1·95	2·03	2·11	1·99	1·79	1·91	1·79	1·91	1·91	1·75	1·95	1·95	1·99	1·87	2·11
·20	2·02	2·20	1·84	2·13	2·02	2·09	2·16	2·06	1·81	1·95	1·84	1·99	2·02	1·84	2·02	1·99	2·02	1·92	2·23
·25	2·02	2·18	1·87	2·15	2·02	2·12	2·15	2·06	1·84	1·96	1·84	1·99	2·06	1·87	2·02	1·99	1·99	1·96	2·24
·30	1·99	2·13	1·83	2·10	1·99	2·08	2·10	2·02	1·83	1·97	1·80	2·10	2·05	1·86	1·99	1·97	1·94	1·94	2·21
·35	1·98	2·12	1·83	2·10	1·98	2·07	2·07	2·00	1·85	1·98	1·78	1·98	2·07	1·88	2·00	1·95	1·95	1·95	2·25
·40	1·95	2·08	1·81	2·08	1·95	2·06	2·06	1·99	1·83	1·95	1·75	1·97	2·10	1·88	1·99	1·95	1·92	1·92	2·21
·45	1·93	2·05	1·79	2·05	1·93	2·03	2·03	1·97	1·83	1·93	1·71	1·93	2·09	1·85	1·97	1·91	1·91	1·91	2·20
·50	1·90	2·03	1·79	2·03	1·90	2·03	2·01	1·96	1·81	1·92	1·68	1·90	2·12	1·84	1·94	1·88	1·88	1·88	2·18
·55	1·89	2·01	1·79	2·03	1·89	2·03	1·99	1·94	1·80	1·92	1·68	1·91	2·15	1·84	1·92	1·86	1·87	1·87	2·16
·60	1·89	2·00	1·78	2·03	1·89	2·02	1·98	1·94	1·79	1·94	1·68	1·89	2·17	1·83	1·90	1·86	1·87	1·86	2·16
·65	1·86	1·99	1·75	2·01	1·86	2·00	1·94	1·88	1·77	1·91	1·67	1·86	2·15	1·78	1·87	1·84	1·83	1·83	2·13
·70	1·85	1·97	1·75	2·01	1·85	1·98	1·90	1·87	1·73	1·90	1·65	1·84	2·12	1·76	1·84	1·83	1·80	1·82	2·09
·75	1·84	1·96	1·73	2·01	1·83	1·97	1·89	1·84	1·71	1·89	1·65	1·83	2·08	1·75	1·82	1·82	1·78	1·80	2·07
·80	1·80	1·91	1·70	1·98	1·80	1·93	1·83	1·79	1·65	1·85	1·60	1·78	2·00	1·69	1·76	1·79	1·71	1·76	2·00
·85	1·81	1·89	1·71	1·97	1·81	1·94	1·81	1·77	1·65	1·83	1·57	1·77	1·94	1·68	1·74	1·78	1·70	1·74	1·97
·90	1·80	1·85	1·72	1·94	1·79	1·94	1·76	1·72	1·67	1·79	1·51	1·73	1·84	1·65	1·72	1·76	1·65	1·70	1·94
·95	1·78	1·81	1·72	1·91	1·78	1·89	1·68	1·68	1·59	1·75	1·45	1·72	1·72	1·61	1·68	1·79	1·64	1·63	1·93
Means ...	1·90	2·04	1·77	2·04	1·89	2·01	1·98	1·81	1·76	1·89	1·07	1·93	2·02	1·79	1·90	1·88	1·87	1·84	2·12
DESORPTION																			
·95	1·86	1·93	1·72	1·80	1·75	1·83	1·86	1·78	1·67	1·68	1·50	1·75	1·71	1·71	1·76	1·71	1·72	1·72	1·93
·90	1·74	1·83	1·66	1·79	1·70	1·79	1·77	1·75	1·79	1·69	1·47	1·69	1·74	1·65	1·67	1·63	1·65	1·67	1·87
·85	1·70	1·79	1·65	1·75	1·64	1·78	1·72	1·70	1·69	1·69	1·44	1·66	1·77	1·60	1·64	1·63	1·61	1·62	1·83
·80	1·68	1·78	1·59	1·73	1·62	1·79	1·72	1·69	1·65	1·67	1·43	1·67	1·80	1·56	1·63	1·57	1·60	1·62	1·82
·75	1·68	1·80	1·60	1·74	1·64	1·82	1·74	1·71	1·64	1·69	1·44	1·68	1·71	1·59	1·65	1·60	1·61	1·63	1·84
·70	1·66	1·81	1·59	1·74	1·65	1·83	1·75	1·72	1·65	1·70	1·46	1·70	1·73	1·59	1·67	1·59	1·64	1·65	1·86
·65	1·67	1·83	1·63	1·75	1·67	1·86	1·78	1·75	1·68	1·73	1·48	1·72		1·62	1·70	1·62	1·66	1·67	1·90
·60	1·70		1·67	1·79	1·70	1·91	1·83	1·81	1·69	1·78	1·52	1·77		1·65	1·73	1·65	1·70	1·70	1·96
·55	1·72		1·69	1·82	1·74	1·94	1·86	1·83	1·71	1·80	1·54	1·79		1·68	1·76	1·68	1·74	1·74	2·00
·50	1·75		1·70	1·84	1·75	1·97	1·88	1·84	1·72	1·82	1·57	1·81		1·70	1·78	1·69	1·75	1·73	2·02
·45	1·78		1·75	1·86	1·77	2·03	1·93	1·88	1·75	1·85	1·62	1·85		1·73	1·83	1·72	1·78	1·77	2·08
·40	1·81		1·79	1·88	1·79	2·05	1·96	1·92	1·78	1·88	1·65	1·87		1·76	1·85	1·76	1·81	1·79	2·12
·35	1·87		1·85	1·93	1·83	2·09	2·01	1·97	1·81	1·93	1·69	1·91		1·81	1·89	1·79	1·85	1·83	2·15
·30	1·85		1·87	1·93	1·84	2·11	2·04	2·00	1·82	1·93	1·71	1·91		1·80	1·89	1·80	1·87	1·84	2·18
·25	1·94		1·92	1·97	1·89	2·17	2·12	2·07	1·87	1·99	1·77	1·97		1·87	1·94	1·87	1·92	1·89	2·22
·20	1·98		1·95	2·01	1·93	2·21	2·16	2·13	1·90	2·04	1·78	1·98		1·87	1·95	1·90	1·95	1·90	2·24
·15	2·02		1·95	2·05	1·99	2·22	2·19	2·19	1·92	2·05	1·78	2·02		1·88	1·95	1·95	2·02	1·89	2·26
·10	1·95		1·95	2·03	1·99	2·11	2·15	2·15	1·95	2·03	1·71	2·03		1·87	2·03	1·99	2·11	1·83	2·28
·05	1·93		1·99	2·16	1·99	2·16	2·28	2·16	1·93	2·11	1·58	2·11		1·93	2·17	2·16	2·16	1·75	2·40
Means ...	1·81		1·76	1·87	1·78	1·98	1·93	1·90	1·78	1·84	1·59	1·84		1·73	1·92	1·75	1·80	1·74	2·05

Table II
Adsorption of Water by Rayon at 25° C.

Relative Vapour Pressure p/P	Grams Water per Gram Dry Rayon, a																					
	Viscose Rayons										Lilienfeld Viscose Rayons			Cuprammonium Rayons					Nitro Rayon	Acetate Rayons		
	"A Quality"	"Escorto"	"Dulesco"	"Tudenna"	"Dulenna"	"Celta"	"Saia"	"Fibro"	"Vistra"	"Cellophane"	"Sample A"	"Durafil"	"Tenasco"	"Brysilka" Unbleached	"Brysilka" Unbleached, Descaped	"Brysilka" Bleached	"Bemberg"	"Bemberg" Descaped	"Obourg"	"Celanese"	"Seraceta"	"Seraceta" Descaped
														ABSORPTION								
·05	·026	·031	·024	·023	·026	·027	·029	·027	·021	·022	·021	·025	·026	·027	·027	·027	·030	·025	·030	·005	·004	·005
·10	·039	·043	·035	·042	·037	·039	·042	·039	·034	·033	·033	·037	·037	·034	·039	·039	·040	·037	·042	·009	·008	·009
·15	·048	·053	·044	·051	·048	·050	·052	·049	·044	·047	·044	·047	·047	·043	·048	·048	·049	·046	·052	·013	·012	·012
·20	·057	·062	·052	·060	·057	·059	·061	·058	·051	·055	·052	·056	·057	·052	·057	·058	·057	·054	·063	·017	·017	·017
·25	·065	·070	·060	·069	·065	·068	·069	·066	·059	·063	·059	·064	·066	·060	·065	·064	·064	·063	·072	·021	·021	·021
·30	·073	·078	·067	·077	·073	·076	·077	·074	·067	·072	·066	·077	·075	·068	·073	·072	·071	·071	·081	·024	·025	·025
·35	·080	·086	·074	·085	·080	·084	·084	·081	·075	·080	·072	·080	·084	·076	·081	·079	·079	·079	·091	·028	·029	·029
·40	·087	·093	·081	·093	·087	·092	·092	·089	·082	·087	·078	·088	·094	·084	·089	·087	·086	·086	·099	·032	·033	·034
·45	·095	·101	·088	·101	·095	·100	·100	·097	·090	·095	·084	·095	·103	·091	·097	·094	·094	·094	·108	·036	·037	·039
·50	·102	·109	·096	·109	·102	·109	·108	·105	·097	·103	·090	·102	·114	·099	·104	·101	·101	·101	·117	·042	·042	·044
·55	·110	·117	·104	·118	·110	·118	·116	·113	·105	·112	·098	·111	·125	·107	·112	·109	·109	·109	·126	·048	·047	·050
·60	·119	·126	·112	·128	·119	·127	·125	·122	·113	·122	·106	·119	·137	·115	·120	·117	·118	·117	·136	·053	·052	·056
·65	·128	·137	·121	·139	·128	·138	·134	·130	·122	·132	·115	·128	·148	·125	·129	·127	·126	·126	·147	·060	·059	·063
·70	·140	·149	·132	·152	·140	·150	·144	·141	·131	·144	·125	·139	·160	·133	·139	·138	·136	·137	·158	·067	·068	·071
·75	·153	·163	·144	·167	·152	·164	·157	·153	·142	·157	·137	·152	·173	·145	·151	·151	·148	·150	·172	·075	·077	·080
·80	·169	·179	·160	·180	·169	·181	·172	·168	·155	·174	·150	·167	·188	·159	·165	·168	·161	·165	·188	·084	·087	·092
·85	·191	·200	·181	·208	·191	·205	·191	·187	·164	·193	·166	·187	·205	·177	·184	·188	·179	·184	·208	·095	·099	·106
·90	·221	·226	·211	·239	·220	·238	·216	·212	·189	·220	·186	·213	·226	·203	·211	·216	·203	·208	·239	·110	·116	·125
·95	·270	·275	·260	·290	·270	·288	·264	·264	·241	·265	·220	·261	·261	·244	·254	·271	·248	·247	·292	·150	·140	·150
														DESORPTION								
·95	·340	·354	·315	·329	·321	·335	·340	·326	·342	·290	·275	·320	·312	·312	·323	·312	·315	·315	·353	·157	...	...
·90	·261	·275	·249	·269	·255	·269	·265	·262	·268	·253	·220	·253	·261	·248	·251	·245	·247	·250	·281	·140	...	·157
·85	·223	·235	·211	·230	·215	·234	·226	·223	·222	·221	·189	·216	·232	·210	·215	·209	·211	·213	·240	·125	·127	·138
·80	·197	·209	·187	·203	·191	·210	·202	·199	·194	·196	·168	·196	·212	·184	·192	·185	·188	·190	·214	·111	·112	·122
·75	·177	·190	·168	·183	·173	·192	·183	·180	·173	·178	·152	·177	·180	·167	·174	·168	·170	·172	·194	·098	·100	·108
·70	·159	·174	·153	·167	·158	·176	·168	·165	·156	·163	·140	·163	·166	·153	·160	·153	·157	·158	·179	·086	·089	·097
·65	·146	·160	·142	·153	·146	·162	·155	·153	·145	·151	·129	·150		·141	·148	·141	·145	·146	·166	·075	·080	·087
·60	·135	–	·132	·142	·135	·151	·145	·143	·134	·141	·120	·140		·131	·137	·131	·135	·135	·155	·066	·071	·078
·55	·125	–	·123	·132	·126	·141	·135	·133	·124	·121	·112	·130		·122	·128	·122	·126	·126	·145	·058	·062	·071
·50	·117	–	·114	·123	·117	·132	·126	·123	·115	·122	·105	·121		·114	·119	·113	·117	·118	·135	·051	·054	·063
·45	·108	–	·106	·113	·107	·123	·117	·114	·106	·112	·098	·112		·105	·111	·104	·108	·107	·126	·044	·048	·055
·40	·100	–	·099	·104	·099	·113	·108	·106	·098	·104	·091	·103		·097	·102	·097	·100	·099	·117	·039	·043	·049
·35	·093	–	·092	·096	·091	·104	·100	·098	·090	·096	·084	·095		·090	·094	·089	·092	·091	·107	·034	·038	·043
·30	·085	–	·084	·087	·083	·095	·092	·090	·082	·087	·077	·086		·081	·085	·081	·084	·083	·098	·029	·033	·037
·25	·077	–	·076	·078	·075	·086	·084	·082	·074	·079	·070	·078		·074	·077	·074	·076	·075	·088	·025	·027	·032
·20	·069	–	·068	·070	·067	·077	·075	·074	·066	·071	·062	·069		·065	·068	·066	·068	·066	·078	·020	·022	·026
·15	·060	–	·058	·061	·059	·066	·065	·065	·057	·061	·053	·060		·056	·058	·058	·060	·056	·067	·015	·018	·021
·10	·048	–	·048	·050	·049	·052	·053	·053	·048	·050	·042	·050		·046	·050	·049	·052	·045	·056	·010	·012	·015
·05	·033	–	·034	·037	·034	·037	·039	·037	·033	·038	·027	·036		·033	·037	·037	·037	·030	·041	·006	·007	·008

14—THE CORTICAL CELLS OF MERINO, ROMNEY AND LINCOLN WOOLS

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Recent investigations at this College into the cause of pink rot in wool have shown that this defect is brought about by bacteria whose by-products are capable of disintegrating the wool fibre. These by-products appear to attack the intercellular substance holding the cells of the fibre together, to dissolve it, and so cause the fibre to fall apart into its component cells. These are (1) the outer protective layer of thin, scaly cells, an empty tube of which is shown in Fig. 2 ; (2) the long spindle-shaped cortical cells making up the bulk of the fibre in good wool, and tightly packed together with their long axes parallel to the long axis of the fibre. Fig. 2 shows cells of this kind broken apart ; and (3) in hairy wool, the spheroidal cells forming a pithy central core known as the medulla.

A bacterium has been isolated by Waters (1932) from pink rotted wool, has been grown in pure culture, and when inoculated into sound wool has produced the same disintegration under artificial conditions. Use of this organism is being made in studying the cell characters of different wools.

Previous methods used for breaking up the fibres for the study of their cellular structure appear, in some cases, to have had the disadvantage of swelling or otherwise damaging the cells. Nathusius (1894) used ammonia ; Matthews (1916) cites the use of sulphuric acid, caustic potash, chromic acid and ammoniacal copper oxide, and remarks that most of these cause the cells to swell considerably ; and Meunier and others (1927) employed pancreatine. Dyck (1910) patented a digestive process for removing scales, scurf, etc. from wool using pepsin or pancreatine. The experiments of O. H. Keys at this College have shown that not only does pepsin remove the scales but also causes a disintegration or " retting " of the whole fibre.

It appears from the following experiment that the products of the pink rot organism do not readily alter the structural details of the wool cells. Some 60 grams of wool were placed in two jars, covered with broth inoculated from a culture of the organism, and incubated at 37° C. After several days the fibres were commencing to break up, and in thirty days most of the fibres had fallen to the bottom of the jars as a silt of free cells and small portions of fibre. Four months after the commencement of the experiment, cells from this retted wool, when compared with freshly retted material, showed no apparent alteration.

The next experiment was a test for changes in freshly retted material. Three short pieces of glass capillary tubing were threaded with wool fibres so that each contained one fibre just its own length. Any expansion or contraction of the fibres would then be easily seen. The fibres in their tubes were inoculated and examined periodically. In ten days the two shortest pieces of wool were retted from end to end but showed no alteration in length. The longest piece (1¼") was retted for a short distance inward from each end, and the middle portion was retted in patches. No change in length was apparent in this fibre either, and the retted patches had not

swelled to any greater diameter than that of the unretted portions. This method, however, is not sensitive to minute changes in the dimensions of the fibres, but it may safely be said that no great alteration in length or breadth of the fibre occurred as the result of retting. There is, therefore, some reason for assuming that the component cells of these fibres were not greatly changed in length or breadth.

With this convenient method of separating the cells of wool fibres, it was decided to ascertain, if possible, if there were any notable differences between the cortical cells of different kinds of wool. Assuming that the differences would be greatest in fibres of widely divergent characteristics and different origin and breeds, the following fleece wool types were taken :—

(1) An Australian Merino, 100 to 120s.
(2) An Australian Lincoln, 36s.
(3) A New Zealand Romney, 48s.

The extremely fine Merino fibres (one of the finest wools produced) and the coarse Lincoln fibres would, it seemed, probably show appreciable differences in the nature of their constituent cortical cells.

Specimens of these wools were inoculated with the pink rot organism and in ten days were sufficiently retted for examination. Portions of the retted fibres were then placed in test tubes with water and a few beads. Gentle shaking produced clouds of free cells which were mounted in water and examined under the microscope.

Measurements of the length of the cortical cells were then made for each sample of wool. The results are shown in Table I.

Table I
Comparison of lengths of Cortical Cells

Mid Value of Class Microns	Number of Cells		
	Merino 120/125s	Romney 48s.	Lincoln 36s.
72·5	4	12	3
77·5	8	11	4
82·5	13	16	15
87·5	20	24	11
92·5	27	30	25
97·5	31	43	32
102·5	58	38	53
107·5	54	43	44
112·5	60	38	86
117·5	49	41	44
122·5	35	30	45
127·5	26	28	40
132·5	10	13	45
137·5	3	15	28
142·5	2	9	15
147·5	0	5	5
152·5	0	4	4
Total	400	400	500
Average length	106·9	108	114
Standard deviation	13·7	17·85	16·0
Co-efficient of dispersion	0·128	0·165	0·140

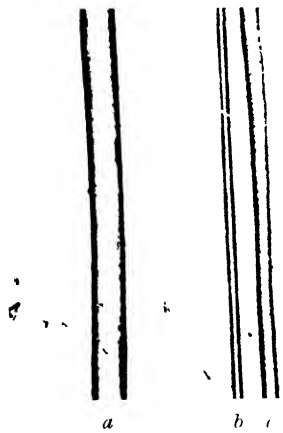


Fig 1 × 300. To show the relative fibre thicknesses of (*a*) Lincoln 36s (*b*) Merino 100-120s. (*c*) Romney 48s.

Fig. 2 × 300. Cortical cells from Romney wool. Note the slight curve of some cells. An empty tube of scale cells is also shown.

Fig. 3 × 300. Cortical cells from Lincoln wool. Note their straightness, and the two split ends. Free scale cells are also shown.

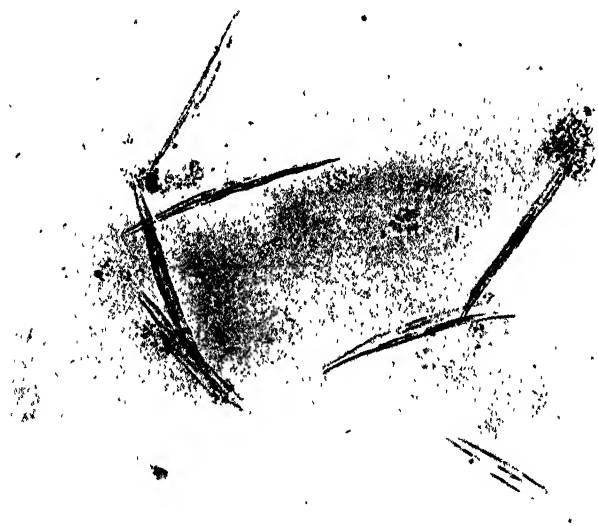
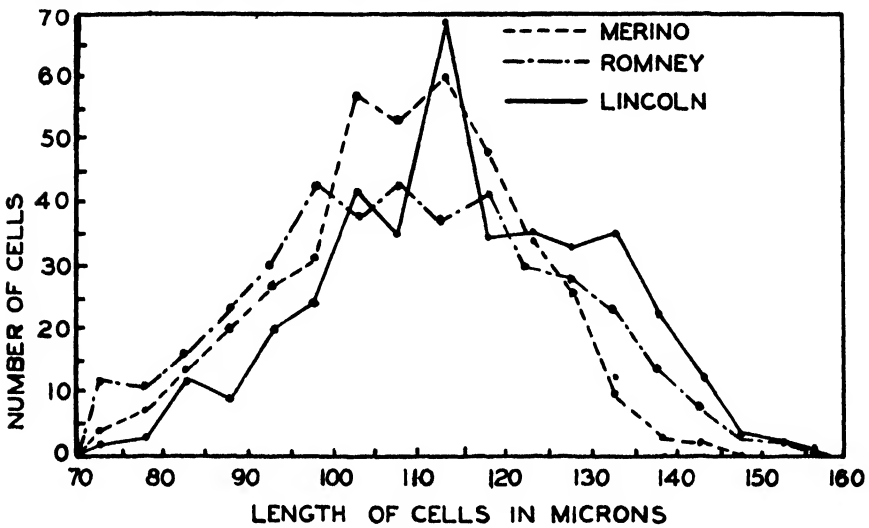


Fig. 4. × 300. Cortical cells from Merino Wool. Note the curved cells.

The above table indicates that the average length of the Lincoln cortical cells is only seven microns greater than that of the Merino, and six microns greater than that of the Romney. These values are really remarkably close. Comparisons of the degrees of variation from the average length may be made from the co-efficients of dispersion shown in the table. Thus the Romney wool displays a greater variation in this respect than either the Lincoln or Merino samples. The curves plotted from Table I show the frequency distribution of the length of cortical cells of each of the three samples.

FREQUENCY DISTRIBUTION OF LENGTH OF CORTICAL CELLS.



The Lincoln cortical cells were not markedly wider, on the average, than either the Merino cells or the Romney. No actual measurements were made, but a glance at the Photomicrographs will show how much alike the cells of each wool appear. Broad flat cells did, however, occur in the Lincoln fibres more than in the others. Cells of this type are shown in Fig. 3. The Lincoln cells were straight, and often appeared to possess one forked end. This may have been the appearance of two cells lying one above the other, one pair of ends coinciding, the other pair slightly separated from one another. Whatever the explanation, it seemed a distinct feature of the Lincoln cells.

The Romney cells were often slightly curved, few broad cells occurred, and the ends were usually well tapered and single pointed.

The Merino cells appeared more distinctly and more frequently curved. Many cells tapered to an extremely thin, long needle point.

Table II

Wool	General appearance	Curvature of cells	Crimp of fibre Approximate Radius of curvature
Lincoln	Frequent broad cells and split cells	Straight	1·25 cms. to 2·5 cms.
Romney	Few broad cells	Many slightly curved	·3 cm. to ·5 cm.
Merino	Ends often taper to long fine needle points	Most cells distinctly curved	·07 cm. to ·15 cm.

Table II summarises these differences and suggests that the curvature of cells is probably related to the crimp of the original fibre.

SUMMARY

(1) A new method has been used for breaking up wool fibres for the study of their cellular characters.

(2) Measurements have been made of the length of the cortical cells in wools of different origin and breed, and of very different fibre thicknesses, and the cells examined generally for any notable differences.

(3) Great differences have not been found, and the cortical cells of extremely fine Australian Merino fibres were remarkably similar to those of the coarse Lincoln fibres.

(4) The slight differences that did occur in average length, variation from the average, and in general appearance are noted.

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15—THE SHRINKAGE OF COTTON YARN AND THE VISCOSITY OF ITS SOLUTIONS IN AQUEOUS CAUSTIC SODA—CUPRAMMONIUM HYDROXIDE

By Sidney Maurice Neale and William Arthur Stringfellow
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INTRODUCTION

It has been shown by Hess and Trogus[6] that when sodium hydroxide is added to the system cuprammonium hydroxide-cellulose, the absorption of copper is increased, whilst the amount of cellulose dissolved rises to a maximum and then falls. Brownsett, Farrow and Neale[3] have shown that the alkali effects an increase in copper absorption even at concentrations so low that the cellulose is not swollen. It is to be presumed from the results of Hess and Trogus that the addition of small amounts of caustic soda increases the swelling effect and the solvent power of dilute cuprammonium solutions. The object of the present work was to follow as a necessary preliminary the changes in swelling by measuring the shrinkage of cotton yarn in such solutions, and then to investigate whether there are any correlative viscosity changes in the region of complete solution. The linear contraction of cotton yarn may be used as a convenient, though somewhat arbitrary index of swelling of the cotton cellulose since, presumably on account of the spiral configuration of the structural elements, the cotton hair shrinks in length as it increases in diameter when placed in solutions causing swelling.[5]

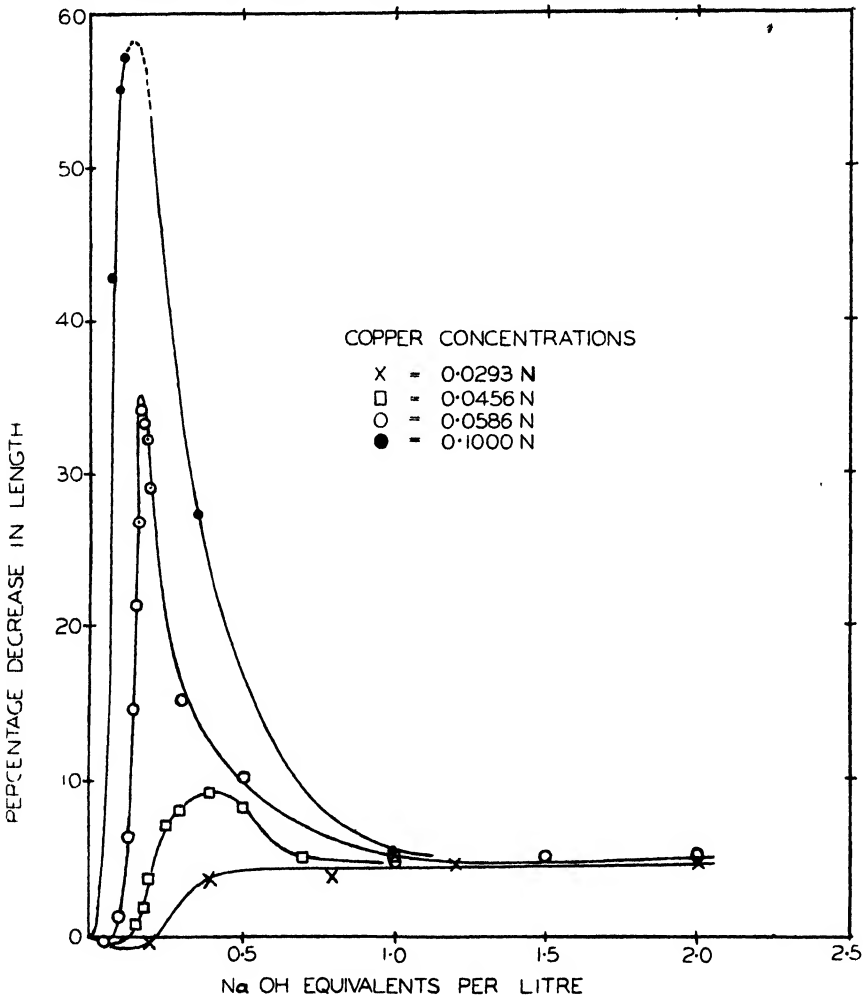
The results of the yarn shrinkage measurements, which are shown in the figure were such as might be expected from the findings of Hess and Trogus. Increasing the caustic soda concentration at constant concentration of cuprammonium caused the shrinkage to increase to a maximum and then fall. The maximum lay between 0·1 and 0·3 N sodium hydroxide, according to the value of the copper concentration. The more sharply defined maxima occurred at values of the caustic soda concentration corresponding closely with those found by Hess and Trogus from measurements of the amount of cellulose dissolved.

There is indeed a general similarity between the curves of the figure and those of Hess and Trogus for the amount of cellulose dissolved, but a strictly quantitative comparison cannot be made, on account of differences in the conditions of experiment ; namely, the much greater proportion of cellulose to solution in the work of these authors, and the fact that it was necessarily carried out over a higher range of copper concentrations.

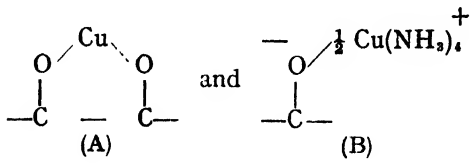
The effect of the added caustic soda is very considerable—a solution tenth normal in both copper and soda gives a shrinkage of, approximately, 50 per cent., whereas a cuprammonium solution of similar copper content but containing no caustic alkali is without appreciable swelling effect[3]. It has been found that the yarn used in the present experiments shows a maximum contraction of 18 per cent of its length in pure caustic soda solutions, at a concentration of about 4 N.

According to the theory which Hess and Trogus put forward, cellulose, in common with other polyhydroxy bodies such as glycerol, reacts with

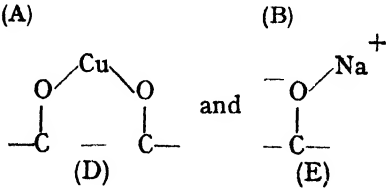
cuprammonium solutions in two distinct ways. One atom of copper may be linked by way of two separate oxygen atoms to two carbon atoms of the glucose residue, as shown at (A). This is a non-ionising linkage, but in



addition to this, cuprammonium hydroxide, acting as a moderately strong base, forms an ionising polar linkage with a third hydroxy-group, as shown at (B).



(In pure cuprammonium)



(In the mixture)

When sodium hydroxide is present, it is supposed that copper still reacts to form the complex (A), but in place of (B) a compound (E) containing cationic sodium may be formed. As sodium hydroxide is a stronger base than cuprammonium hydroxide, more reaction and therefore greater swelling occurs in the mixed solutions than in cuprammonium solutions alone.

When the copper concentration is raised above 0·2 N the cellulose goes into solution, and it might be surmised that addition of caustic soda in suitable concentration would reduce the viscosity, more especially as increasing the copper concentration in the absence of caustic soda is known to have this effect. If such an effect occurred it would obviously be of great industrial importance in the manufacture of rayon. It was, however, found that the viscosity was unaffected by the presence of caustic soda up to the point where the solvent power of the solution was so reduced that the cellulose was no longer completely dissolved.

EXPERIMENTAL

1. Shrinkage Measurements

Material: Twofold 40's.

(Singles twist, 13·2 T.P.I. twist way; Doubling twist 10·6 T.P.I. weft way.)

Sakel Egyptian yarn was scoured by boiling, with exclusion of air, in 2 per cent. caustic soda. Solutions containing various amounts of sodium hydroxide and cuprammonium hydroxide were made up immediately before use, the required concentration of the latter constituent being obtained by dilution of cuprammonium solution prepared according to the British Cotton Industry Research Association specification,[4] and containing:

Cu ..... 14·9 grams/litre.
NH_3 .....240 grams/litre.
Sucrose ..... 1 gram/litre.
HNO_3 ..... <0·2 gram/litre.

Method. Pieces of the yarn about 6 cms. long were suspended from nickel wire hooks and kept taut by 0·3 gram nickel wire weights attached to the lower end. This load, which corresponds to 1·2 mg. per single hair, was found to be the minimum necessary to straighten the yarn when suspended in water.

The length of the yarn was measured by means of a Leitz travelling microscope, (*a*) when suspended in distilled water at 25° C. and (*b*) after immersion for 16-18 hours in the cuprammonium-caustic soda solution, contained in a well-corked tube kept in a water-thermostat at 25° ± 0·02° C. Preliminary experiments upon the rate of shrinkage showed that this was practically complete at the end of eight hours. The volume of solution chosen (36 c.c. per 6 cm. length of yarn) was such that in no case could the copper concentration decrease by more than about 1 per cent. through absorption of copper by the yarn. Interpretation of the results of Hess and Trogus is rendered more difficult because in their experiments a much larger fraction of the total copper was absorbed.

Table I

Percentage Contractions of Cotton Yarn in Cuprammonium—Caustic Soda Solutions.

(" B " indicates that the threads broke before maximum contraction was reached.)

(Cu) Equivs./litre	0·0293	0·0326	0·0456	0·0586	0·1000
(NH_3) Equivs./litre	0·8823	0·9815	1·3725	1·765	3·113
(NaOH) Equivs./litre					
0·050	—	—	—	−0·2	—
0·070	—	—	—	—	4·3
0·090	—	—	—	—	55·0
0·100	—	—	—	1·30	—
0·110	—	—	—	—	57·0
0·130	—	—	—	6·4*	—
0·140	—	—	—	14·6	—
0·150	—	—	—	21·4†	B
0·160	—	−0·5	0·8	26·8	—
0·170	—	−0·4	—	34·1†	—
0·175	—	—	—	33·4	—
0·180	—	—	1·9	32·3	—
0·190	—	−0·4	—	29·0	—
0·200	−0·4	—	3·8	—	B
0·250	—	—	7·2	—	—
0·300	—	—	8·1	15·3	—
0·350	—	—	—	—	27·3
0·400	3·6	—	9·2	—	—
0·500	—	—	8·3	10·1	—
0·700	—	—	5·1	—	—
0·800	3·8	—	—	—	—
0·980	—	—	—]	—	5·5
1·000	—	—	5·2	4·9	—
1·200	4·7	—	—	—	—
1·500	—	—	—	5·1	—
2·000	4·7	—	—	5·1‡	—

* = mean of two measurements.
† = ,, ,, six ,,
‡ = ,, ,, eight ,,

Discussion of Results. The results of the shrinkage measurements are recorded in Table I, and are represented graphically in the accompanying figure. Except where otherwise stated, each of the values given is the mean of four measurements which, with few exceptions, agreed with one another to within 5 per cent. The agreement was particularly good in the case of high values; with small contractions, on the other hand, there were marked variations which could not be attributed to experimental error.

Since, apart from any swelling effects, addition of caustic soda increases the absorption of copper,[8] it may be inferred that the occurrence of reaction of the type (E) facilitates further reaction of the type (A). It has already been indicated that the theory of Hess and Trogus affords a qualitative explanation of the fact that small additions of caustic soda increase the swelling of cellulose in dilute cuprammonium. The swelling decreases, however, when more alkali is added. This is a general phenomenon in the swelling of cellulose in aqueous solutions, and has been explained[7] by the withdrawal of water on account of the relatively greater increase in the osmotic water attraction of the external phase. It will be noticed, however, that the peaks at the higher copper concentrations are sharper than might be anticipated on these grounds. It seems, however, that a sharp-peaked

swelling curve is generally obtained when powerful swelling agents are used.[1,2,7] A structural explanation rather than a chemical one is indicated, and may be provided by supposing that when the swelling pressure exceeds a certain value the distension of the cellulose structure is disproportionately great.

It is apparent from the figure that, as the copper concentration is increased the addition of alkali necessary to effect maximum swelling decreases.

The small negative values of the shrinkage which appear on some of the curves are probably due to removal of the convolutions of the cotton hair, which usually occurs in dilute solutions.[5]

II. Viscosity Measurements

These were made with capillary-tube viscometers of the type specified by the British Cotton Industry Research Association, using the technique described by Clibbens and Geake.[4] In making up the solvent mixtures, care was taken to free the caustic soda solution from dissolved air before adding the cuprammonium. The steel stirrers used in dissolving the cotton were fitted with short spiral steel springs at each end, to avoid the risk of breaking the viscometer tubes.

The viscosities of 0·5 per cent. solutions of the scoured cotton yarn, dissolved in mixed solutions of cuprammonium and sodium hydroxide, are given in Table II.

Table II.

Viscosities of 0·5 per cent. solutions of Cellulose in Cuprammonium-Sodium Hydroxide.

No. of determinations	(Cu) equivs /litre	(NH_3) equivs /litre	(NaOH) equivs./litre	η (mean) in C.G.S. units
2	0·4506	13·58	0·048	0·345*
2	0·4686	14·12	0	0·343
6	0·4686	11·47	0	0·329
2	0·2343	7·06	0	0·588
6	0·2343	5·735	0	0·562
4	0·2343	5·735	0·1	0·562
2	0·2343	5·735	0·13	0·568
2	0·2343	5·735	0·15	0·609
2	0·2343	5·735	0·17	0·206†
2	0·2343	5·735	0·20	0·038†

* = Solution not quite complete. † = Solution incomplete.

It will be seen that there is no definite change in viscosity until the concentration of sodium hydroxide exceeds 0·15 N, and the large fall which then occurs is apparently due to incomplete solution of the cotton. It appears, therefore, that whilst small amounts of added sodium hydroxide have a profound effect on the swelling of cellulose in dilute cuprammonium hydroxide, they have no such effect on the viscosity of the solution obtained when the copper concentration is such that the cellulose dissolves.

No adequate explanation of this can be given. It might be explained by supposing that in concentrated solutions the cuprammonium itself effectively completes the reaction of type B, so that addition of sodium is

without further effect. Alternatively, it might be supposed that the cellulose is in any event broken down into separate chains in these solutions. It is, however, difficult to reconcile either of these explanations with the fact that the viscosity is by no means independent of the copper concentration, as is shown in Table II.

SUMMARY

1. The shrinkage of cotton yarn in mixed solutions of sodium hydroxide and cuprammonium hydroxide shows a maximum value at concentrations of sodium hydroxide between 0·1 N and 0·3 N.

2. This maximum becomes very sharp and pronounced for concentrations of cuprammonium hydroxide within the range 0·05 to 0·1 N.

3. Solutions obtained by dissolving the cotton yarn in sodium hydroxide-cuprammonium mixtures containing a still higher proportion of the latter constituent show no marked change in viscosity over the range of sodium hydroxide concentrations in which the observed variations in shrinkage occur.

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16—THE EFFECTS OF DIFFERENT TAKER-IN SPEEDS ON CARD WASTES, SLIVER, AND YARN

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SUMMARY

The research described in this paper was undertaken in order to determine the effects of different taker-in speeds on: (*a*) waste extraction at the various parts of the card, (*b*) sliver and yarn properties, and (*c*) expense of treatment.

The cotton used was Sakellaridis (Egyptian) with a mean fibre length of 22·2 mm. and a most frequent length of 30·0 mm. Throughout the investigations the only factor subject to alteration was the speed of the taker-in, for which ten speeds were chosen, giving approximately uniform increases within the limits of 286 and 845 r.p.m. The slivers resulting from each speed were tested for regularity and spun into 40s ring twist for yarn strength and regularity determinations.

The results of the investigations may be summarised as follows:—

(*a*) At the slowest taker-in speeds (up to 309 r.p.m.) the flat strips are more flocky and dirty, containing more short fibre; the web is more irregular and cloudy, showing that such taker-in speeds are unsatisfactory.

(*b*) Raising the taker-in speed has the following consequences:—The taker-in waste increases almost proportionately and contains a higher proportion of good cotton, whereas the cylinder and flat strips decrease, but in a less degree, so that the total card loss increases slightly on balance; the sliver contains rather more short fibre, but its regularity (in weight per yard) is unaffected; the yarn, however, is stronger and not appreciably different in appearance.

(*c*) There is an upper limit to the taker-in speed, at which fibre accumulates on the teeth; this upper limit lies between 649 r.p.m. and 845 r.p.m., when the surface speed of the cylinder is respectively 1·28 and 1·05 times that of the taker-in.

(*d*) The cost of carding increases with the speed of the taker-in, largely owing to the loss of good cotton in the taker-in fly, but this disadvantage might be overcome by suitable modifications of the encasement.

It must not be assumed that the findings of this research are applicable only to cotton of the type used, for the results of bulk tests on American cotton are substantially the same as those given.

If the tests are repeated under mill conditions and with different constructional details of the encasement, the results must be expected to vary according to the extent to which the conditions differ from those given in this paper.

COTTON AND PROCESSING DETAILS

The cotton used throughout the tests was Sakellaridis (Fine), a sorter trace of which is given in Fig. 1. The mean and most frequent lengths respectively are 22·2 mm. (0·88 in.) and 30·0 mm. (1·17 in.). Each series of investigations was performed on one lap, the tests being carried out

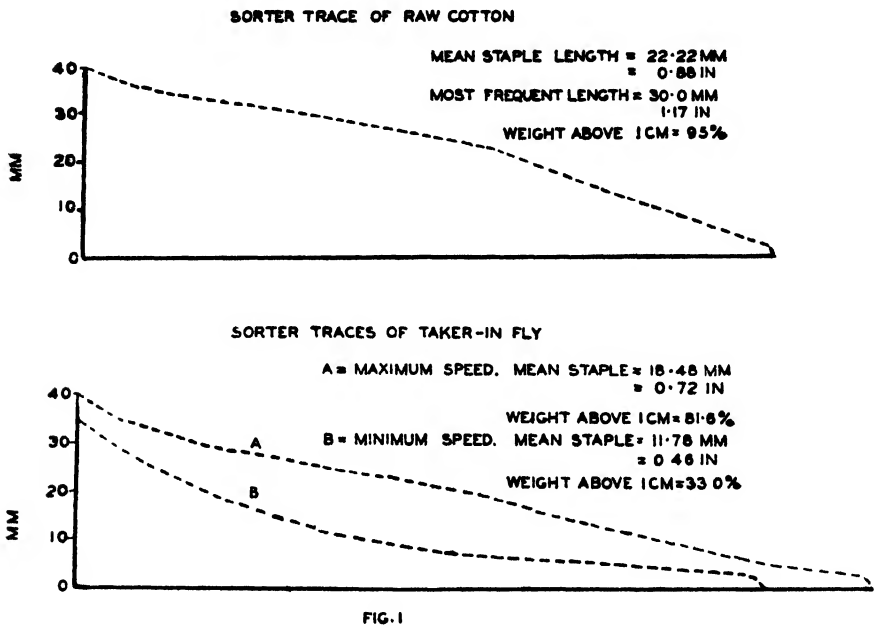


FIG. 1

on three scutcher laps, prepared in succession and under identical conditions. Particulars of the machinery employed and the processing technique are as follows :—

Blowing room sequence. Hopper bale opener, hopper feeder, single porcupine cylinder (41 inch diameter) opener with two bladed beater and lap former, finisher scutcher. Weight per yard of lap, 11½ ounces.

Card room sequence. (*a*) Revolving flat card (Hetherington) with single rope drive to the taker-in, doffer and flats. The constructional features and settings of the taker-in encasement and particulars of the tooth section are indicated in Fig. 2.

Production : 10·2 lbs. per hour.

Speeds and Counts of Wire.

Cylinder	164 r.p.m.	110s
Doffer	10·5 r.p.m.	120s
Flats	2·5 inches/min.	120s

Settings.	Feed plate to taker-in ...	...	10s
	Taker-in to cylinder ...	...	7s
	Flats to cylinder ...		10, 9, 8s
	Doffer to cylinder ...	...	5s
Points per square inch of Taker-in ...		...	32

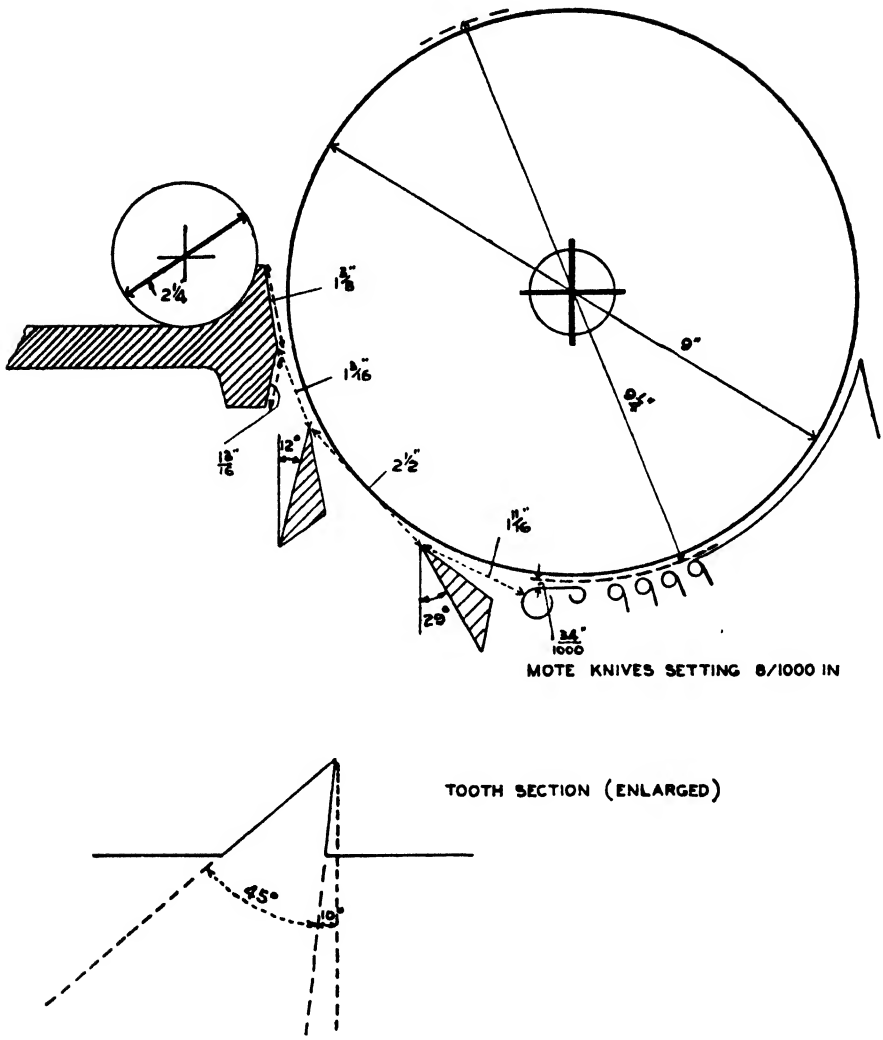


FIG. 2.

Card Technique. In order to ensure that the carding was taking place under normal conditions after stripping the cylinder, the machine was allowed to run until ten flats had passed a given point on the flexible bend. The card was then stopped, the flats put out of gear and all fly, etc., removed. The machine was re-started and allowed to operate until thirty flats had passed the given point on the bend. The flat strips, taker-in fly and sliver produced during this time were weighed, as also was the cylinder strip made during the movement of the whole forty flats.

Table I

Sample	A	B	C	D	E	F	G	H	I	J
Taker-in speed (r.p.m.)	286	309	358	408	420	472	494	570	694	845
Ratio... $\frac{\text{Cylinder surface speed}}{\text{Taker-in surface speed}}$	3·09/ /1	2·87/ /1	2·48/ /1	2·18/ /1	2·12/ /1	1·88/ /1	1·79/ /1	1·56/ /1	1·28/ /1	1·05/ /1
Taker-in fly (Grains)	143·9	150·3	168·4	193·0	206·0	237·9	259·0	333·3	468·0	
Flat strip ,, ...	269·3	261·3	253·6	263·4	264·2	257·7	260·7	260·4	257·9	
Cylinder strip ,, ...	755·5	746·0	740·1	739·6	752·0	755·8	745·2	758·6	739·8	
Total Waste ,, ...	1168·7	1157·6	1162·1	1196·0	1222·2	1251·4	1264·9	1352·3	1465·7	
Sliver ,, ...	18156·0	18265·0	17833·0	17719·0	18156·0	18375·0	18156·0	18375·0	17938·0	
Input ,, ...	19324·7	19422·6	18995·1	18915·0	19378·2	19626·4	19420·9	19727·3	19403·7	
Taker-in fly percentage of Input	0·75	0·77	0·89	1·02	1·06	1·21	1·33	1·69	2·41	
Flat strip ,, ,, ...	1·39	1·35	1·33	1·39	1·36	1·31	1·34	1·32	1·33	
Cylinder strip ,, ,, ...	3·91	3·84	3·90	3·91	3·88	3·85	3·84	3·84	3·81	
Taker-in fly percentage of Total Waste	12·30	12·98	14·49	16·14	16·86	19·02	20·47	24·65	31·92	
Flat strip ,, ,, ,, ...	23·03	22·56	21·82	22·03	21·62	20·60	20·61	19·27	17·59	
Cylinder strip ,, ,, ,, ...	64·62	64·42	63·68	61·83	61·53	60·42	58·92	56·11	50·61	
Total Waste percentage of Input...	·05	5·96	6·12	6·32	6·30	6·37	6·51	6·85	7·55	

Tests abandoned.

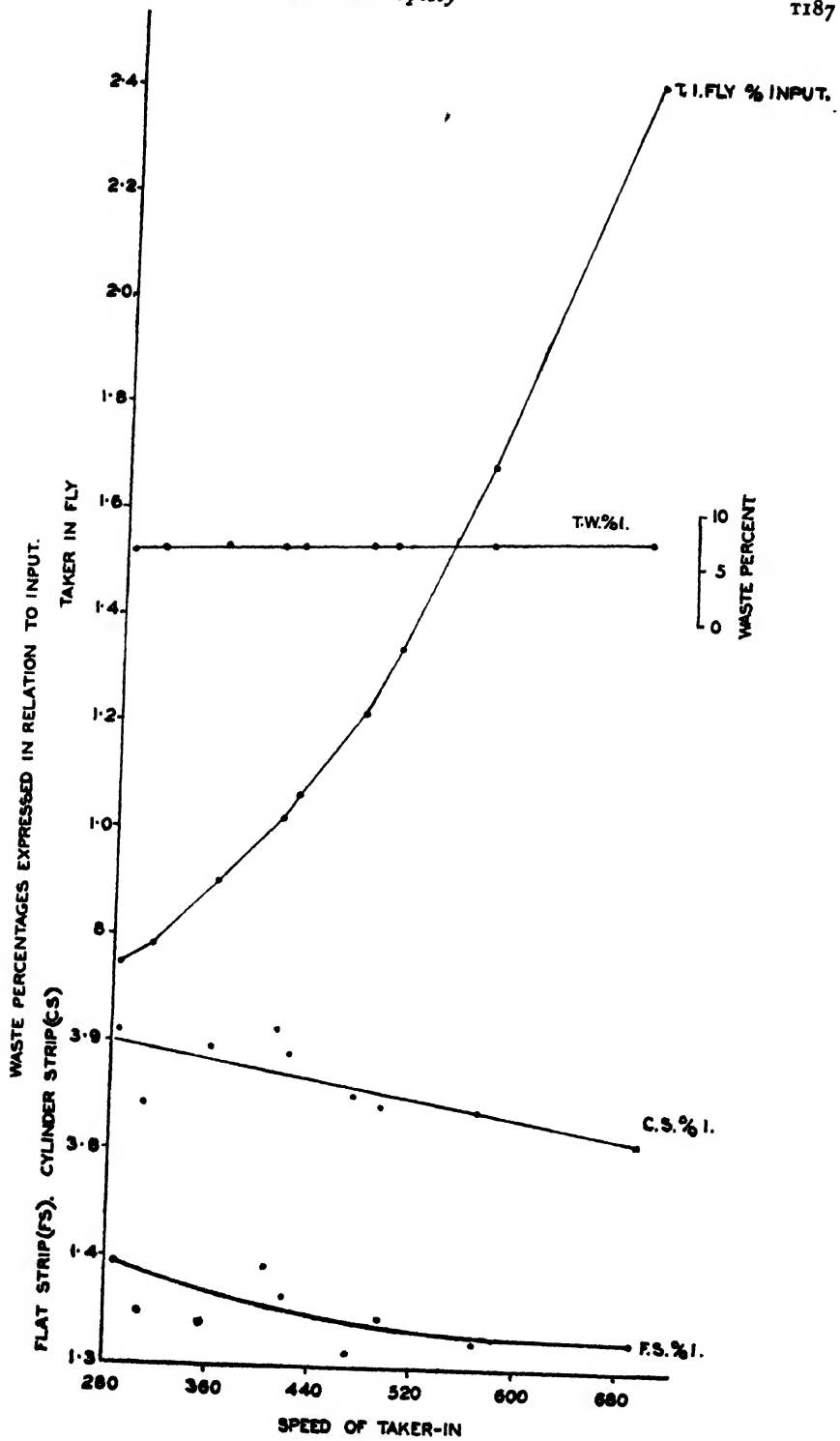

T.I.FLY % INPUT.
T.W.%I.
10
5
0
WASTE PERCENT
2·4
2·2
2·0
1·8
1·6
1·4
1·2
1·0
·8
3·9
3·8
1·4
1·3
C.S.%I.
F.S.%I.
280
360
440
520
600
680
SPEED OF TAKER-IN
TAKER IN FLY
FLAT STRIP(FS), CYLINDER STRIP(CS)
WASTE PERCENTAGES EXPRESSED IN RELATION TO INPUT.

FIG. 3.

After this procedure the taker-in pulley was changed and the above cycle of operations repeated. The changing of the pulley, which in no way interfered with the drive to the other parts of the card, was easily effected and uniform tension was maintained on the driving band by means of an adjustable tension pulley. The cylinder speed was constant during the investigations and the taker-in speeds, as indicated by tachometer readings taken whilst the cotton was passing through the machine, are expressed in relation thereto in Table I.

On completing the test for each speed the lap was turned back and the fringe examined to obtain some idea of the nature of the fibre removal action by the taker-in teeth. The fringe also was measured at regular intervals along the width of the lap and an average length obtained. Little information, however, could be derived from this observation.

(*b*) Three heads of draw frame.

(*c*) Slubbing, Intermediate and Roving frames.

(*d*) Spinning. Ring frame, three line self-weighted roller system, operating on 13 hank double roving and producing 40s* twist. During the processing, the samples resulting from each speed of the taker-in were, as far as possible, tested and treated simultaneously, the same spindles being used for all the samples.

ANALYSIS OF RESULTS

The various wastes,—fly, cylinder and flat strips, resulting from each speed test were collected and, to afford accurate comparison, the mean amounts of the wastes from the three series of investigations were expressed as percentages of in-put and total waste respectively. These values are given in Table I and the percentages of in-put are represented graphically in Fig. 3, from which it is clear that raising the taker-in speed has the following results,—the taker-in waste increases almost proportionately whereas the cylinder and flat strips decrease, in a less degree, so that the total card loss increases slightly on balance.

(*a*) TOTAL WASTE.

As the taker-in speed is raised there is a gradual increase in the total waste percentage because the increase in the taker-in fly is more than sufficient to counterbalance the combined reductions in the strip percentages of the flats and cylinder.

(*b*) TAKER-IN FLY

An increase in the speed of the taker-in is accompanied by an approximately proportionate increase in the percentage of taker-in fly.

Regarding the fibre extract at the taker-in, this depends on many factors, but especially on the following :—

(1) the shape of the taker-in tooth, which is a governing factor in its retentive or holding power ;

(2) the spacing of the points and the number per unit area of the taker-in surface, and

(3) the settings and characteristics of the taker-in encasement, viz., mote knives and undercasing.

* (This, it is recognised, is a low count for the cotton used but, under the circumstances, was most expedient and is not considered to affect, in any way, the results obtained.)

Considering that these factors remained unaltered during the investigations, the almost proportionate increase in the taker-in fly to the speed may be accounted for in several ways.

Firstly, as the speed is increased the number of teeth passing through the lap per unit time increases proportionately and, as a consequence, the opening and cleaning action at the feed plate is rendered more effective.

Secondly, the deposit of fibre per unit of taker-in surface becoming less as the speed increases, there will be a greater facility for fibre to be taken out or fall out.

Thirdly, the effect of centrifugal force will result in a tendency for more fibre, etc., to be thrown out at higher speeds. This effect, however, is rendered more complex on account of the diminishing density of fibre on the taker-in as the speed is increased.

A hand-grading of the taker-in fly showed that the percentage of sand and dirt increased almost proportionately with the speed. This would be expected because of (*a*) the more intensive combing action at the feed plate, and (*b*) the fibre layer on the taker-in becoming less dense, is more conducive to the release of material such as sand.

Each sample of taker-in fly was stapled on the Baer Sorter and typical fibre diagrams were obtained to ascertain the mean length of fibre ejected at each speed. The following table shows the maximum and mean lengths of each sample, whilst the sorter traces of fly resulting from the maximum and minimum speeds are given in Fig. 1. It is interesting to compare the percentages of fibre above 1 cm. for the extreme speed samples.

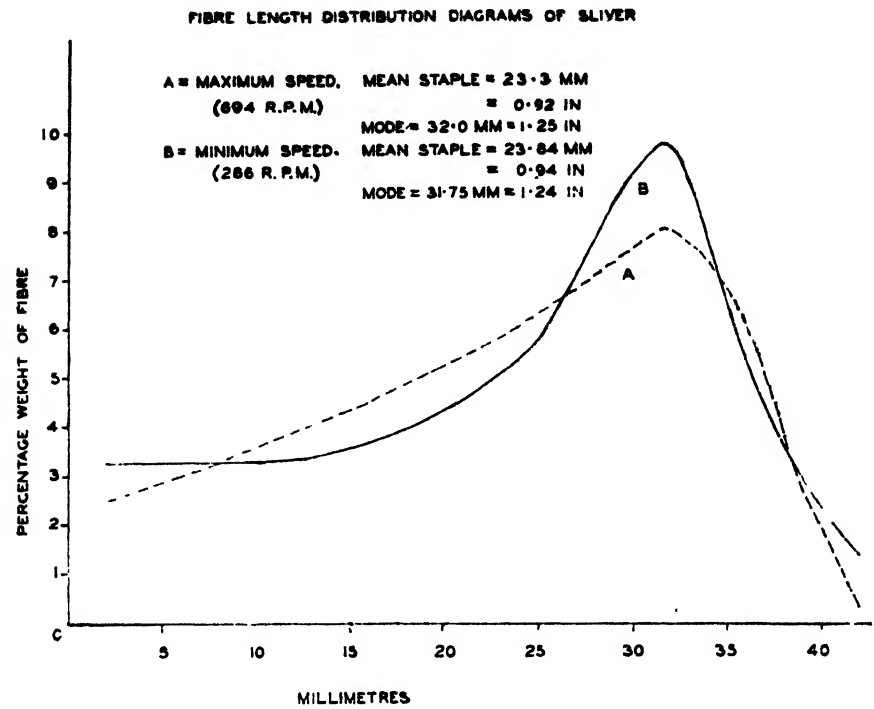
Sample	A	B	C	D	E	F	G	H	I	J
Maximum ...	1 5/16″	1 5/16″	1 6/16″	1 6/16″	1 6/16″	1 7/16″	1 7/16″	1 8/16″	1 8/16″	1 8/16″
Mean	19/32″	19/32″	20/32″	21/32″	21/32″	22/32″	23/32″	24/32″	25/32″	26/32″

The results indicate that as the quantity of fly increases with the speed the mean length of its staple increases also.

At the highest speed of the taker-in (J—845 r.p.m.—ratio 1·05/1) the accumulation of fibre on the teeth was noticed after running for a few minutes, thus indicating the inability of the cylinder to remove cotton from the taker-in. The fringe of the lap, on withdrawal, was extremely irregular and " taily " and the quantity of fly produced was excessive, containing an extraordinarily large amount of good staple cotton. This test therefore was abandoned, but it does indicate that as the surface speed of the taker-in approaches that of the cylinder the removal of cotton from the taker-in surface becomes increasingly difficult. It is obvious then that there must be an adequate margin of safety in the taker-in speed to prevent damage to the card wire and to the cotton. For these investigations the critical speed of the taker-in lies between 694 and 845 r.p.m., when the surface speed ratios of cylinder to taker-in are 1·28/1 and 1·05/1 respectively. It would appear that the speeds normally employed in practice are considerably lower than the margin of safety would require.

(*c*) Flat Strip.

The flat strip percentage shows a gradual decline as the speed of the taker-in increases. This may be attributed to the fact that fibre which


FIBRE LENGTH DISTRIBUTION DIAGRAMS OF SLIVER
A = MAXIMUM SPEED. (694 R.P.M.)
MEAN STAPLE = 23·3 MM = 0·92 IN
MODE = 32·0 MM = 1·25 IN
B = MINIMUM SPEED. (286 R.P.M.)
MEAN STAPLE = 23·84 MM = 0·94 IN
MODE = 31·75 MM = 1·24 IN
PERCENTAGE WEIGHT OF FIBRE
MILLIMETRES
A
B

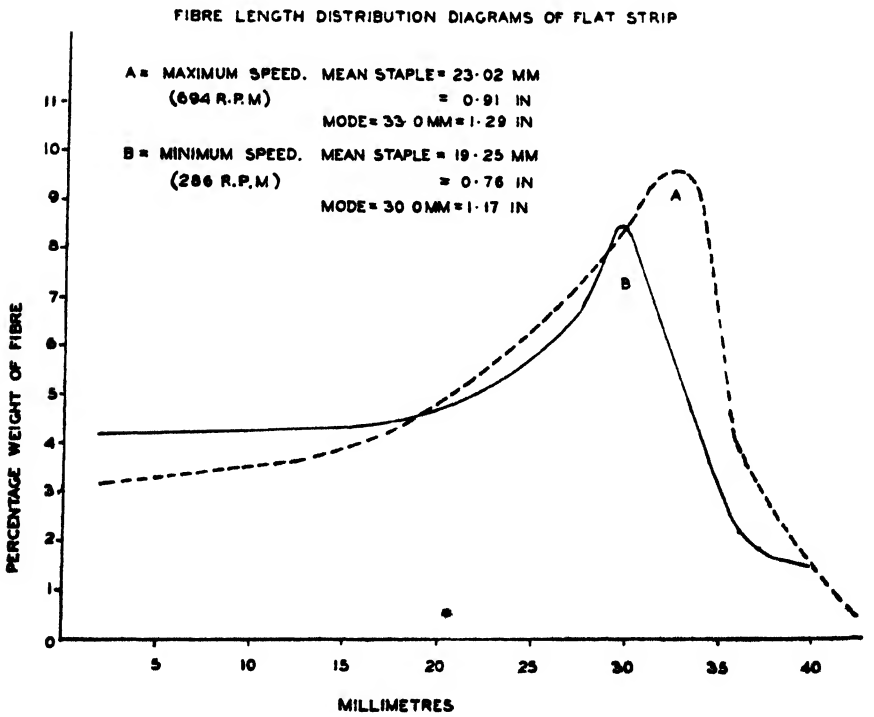

FIBRE LENGTH DISTRIBUTION DIAGRAMS OF FLAT STRIP
A = MAXIMUM SPEED. (694 R.P.M)
MEAN STAPLE = 23·02 MM = 0·91 IN
MODE = 33·0 MM = 1·29 IN
B = MINIMUM SPEED. (286 R.P.M)
MEAN STAPLE = 19·25 MM = 0·76 IN
MODE = 30·0 MM = 1·17 IN
PERCENTAGE WEIGHT OF FIBRE
MILLIMETRES
A
B

FIG. 4.

normally would be extracted by the flats has now been removed by the taker-in. Moreover, the better opening action taking place at higher speeds will result in less entangled fibrous masses being thrown on to, or retained by the flats.

The fibre length distribution diagrams of the flat strips produced at the maximum and minimum speeds are shown in Fig. 4. At the higher speeds a smaller percentage of short fibre is taken out by the flats, and the mean and most frequent lengths respectively are greater,—results that accord with practical observations. Although the appearance of the flat strips at the successive speeds did not change very materially, the differences between the strips at the extreme speeds were considerable. More entangled fibrous bodies were present at the slower speeds and the strips contained more impurity.

(*d*) Cylinder Strip.

There is a reduction in the percentage of cylinder strip as the speed of the taker-in is raised, for the same reasons as expressed in (*c*) above. The extent of the reduction is more pronounced than in the case of the flat strips.

The fibre length distribution diagrams of the cylinder strips resulting from the different taker-in speeds show no significant differences.

From (*b*), (*c*) and (*d*) above, it is clear that at the different speeds of the taker-in there is a transference of opening and cleaning from one part of the card to another. Thus, at the higher speeds there is a transference of work from the cylinder and flats to the taker-in. With low grade cotton this is very desirable, for the finer points of the flats and cylinder will be relieved of work for which the taker-in is more adapted.

(*e*) Sliver

The main feature concerning the web was the absence of abnormal evidence of fibre damage or nepping at any speed of the taker-in, although at speeds A and B it appeared cloudy. This suggests that (1) at the lower speeds the preparation of the cotton by the taker-in is unsatisfactory, and (2) at all other speeds the cotton is subjected to carding in a sufficiently opened state. The production of nep will depend also on the settings of the machine, but it may be concluded that provided these are satisfactory the taker-in is not conducive to nep formation.

Fibre length distribution diagrams of the sliver produced at the maximum and minimum speeds (Fig. 4) show that the mean staple length is slightly greater at the slowest speed although the most frequent lengths are almost identical. Moreover, the variability of the staple is less at the slowest speed. These two characters of the sliver produced at the minimum speed can be accounted for by results previously mentioned. At this speed the wastes extracted consist mainly of short staple fibre, the mean length gradually increasing until, when the maximum speed is attained, the percentage of long fibre in the waste becomes excessively high. Owing to this fact the percentage of long fibre in the sliver becomes correspondingly less, the short fibre percentage greater, and the mean staple length is reduced.

To ascertain the effect of taker-in speed on sliver regularity, 75 consecutive yards of sliver from each sample were weighed. This was done for each of the three scutcher laps, making the total number of tests per sample 225. The means, probable errors, and irregularities (Standard Deviation per cent. Mean) were calculated for each of the tests performed at any one speed.

From the results (Table II) it may be concluded that the taker-in speed does not influence the regularity (in weight per yard) of the card sliver.

YARN TESTS

Single Thread Tests. To determine the effects of taker-in speed on the strength and regularity of the yarn, 1,400 single thread tests were made on the samples produced from each speed test, the Moscrop tester being used. A rotation system of testing was adopted whereby a definite number of tests on one set of samples was immediately followed by an equal number on the next set and so on throughout the entire range. By this means any variations in atmospheric conditions during the period of testing were distributed over the whole range as uniformly as possible. The breaking load (corrected) and irregularity (coefficient of variability) for each sample are given in Table II.

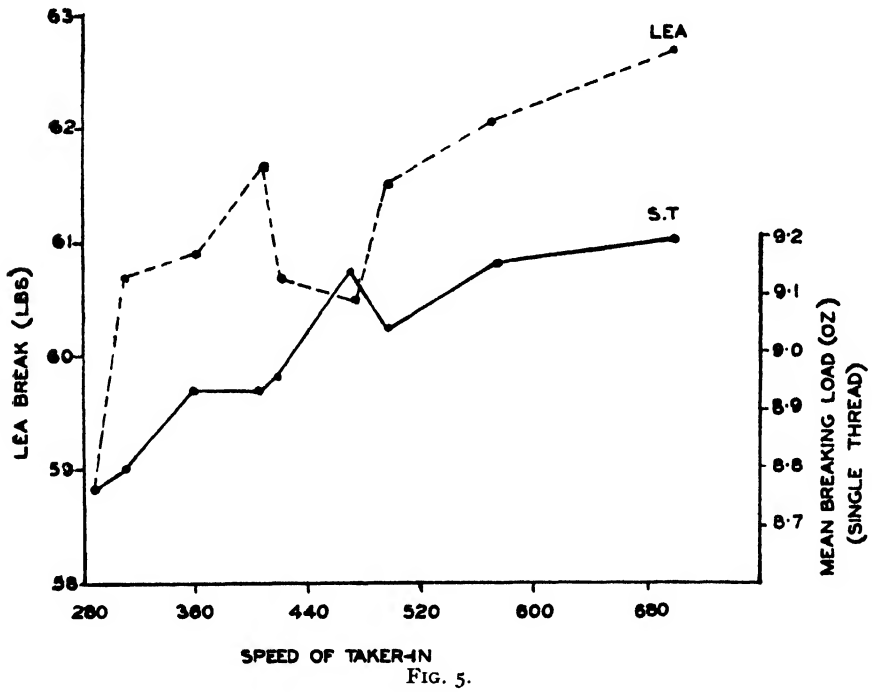


FIG. 5.

Table II

SAMPLE	Sliver Irregularity (per cent.)	SINGLE THREAD TESTS		LEA TESTS	
		Mean Breaking Load (oz.)	Irregularity Coeff. of variability	Mean Breaking Load (lbs.)	Irregularity Coeff. of variability
A	4·18	8·76	13·36	58·8	6·22
B	4·28	8·80	13·47	60·7	6·82
C	5·73	8·94	11·60	60·9	5·43
D	4·67	8·94	14·40	61·7	6·73
E	5·24	8·96	14·17	60·7	5·35
F	4·27	9·14	12·23	60·5	6·06
G	5·52	9·05	12·94	61·5	6·11
H	4·97	9·16	12·74	62·1	4·44
I	4·99	9·20	12·32	62·7	5·32

Curves (Fig. 5) drawn from these results show that the mean breaking load of the yarn increases with the speed of the taker-in. The validity of this relationship is established by the correlation coefficient, which has a value of + 0·93,—a value which is statistically significant.

The coefficient of variability appears to decrease as the speed increases, thus indicating a decrease in irregularity of strength. To ascertain the significance of the differences in variability, at the different speeds of the taker-in, an approach was made by way of the probable error of the standard deviation. The results, however, indicate that the differences in variability of strength of the samples are insignificant.

Further to investigate the relationship between yarn strength variability and taker-in speed, the correlation coefficient (r) was determined, but, being of low value (−0·327) with a probable error, P.E.r, of ± 0·201 (the ratio r/P.E.r being 1·6) evidence of any such relationship must be regarded as inconclusive.

Lea Tests

In addition to the above single thread tests, 72 lea tests were made on each sample (three sets of 24). Correction was made for count, the mean breaking load and irregularity calculated and tabulated (Table II). The results derived from the lea tests confirm those already expressed concerning the single thread tests. Fig. 5 shows the means of the 72 lea breaking loads on each sample plotted graphically, exhibiting the tendency for increased strength at higher speeds of the taker-in.

Although the coefficients of variability show a tendency to decrease at higher speeds, the differences are insignificant.

The increase in the yarn strength at higher speeds of taker-in, whilst scarcely to be expected from the results of the sliver analyses, can probably be attributed to the more open condition of the fibres resulting in a greater response to the drafting operations and hence greater uniformity in fibre distribution. The appearances of the yarns show no appreciable differences.

COST EFFECT OF THE CARD

To ascertain the effects of different speeds on the cost at the card, quantities of taker-in fly, flat and cylinder strips resulting from each speed test were sampled and their relative values fixed by an independent trade authority. These are given below :—

Sample	A	B	C	D	E	F	G	H	I
Taker-in Fly ...	½d.	½d.	1d.	1d.	1½d	1½d.	1½d.	2d.	2d.
Flat Strip... ...	7½d.	7½d.	7½d.	7½d.	7½d.	7½d.	7½d.	7½d.	7½d.
Cylinder Strip ...	8½d.	8½d.	8½d.	8½d.	8½d.	8½d.	8½d.	8½d.	8½d.

It will be noticed that whilst the values of the strips remain constant, the values of the taker-in fly fluctuate on account of the variations in dirt content and staple. Assuming cotton at the scutcher lap to be 15·2d. per lb. (30.5.1930) the following table (Table III) shows the resultant costs at

the card at the different speeds. These costs have been calculated on the following basis :—

Sample D.

Losses :	Flat Strip	1·39 lbs. per cent. @ 7½d.	=	10·42d.
	Cylinder Strip	3·91 lbs. per cent. @ 8½d.	=	33·24d.
	Taker-in Fly	1·02 lbs. per cent. @ 1d.	=	1·02d.
	Total	6·32		44·68d.

Weight put through = 100 lbs. @ 15·2d. per lb.

Loss ... ... = 6·32 lbs.

93·68 lbs. @ 15·2d. per lb. = 1423·94d.

Waste value ... ... = 44·68d.

1468·62d.

Material loss per lb. ... ... 0·514d.

Table III.

Sample	A	B	C	D	E	F	G	H	I
Loss (d/lb.) ...	·479	·479	·495	·514	·514	·529	·544	·586	·679

It is clear then that higher taker-in speeds are accompanied by higher costs, largely owing to the loss of good cotton in the taker-in fly. This disadvantage might be overcome by suitable modifications of the encasement and it is proposed to extend the investigations in this direction.

For assistance in the practical work, thanks are due to Messrs. W. Miller and K. C. Brown.

17—SHUTTLE TAPPING: A SOURCE OF FABRIC DEFECTS

By F. KENDALL, A.T.I.

One of the most serious defects prevalent in textile materials during the past twenty-five years, which has been a source of considerable trouble to bleachers, dyers, finishers and printers, has been the frequent repetition of small holes, of a certain definite character, occurring in pieces in a very irregular manner. The causes of this defect have until recently remained obscure, the general conclusion—although there was no positive evidence to support it—being that the trouble arose out of something connected with the finishing processes.

Minute examination of large numbers of pieces, both in the grey and at various stages of processing proves that the remedy is in the hands of the manufacturer. The writer's investigations enable him to place before the industry a practical method of locating definitely the exact point at which the damages have been created, no matter to how many processes the pieces have been subsequently subjected.

The distribution of the holes is of such an irregular nature that the elucidation of the defects has been more than usually baffling. These damages are usually confined to one side of the fabric, appearing at various distances from the selvedge, and with no definite frequency or repeat warp way.

The distribution of these holes may be classified into two distinct headings, as follows :—

Firstly. Holes which have no regularity in their position from the selvedge, and also have no definite periodicity or repeat warp way.

Secondly. Holes which appear in definite straight lines, that is, being parallel with the selvedge but with no definite repeat warp way.

Perhaps it would be well to enumerate the types of fabrics in which the fault is prevalent :—

1. Limbrics.
2. Cambrics.
3. Umbrella styles.
4. Downproofs.
5. Sateens.
6. Twills.
7. Repps and cords.
8. Cotton Warp, Art. Silk Weft styles for the rubber proofing trade, etc.
9. Ray-de-Chine styles in plain and fancies.
10. All types of Art. Silk Warp fabrics with art. silk and Pure Silk Weft, etc., including Georgettes and Crêpe-de-Chines.
11. Solid Art. Silks, linings, etc.

It will be appreciated that the small holes referred to are prevalent in a wide range of productions, both wide and narrow width productions being similarly affected.

At first research was confined to wide width fabrics, but after gaining evidence which led to the discovery of the origin of the holes, the field of research was extended, and the identical type of holes found in the narrower width fabrics. In fact, at the present time, in certain districts where the narrow width cloths are produced, quite a large percentage show this fault and, to quote a case recently investigated, over 30 pieces out of a consignment of 78 pieces contained these holes. With another firm in the same district, 169 pieces were affected out of a consignment of 500 pieces. Whilst the percentage of faulty pieces may appear very high, these are by no means isolated instances, and the object of this communication is to place before the trade certain definite suggestions as to how measurements can be made on a finished piece which will enable the maker to prove conclusively whether the damages were created by Shuttle Tapping or not.

The small holes referred to, in all cotton fabrics, usually resemble small square punched holes, but these vary considerably according to the type of fabric in which they appear. The three photomicrographs (Plate I) will enable one to visualise readily the typical damages in question.

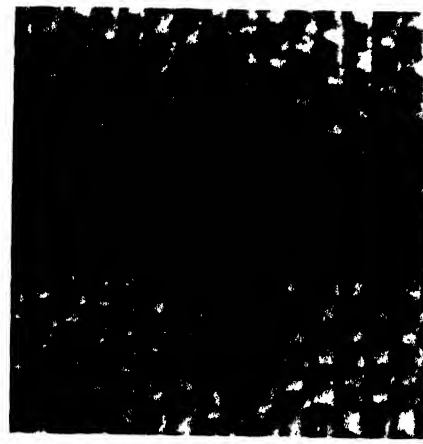
(*a*) Taken from an ordinary cotton limbric.
(*b*) Obtained in a hard twisted crêpe cotton warp and soft twisted two-fold cotton weft fabric.
(*c*) Damages found in a solid art. silk twill lining.

It will be noticed that in all cases the warp has been severed. In the ordinary cotton limbric styles only one up to three warp threads are usually broken, except in cases where the damage is of an exceptionally severe nature; but the weft, being a softer spun yarn, suffers to a greater extent, and in many cases up to ten picks are found to be cut. In the cotton crêpe fabric two warp threads are severed, and only three picks of the two-fold weft. In art. silk styles where the warp is composed wholly of art. silk and wefted with hard twisted crêpe wefts of all types, it is usually found that only the warp has been damaged.

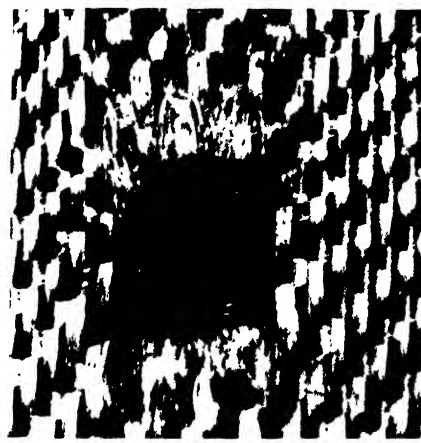
By constantly examining pieces containing these defects it was found that the holes were always on the shuttling side of the pieces. Works were visited both in Lancashire and Yorkshire, and a confirmation of this fact was made, whether the pieces were processed in rope form or at open width. Blacks and colours were similarly affected. In view of this evidence—that without exception the shuttling side of the pieces was affected—a careful study was made of the weaver's manipulation of the shuttle, with a view to discovering how such damages were created, and *it was found possible to establish a definite relationship between the position of cop changes and the holes.* It can be shown conclusively that, when these holes appear frequently in pieces, the occurrence of the fault is consistent with cop changes. For example, in a piece of Java Cambric dyed Aniline Black, three holes were found within a space of approximately four inches and coupled with these holes were three cop changes bearing exactly the same relationship in position. This example is being illustrated at a later stage.

The damage created by " shuttle tapping " is almost unknown to weavers themselves; their overlookers, and even many employers, do not credit its existence. The reason for this lack of knowledge is due to the fact

(*a*) Cotton Lambrie



(*b*) Cotton Crêpe.

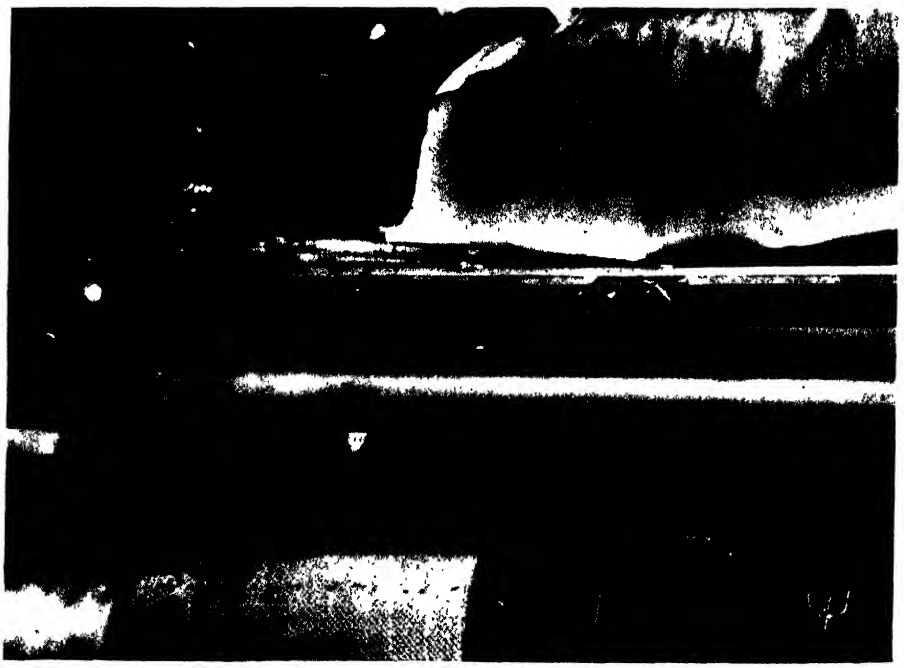


(*c*) Rayon Lining.

PLATE II.

NORMAL LANCASHIRE LOOM

(*a*) Shaded area indicates where "shuttle-tapping" frequently occurs. Projections due to unsatisfactory loom mountings are also shown.



(*b*) Cloth removed to show specific cause of projections.

that the defect is very difficult to detect in the grey, as the damages obtaining in this state may only be fractured, or bruised places, and not actual holes as obtains in the fully processed pieces. These fractured or bruised places are created by the weavers when changing their shuttles, bringing down the *shoulder of the tip* in contact with some part of the loom mechanism (in most cases on the breast beam) with the cloth in between. *This metal to metal contact, though only a very light tap,* is sufficient to weaken the cloth to such an extent that the fractured place develops into a hole during subsequent processing.

In view of the difficulty of detecting this fault in the grey state, special precautions should be taken by the manufacturer to eliminate the cause. In order to do this, he must be able to ascertain the exact position in the loom where the defect is being created.

METHOD TO FOLLOW IN MAKING A PRACTICAL INVESTIGATION

The only reliable method of examination recommended when pieces are submitted for examination for the identification of small holes of a type similar to the foregoing photomicrographs should be as follows :—

Firstly. Make a general inspection of the piece and notice if all the holes are of a similar type.

Secondly. Establish if the majority of these holes are confined to one side of the piece.

Thirdly. Do the damages repeat warp way with a *definite repeat?*

The question of repeats requires careful consideration and measurements, for if the defects repeat with a *definite multiple of a common factor,* " shuttle tapping " is not responsible. *But if there is only a suggestion of a repeat, " shuttle tapping " may be the cause of the defect,* subject, of course, to their conforming to other measurements described below. (See diagram of the bleached cotton piece.)

Fourthly. If there is no definite repeat of the holes warp way, examination is then made to ascertain on which side the piece has been shuttled, or in other words, the " setting-on " side of the loom, where the shuttles are usually replaced. If the holes have been created by " shuttle tapping," the damages will be found on this " setting-on " side. There are, however, occasions when an isolated hole is found on the opposite side of the piece, particularly may this obtain in narrow width plain goods, but a close examination will reveal that the shuttle has been changed in this case at the " off side."

Fifthly. In order to establish the origin of the holes, further measurements have to be taken, and we have to establish which way the piece has been woven. In some cases this is rather a difficult matter for an inexperienced person, but that can be solved by duplicating certain measurements.

The measurements now to be taken are :—

(*a*) The position of the holes from the *selvedge.*

(*b*) The distance of the holes from the *fell of the cloth,* or, in other words, the end of the cop where the shuttle was changed.

After making these measurements it is very desirable to plot out the results on point paper and the graph will show at a glance :—

1. Whether the holes have a definite position or positions from the selvedge, or whether they are erratic in their position from the selvedge.
2. At what measurement from the fell of the cloth the holes appear.

After making due allowances for the processing the fabric has been subjected to in regard to shrinkages or length yield, the measurements obtained can readily be attributed to the position in the loom where the damages were created.

The photographs of an ordinary Lancashire Loom (Plate II) are given to illustrate the various positions where shuttle tapping may occur. As the majority of shuttle tapping holes are created by a fracture of the cloth on the breast beam (the shaded portion in the photograph), it will be readily observed that the measurements referred to represent a variable position from the selvedge, but show almost a constant or uniform distance from the fell of the cloth (change of cop), see Fig. 1.

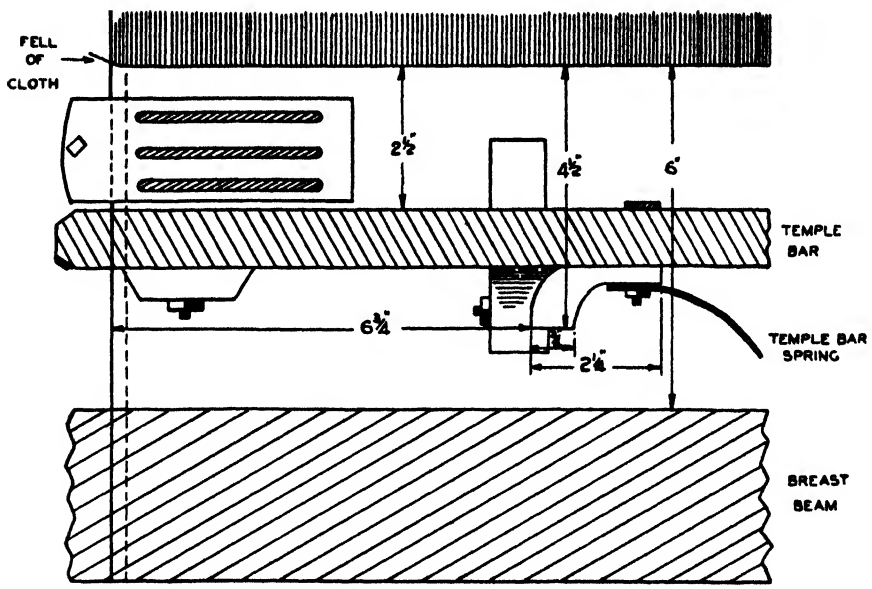


FIG. 1. Plan of Loom mountings shown in Plate II. Measurements indicate approximate relationships of mountings to fell of cloth.

Any damages created by a fracture of the cloth on a projection *will have a definite position* both in respect to the distance from the selvedge, and also to the cop change. In artificial silk warp styles the weaver may, when changing the shuttle, accidentally tap the shuttle tip against the temple bar, ultimately resulting in holes appearing in the finished cloth at another definite distance from the cop change. The diagram of loom mountings has been specially prepared to illustrate the positions referred to above, and no doubt the manufacturers will take steps to prevent a repetition

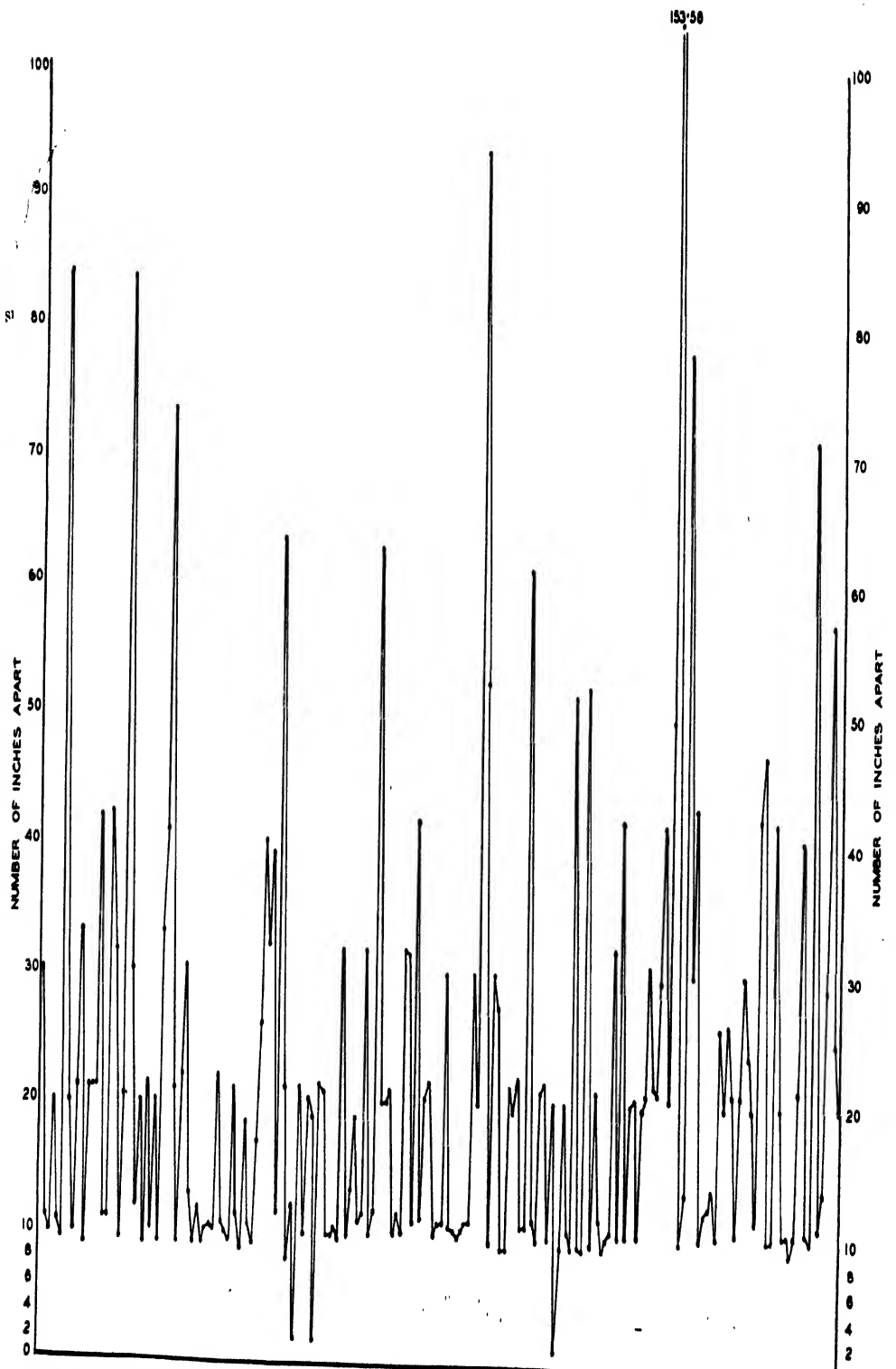


FIG. 3. Bleached Cotton Shirting: showing distances between "shuttle-tapping" holes, measured warp-way. Average length woven by full cop—10 inches.

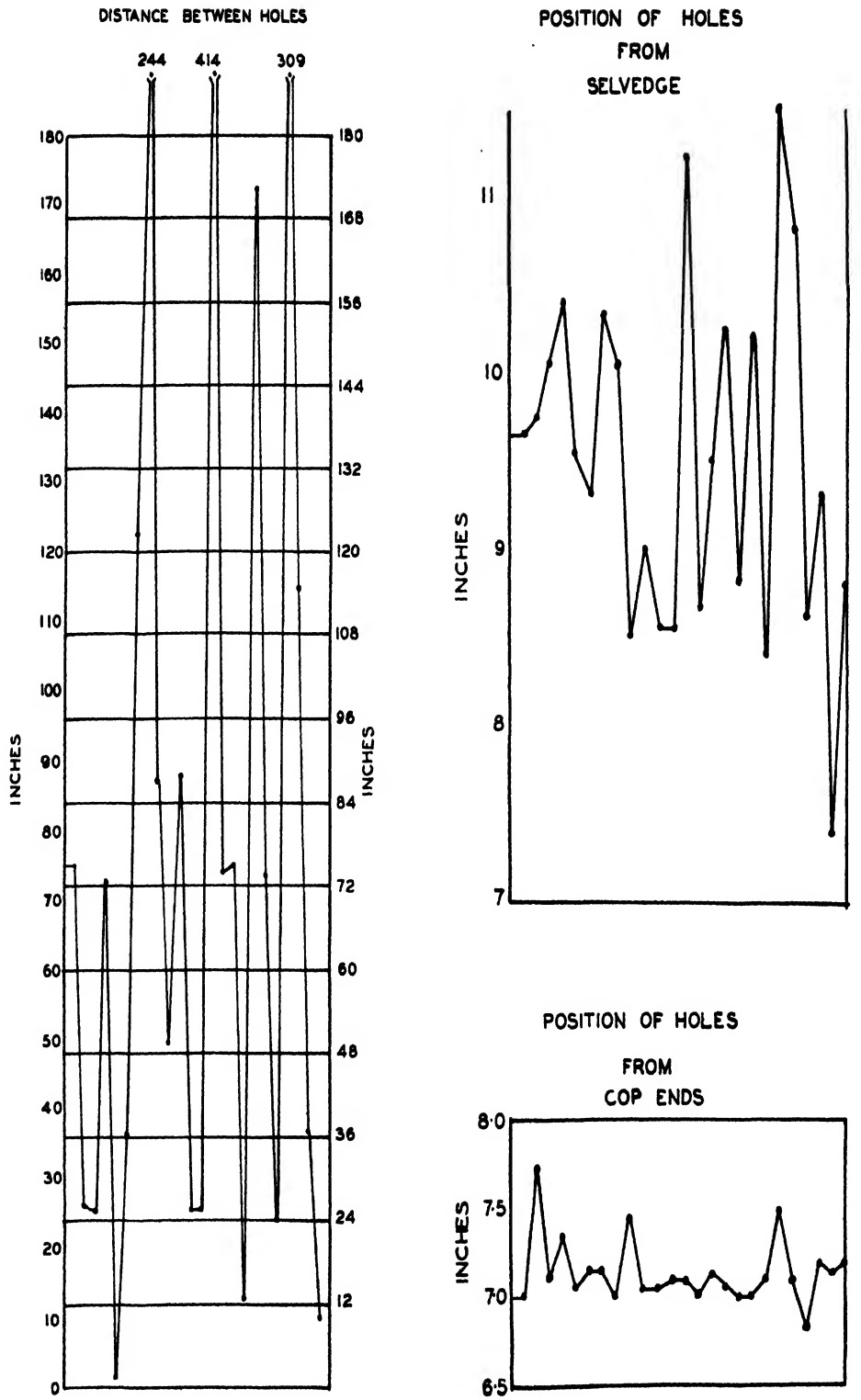


FIG. 4. Pink Limbric: Series of Graphs definitely indicating conditions produced by "shuttle-tapping."

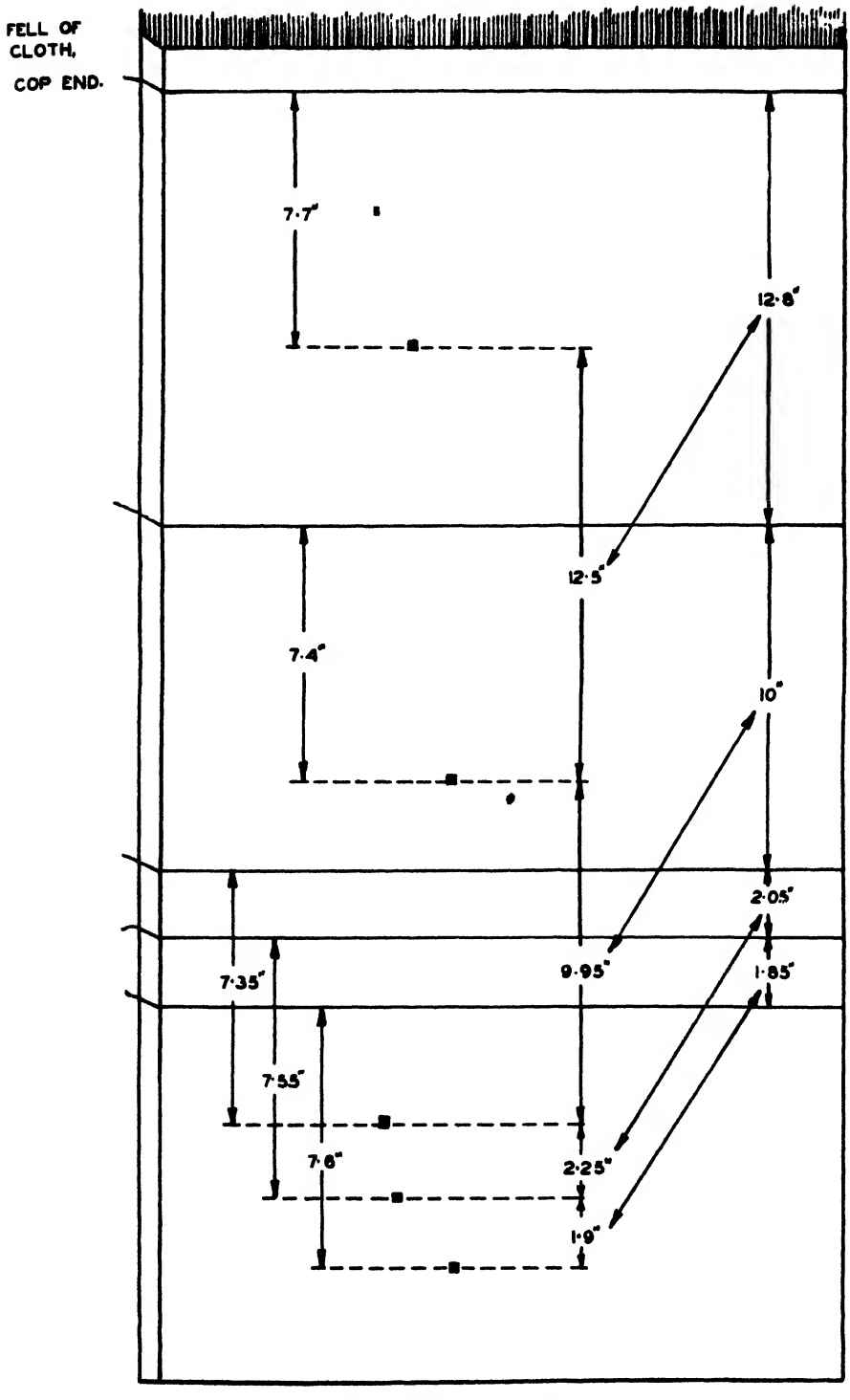


FIG. 2. Relationship of holes to cop changes. (Taken from Aniline Black dyed Java Cambric.)

of these faults by removing the projections, and also in their own way make some attempt to prevent damages occurring on the breast beam.

The relationship of the position of the holes to cop changes is the outstanding factor which unquestionably proves the source of the trouble. This is illustrated in the example of the Aniline Black Java Cambric (see Fig. 2). It is necessary to draw attention to the periodicity of the holes. Many parties both at home and abroad have failed in their investigations because of the fact that they have diagnosed the defect as a roller damage. Careful measurements are necessary, as will be appreciated when a study is made on the two graphs.

Example I. Investigation on piece of Bleached Cotton Shirting (Fig. 3).
Example II. Investigation on Pink Dyed Limbric (Fig. 4).

In the bleached cotton piece the amount of cloth woven by a normal cop averages approximately 10 ins.; therefore, there is a periodic changing of the shuttle every 10 ins. or thereabouts. This sequence of changing the shuttle is broken by the introduction of a short cop, therefore the indefinite repeat of the holes every 10 ins. is broken by the hole due to the introduction of the short cop, which only wove approximately 2 ins. Exactly the same conditions obtain in the Pink Dyed Limbric excepting that the cop changes average 12 ins., and again the short cop breaks the sequence. And so it is with hundreds of other cases investigated; holes created by shuttle tapping have a direct relationship to the changing of the shuttle.

18—TENSILE STRENGTH: A LIMITING FACTOR IN WEAR

By H. P. GURNEY and E. H. DAVIS

INTRODUCTION

The capacity of offering resistance toward wear is often regarded as an independent property of materials, quite apart from other properties such as tensile strength, modulus of elasticity, or elongation at rupture, although it is commonly regarded as highly correlated with tensile strength. Dr. W. F. Edwards, in discussing the nature of resistance to wear[1], states that no satisfactory theoretical basis for the measurement of wear resistance, or simply wear, has been worked out, probably on account of the complexity of the subject. Owen and Locke[2] agree that the abrasive quality of materials is a property which cannot be defined in terms of the measurable properties of the substance, and it probably depends upon many distinct physical characteristics contributing in unknown proportions.

Wear may be either partly constituted of an external or surface wear instigated by abrasive causes, or it may consist of internal wear resulting from the application of repeated alternating or oscillating stresses. However, in the application of abrasive wear, due to the friction of the fabric surface involved with respect to the abradant, there is necessarily involved the existence of repeated or oscillating stresses. It is, in fact, conceivable that the major portion of the deterioration involved in most cases of wear results from the incidence of oscillating stresses, rather than from pure abrasion, unless the abrasive action partakes of an extreme cutting action. Owen and Locke,[2] in their tests on yarn abrasion against steel pegs, note that rupture often occurred outside the abraded region, where the material had been subjected to the same stress cycle. Abrasion against a smooth glass or porcelain surface often appears to increase the tensile strength, where the number of rubs applied is not excessive.

All wear testing involves the application of stresses fluctuating between certain limits and in any definite method, these limits, specifically their maxima, bear definite ratios to the tensile strength as commonly determined. It would seem simpler after obtaining cycles-to-rupture in wear testing to relate these to the ratio of maximum stress applied in the wear testing to tensile strength, than simply to the maximum stress alone. The subject is complicated enough, and any sort of simplification is in order. This automatically introduces a consideration of tensile strength as a limiting factor in wear.

APPARATUS AND METHOD

The apparatus employed, shown in the photograph, deviated but slightly from an abrasion machine designed by Alfred J. Amsler and described in the literature[3,4]. The abrasion or wear was produced by pulling a strip of fabric back and forth while held under a definite tension by a definite constant load and abrading through a steel comb shown in Fig. 1. This comb consists of two pairs of teeth placed opposite each other and consisting of steel plates with rounded edges, the width being wider than the fabric strips to be abraded. The four steel plates were parallel and of unalterable relative position. The two outside teeth 1 and 4 led the fabric into the comb in such a manner that the angles formed by the strip above 2 and 3 were equal, thereby ensuring an equal pull and stress at the front and back. The speed of the comb was 30 back and 30 forth movements (60 rubs) per

minute. The travel of the comb with respect to the fabric was adjusted to three inches, although the travel of the comb with respect to the machine was necessarily greater, about five inches. It was found necessary to support the gripping plates, holding the fabric strip at its ends, from above, in order that the tensions be definitely known. This feature is not described in the literature.

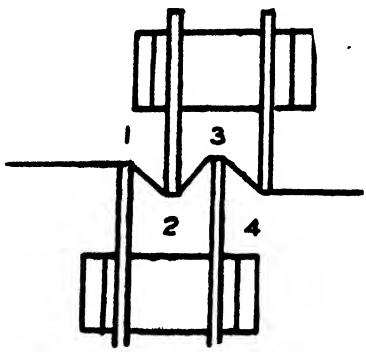


FIG. 1.

In this method of wear testing, it will be seen that there exists not only abrasion, but an oscillation or alternating condition of stress. To bring out this condition quantitatively, the apparatus was modified to operate as in Fig. 2, loading one side only with loads (A) equal to 5·5, 10·5, 16·5, and

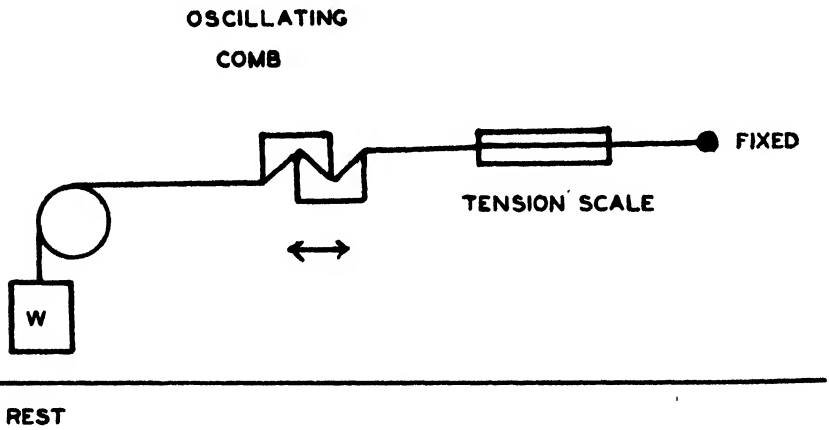
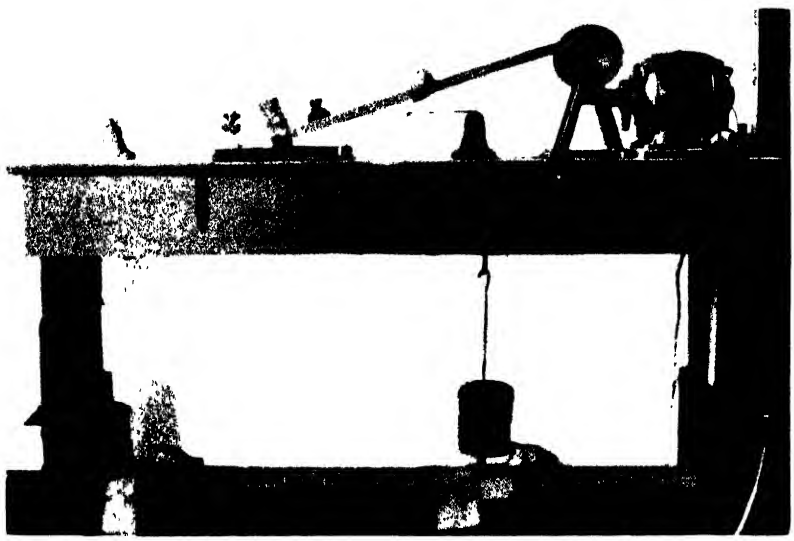


FIG. 2.

22·5 pounds respectively. When so doing, the minimum loads recorded by the tension scale on the other side when being approached by the comb were in the order (B) 2·0, 2·5, 3·5 and 6·5 pounds respectively, while the maximum loads recorded by the tension scale where the comb is receding from it were in the order (C) 19·5, 34·5, 48·5, and 57·5 pounds respectively. The geometric means of these maximum and minimum loads ($\sqrt{BC}$) 6·24, 9·28, 13·03 and 19·34 pounds respectively were of about the same order of magnitude as the applied loads themselves, ($\sqrt{BC}/A$) being 1·134, 0·882 0·790 and 0·860 respectively, while the square roots of the ratios of maximum to minimum loads were 3·12, 3·71, 3·72 and 2·97 respectively. It would appear then, that the ratio of tension of tighter to looser side during the



Abrasion Machine

comb motion ranged between 3 and 4, and was probably the same regardless of whether the applied load was on the tighter or looser side, that is whether the comb was approaching or receding from the tension scale.

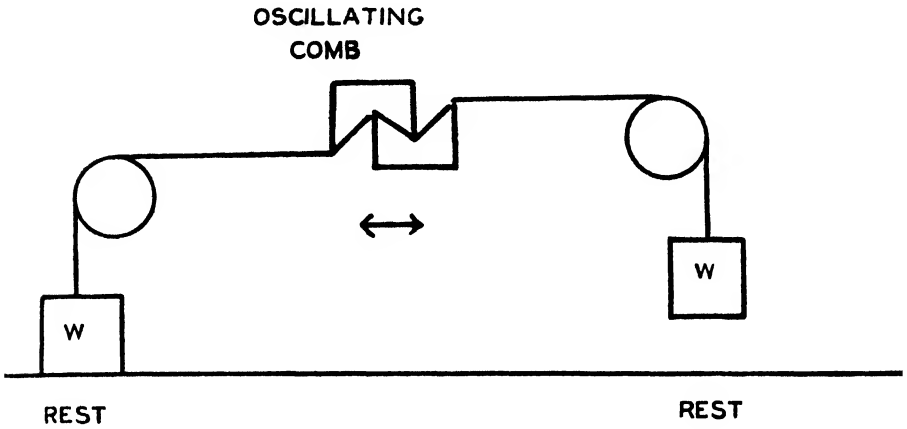


FIG 3.

The normal procedure (Fig. 3) differed from the above described procedure in that neither end is fixed, and the tension scale is simply replaced by another weight, W, equal to the first. In this case the maximum load cannot exceed W, and the minimum load on the slack end (on which side the weight W is being supported by the rest) is somewhere around W/3·5 depending somewhat upon the surface coefficient of friction of the fabric.

The above experiment demonstrated incontrovertibly that besides abrasion and flexing, a condition of oscillating stress existed. The ratio of maximum to minimum stress, 3·5 to 1, is of some incidence. King and Truesdale[5], experimenting with tire cord, showed that not only do cords receiving greatest tension fail sooner, but that the wider the stressing limits, the maxima being equal, the shorter the cord life. This is in accord with the law discovered by Woehler for steel, that as the difference of the stressing limits increases, the maxima remaining constant, the cycles-to-rupture diminish.

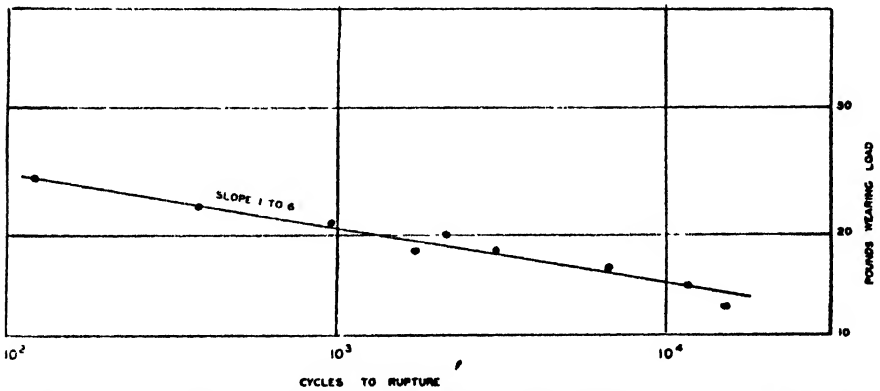
The above discussion should make clear that the specific type of wear applied herein is only one type of wear out of an infinite number of possible types of wear combining abrasion, flexing, and oscillating stressing between limits, bearing all ratios from zero to unity, and that other combinations of types may conceivably yield a different order of merit applied to different fabrics.

CYCLES-TO-RUPTURE *VERSUS* WEARING LOAD

In a preliminary test, a strip of sheeting two inches wide (ravelled down from 2·25 inches) was tested in the filling direction using different loads (W) of 30, 24, 22, 20, 18, 18, 16, 14, and 12 pounds, the samples rupturing after the following cycles 121, 382, 989, 2107, 1687 and 3038 check test, 6745, 11478, and 15000 respectively. These data plotted arithmetically yield a hyperbolic curve, but plotted on double logarithmic plotting paper, the points lie close to a downward sloping straight line. The rate of drop at all points is such as to specify a 6 per cent. increase in cycles-to-rupture for each 1 per cent. diminution in testing load. The assumption that this

exponential relation, graph 1, may be extrapolated indefinitely in both directions may be too far-reaching, for it would follow that rupture would occur at all loads, however small, if the cycles-to-rupture were sufficient in number.

From experiments on steel under alternating stresses, Stromeyer[6] has proposed a formula of the form $N = K/(t - t_0)^n$ in which N is the number of cycles to rupture and K is a constant, t_0 a primitive breaking load at or below which rupture will not take place even where $N = \infty$, and n happens to be 4. Elsewhere the belief is recorded[7] that all experiments with steel tend to the belief that a true endurance limit exists, or at least, a sufficient flattening of the curve to be equivalent to such a limit from an engineering view point. However, in dealing with cotton fabric, it is conceivable that the value of t_0, the primitive breaking stress, is so much lower with respect to the usual wearing loads t, that usually or practically N is proportional to K/t^n.

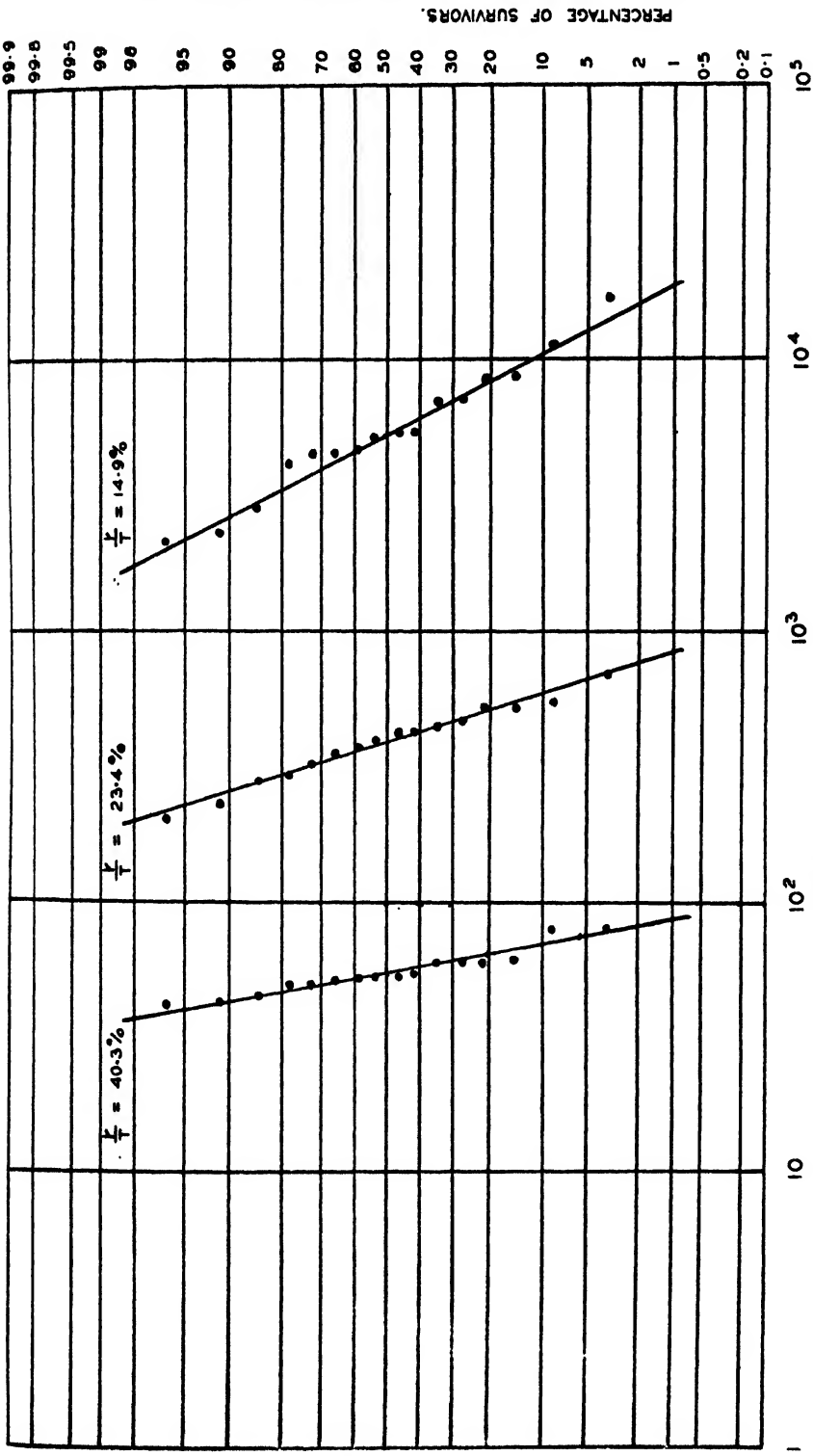


GRAPH. 1.—Relation of Cycles-to-Rupture to Pounds wearing Load in Preliminary Test with modified Amsler Wear Testing Apparatus.

In graph 1, if an exponential relation of the form $N = K/t^n$ be assumed, n would be equal to 6. Several questions then automatically arise. The primary question is whether there exists any relation between K and the tensile strength of the material, and whether n is always equal to 6 or may vary and to what degree it may vary. Obviously if n were constant, wear testing in this manner would yield no information beyond that given by tensile strength.

To answer the above questions in part, sixteen tests were made upon a bleached sheeting, filling direction, at each of three loads 28·5, 16·5 and 10·5 pounds. The fabric was cut 2·25 inches wide but ravelled to two inches. The strength of fabric so ravelled using the same distance between jaws as in the wear tester, was found to be 70·7 pounds with a coefficient of variation of 6·25 per cent. These loads therefore are 40·3 per cent., 23·4 per cent., and 14·9 per cent. respectively of the normal breaking load.

In Table I is given the results of all 48 tests in cycles-to-rupture, the tests being made in rotation with respect to the three different loadings, and the apparatus operating in a room of nearly constant temperature and humidity. Graph 2 exhibits these data plotted as percentage survivors *versus* cycles-to-rupture in the form of three ogive curves on probability logarithmic ruled paper. On paper ruled thusly, the ordinate numbers are values of $\frac{1}{2} \pm \frac{1}{\sqrt{\pi}} \int_0^z e^{-x^2} dx$ at distances from the 50 per cent. of mid-



GRAPH. 2.—Data of Table I. presented on Probability—Logarithmic Plotting Papers as Percentage Survivor/Cycle-to-Rupture Curves.

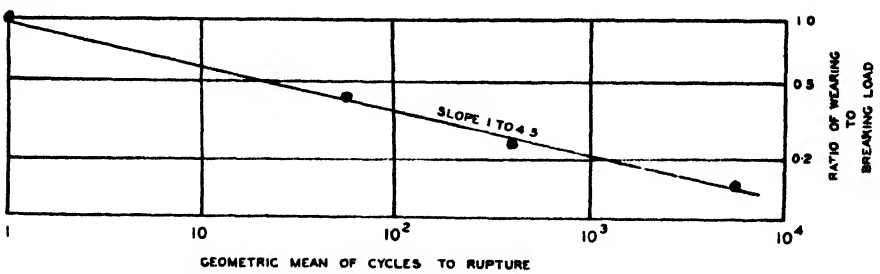
horizontal line proportional to x. The points for each ratio of testing load (t) to breaking load (T) lie reasonably near straight lines, the deviations from verticality increasing with decreasing ratios of t/T in such a way as to denote greater variability the lower the testing load.

Table I

Wear Tests in Cycles-to-Rupture on a Bleached Sheeting, Filling Direction. (The rupturing Load was 70·7 Pounds with Coefficient of Variability 6·25%.)

Testing Load in Pounds	28·5	16·5	10·5
Ratio of Testing to Rupturing Load in per cent. ...	40·3%	23·4%	14·9%
Cycles-to-Rupture arranged from low to high	42	202	2131
	42	234	2307
	44	283	2788
	49	296	4137
	49	327	4488
	51	358	4522
	51	372	4727
	52	395	4953
	52	423	5322
	53	425	5332
	59	449	6983
	59	461	7236
	59	522	8607
	60	524	8657
	78	550	11255
	78	685	16914
Averages:			
Arithmetic	54·9	406·6	6272·5
Median	52	409	5137·5
Geometric Mean	53·9	387·7	5416

From similar survivor cycle-to-rupture distribution curves Owen and Locke[2] proposed that the geometric mean, rather than the arithmetic mean of the cycles-to-rupture, be used. In graph 3 the geometric mean of the cycles-to-rupture is plotted against the respective ratios of t/T on logarithmic paper, with the addition of a point at t/T = 1 and N = 1 corresponding to

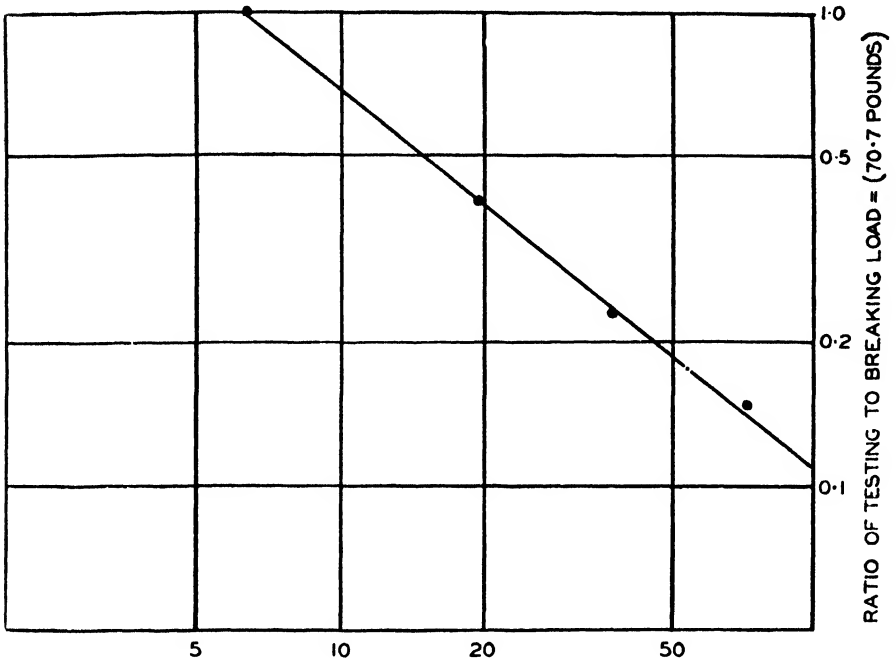


GRAPH. 3.—Geometric means from Table I. plotted t/T ratios.

the breaking strength itself (T) and assuming this to be a one-cycle rupture. Approximately here, or for practical purposes, $N = (T/t)^n$ or $n = \log N/\log T/t$. Further precision researches may indicate consistent digression of n with respect to T/t as with steel, but as a first approximation, the relation possesses the advantage of simplicity.

An exponential relation also holds approximately with respect to variabilities. In graph 4 a measure of variability comparable to the ordinary coefficient of variation is plotted against the ratio of t/T for cycles-to-rupture and at one limit breaking load. At t/T = 1, the coefficient of variation = 6·25 per cent. The measure of variability of cycles-to-rupture was computed by averaging the squares of the logarithms of the ratios of each cycle-to-

rupture to the geometric mean, extracting the square root; then the anti-logarithm of this value, minus unity, is converted to a percentage basis comparable with the usual coefficient of variation. The variability so computed would approach the coefficient of variation asymptotically, as a limit as the variability diminishes.



GRAPH. 4.—Relation of Variability of Cycles-to-Rupture to t/T ratios from data in Table I.

It will be noted from graph 4 that as the wearing load t is halved the percentage variability is doubled, and hence to obtain the same degree of precision of the mean, the number of tests would have to be quadrupled. Also from graph 3 it may be seen that as the load is halved, the cycles-to-rupture increase twenty fold. Taking both factors into account, it will be seen that halving the testing load involves the application of eighty odd times as many total cycles-to-rupture to obtain the same precision of the geometric mean. As t/T lowers, service conditions are undoubtedly approached, but the time consumed in wear testing increases enormously. The question as to how close service conditions should be approached in wear testing is partly a question as to how fundamental or how commercial the work is to be. A compromise must be effected between the speed of tensile tests, and the slowness of tests closer to service conditions.

Wear tests, instead of being defined in terms of cumbersome cycles-to-rupture, may be better defined in terms of tensile strength and an auxiliary variable n, the magnitude and range of which will depend upon the particular type of test.

In Table II data is given from a further test in the same apparatus yielding values of n ranging from 3·7, 5·7, 6·9 to 8·4, whereas in graph 3, $n = 4{\cdot}5$ and in plot 1, $n = 6$.

In still another series of tests applied to knitted wear of various mixtures of silk, rayon, and cotton, the strips in all cases being made two inches wide, the wearing load t set at 13·5 pounds, the values of T in order high to low were 105·5, 74·5, 58·5, 51·0, 43·7, 40·0, 36·5, 35·0, 34·5, 33·3, and 23·5 ; the corresponding values of N were 1530, 1138, 653, 780, 637, 498, 661, 413, 364, 333, and 68 : hence the values of n computed therefrom ($n = \log N/\log T/13{\cdot}5$) were 3·56, 4·12, 4·42, 5·00, 5·49, 5·70, 6·53, 6·32, 6·27, 6·42 and 6·90.

Table II—Wear Tests in Cycle-to-Rupture on Two Fabrics, both Directions and Computed Values of n.

Fabric	A		B	
Testing Load in Pounds (1 in. width) t =	15·5		25·5	
Direction of Load	Warp	Filling	Warp	Filling
Breaking Strength in lbs. (1 in. width) T =	46·4	54·4	59·0	59·0
Average Variation in per cent.	±5·3%	±5·8%	±3·6%	±4·0%
Cycles-to-Rupture Wear Testing arranged from low to high	243	66	532	79
	308	68	594	154
	375	68	640	170
	381	74	665	200
	382	79	760	220
	396	81	784	222
	446	82	838	230
	480	84	919	249
	523	87	985	291
	621	89	1015	301
	626	92	1093	344
	651	94	1115	356
	677	101	1177	371
	678	119	1277	404
	702	123	1714	419
	731	133	1719	493
	765	135	1732	497
	775	146	2032	505
	799	255	2085	523
	816	263	2340	794
Logarithmic Mean (N)	538·3	102·8	1091	302·1
Average Ratio Variation—				
from Geometric Mean	1·355	1·357	1·442	1·496
expressed as a per cent....	±35·5%	±35·7 =	±44·2%	±49·6%
n computed from $\text{Log}_{10}\ N/\text{Log}_{10}T/t$ ...	5·74	3·69	8·34	6·82

It is therefore apparent that n varies for different materials and bears no consistent relation to tensile strength. In Table II, n is higher the higher the strength, whereas in the knitted wear tests it is lower the higher the strength.

OBSERVATIONS ON THE RANGE OF n FROM THE LITERATURE

Not only will n vary with the type of material when subjected to the same type of wear test, but it will probably also vary widely with the type of test. It may be worth while to deduce roughly some values of n obtained under widely varying test conditions. Where the tensile strength or breaking load is not given, n will be deduced from the ratio of percentage cycle-to-rupture increase divided by the percentage load diminution.

Strictly speaking, a uniform constant pull may not appear to be a wear test, nevertheless it may be treated as a limiting factor in wear. Work on the time factor in cotton hair[8] as well as yarn[9] and fabric[10] testing has

shown that as the load decreases 1 per cent., the time to rupture increases 20 per cent. If this treatment be considered to be an oscillating stress with zero amplitude, then n would have a value of 20.

From data presented by Owen and Locke[2] in their figure 7 (p. T577) n would lie between the limits of 7 and 12, and probably 9 and 10.

At another extreme, in rope-bending tests conducted by Schoffstall and Boyden,[11] an extremely severe test, it was shown that as the load applied in testing diminished by 1 per cent., the cycles-to-rupture increased by 1·5 per cent. (n 1·5) from slopes on a double logarithmic plot.

Stavely and Shepard,[12] studying tire cord, found that with carded American 23s/5/3 at three humidity-temperature combinations of 53 per cent., 25·5 C; 56 per cent., 25·5 C; and 59 per cent., 24·5 C with their apparatus, the cycles-to-rupture were 4196, 5173, and 6373 respectively, while with a carded Sakellarides 23s/5/3 the cycles-to-rupture were 6415, 7785, and 9628 respectively. If it be arbitrarily assumed that the breaking strength (T) of the carded American and carded Sakellarides are 16·5 and 19 pounds respectively, t being 6·6 pounds, then from data n would average 8·5 to 9·5 respectively, or broadly 8 to 10.

Also from the same data, assuming that a 1 per cent. increase in humidity increases the tensile strength of the tire cord 0·4 per cent., it would appear that for both cottons a 1 per cent. increase in tensile strength, such as is due to increased regain, increases the cycles-to-rupture by 19 per cent., whereas a 1 per cent. increase in tensile strength, such as is due to the superiority of carded Sakellarides over carded American, only increases the cycles-to rupture by 3 per cent. This exhibits one phase of the complication of fundamental conditions involved in wear or fatigue tests.

Table III—Cycles-to-Rupture of Axles Rotated at Uniform Speed and deduced Values of n

Steel of Carbon Content as given		0·17%	0·55%	0·82%
Tensile Strength in Pounds per Square Inch (T) ...		68000	106100	142250
Cycles-to-Rupture (N) for the Given Maximum Fibre Stresses (t) ... ... t =	60000	$6{\cdot}47\times10^{3}$	$1{\cdot}25\times10^{4}$	$3{\cdot}73\times10^{4}$
	55000			$9{\cdot}38\times10^{4}$
	50000	$1{\cdot}78\times10^{4}$	$9{\cdot}32\times10^{4}$	$2{\cdot}13\times10^{5}$
	45000	$7{\cdot}04\times10^{4}$	$1{\cdot}66\times10^{5}$	$6{\cdot}05\times10^{5}$
	40000	$2{\cdot}94\times10^{5}$	$4{\cdot}55\times10^{5}$	*$1{\cdot}76\times10^{7}$
	35000	$5{\cdot}76\times10^{6}$	$9{\cdot}01\times10^{5}$	*$1{\cdot}92\times10^{7}$
	30000	*$2{\cdot}36\times10^{7}$	*$1{\cdot}99\times10^{6}$	
Computed Values of $n = \frac{\log_{10}N}{\log_{10}T/t}$ from above data t =	60000	70	17	12
	55000			12
	50000	32	15	12
	45000	27	14	12
	40000	24	13	*13
	35000	23	12	*12
	30000	*21	*13	
Average from $n = \frac{\Sigma\log_{10}N}{\Sigma\log_{10}T/t}$		26·2	13·8	12·1

*Discontinued, rupture not having occurred.

CONCLUSIONS

The statements of both Dr. Edwards[1] and Owen and Locke[2] cited in the introduction coincide in the view that wear is usually a complex phenomenon, that rupture occurs not from a single pure type of wear, but from an aggregate of various types of wear simultaneously applied. It would seem

as if much of the complication in wear testing might be reduced, if, instead of simultaneously applying a wide variety of wear types as in the present investigation, an apparatus with method could be developed in which the type of wear with effects could be studied separately and independently and subsequently the laws of their combination or synthesis determined. Wear types might be classified into five types: (1) steady loading wear, (2) oscillation or alternating stresses between limits bearing ratios from 0 : 1 to 1 : 1; the latter being equivalent to (1), (3) flexing wear, that is wear in which the extreme radii of curvature varied from R_0 to R_1, either of which might be infinity, (4) shearing wear, and (5) abrasive wear. The last three types of wear could not be applied to the exclusion of the first two types. Their effects as pure types of wear might have to be inferred wholly from mathematical analysis. Were it possible to formulate the laws governing the different types of pure wear, then it should be possible to further combine these synthetically and estimate any defined combination of wear types.

However, in these special tests, in which the wear or abrasion test really involved three types of wear, repeated or alternating stressing, flexing and surface abrasion upon a material of strength T, subjected to a maximum stress t, the geometric mean cycles-to-rupture N may be evaluated from the exponential formula :—

$$N = \left(\frac{T}{t}\right)^n$$

In which n is an exponent which under the conditions varied from 3 to 9, but which for all types of tests might vary from 1·5 to 25. This exponent n as an auxiliary characteristic combined with T should prove serviceable in better comparing wear tests than could be obtained from T alone, or than could be interpreted from the cumbersome and highly variable cycles-to-rupture.

Variability of cycles-to-rupture is also proportional to $(T/t)^n$ where n under the conditions investigated was nearly unity.

Almost all kinds of wear tests involve the application of repeated or alternating stresses even though apparently abrasion at first appears to be the predominating type of wear.

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TRANSACTIONS

19—VARIATION IN THE PROPERTIES OF COTTON FIBRE IN RELATION TO ITS POSITION ON THE SURFACE OF THE SEED

PART I—(i) FIBRE-LENGTH (ii) FIBRE-WEIGHT (iii) FIBRE-STRENGTH

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SUMMARY

The experiments described in these pages relate to the following fibre-properties in relation to the position of the fibres on the surface of the seed: (i) fibre-length; (ii) fibre-weight; (iii) fibre-strength. The material consisted of a single seed of Surat 1027 A.I.F., and groups of 200 seeds of six Standard Indian Cottons, two of which were also tested for two seasons. The lint was obtained from the following regions of the seed: (1) the apex or the pointed end; (2) the base or the butt end; (3) the right flank; (4) the left flank, and (5) the hairs removed in gentle combing by hand—"the combed hairs." The position of the point of rupture in a single hair break was also examined by mounting fibres between two types of eyelets, one made of brass and the other of aluminium, the former always attached to the basal position and the latter to the apical position of the fibre.

From the study of the graphs and the analysis of the test results the following conclusions have been drawn:—

1. The frequency distribution of fibre-length is approximately symmetrical and normal, not only for fibres taken from the whole seed but also for fibres taken from different regions of the seed.

2. The mean fibre-length for fibres at the base of the seed is significantly greater than for fibres at the apex of the seed, indicating that the basal fibres are longer than the apical ones.

3. Not only is the asymmetrical distribution of fibre-strength a characteristic of all fibres from the seed, but also, in the different regions of the seed, the distribution of fibre-strength is definitely skew.

4. The mean fibre-weight per unit length and the mean fibre-strength are significantly higher for the apical than for the basal fibres.

5. The values of the mean fibre-lengths, the fibre-length distribution, fibre-weight, and fibre-strength are practically the same for the right and the left flanks—the small differences observed between them are well within the sampling error.

6. The fibres which are removed in the process of combing the seed by hand are generally those which have got the least fibre-weight.

7. For the majority of fibres (about 80 per cent.) the point of rupture in single hair breaks is located in the *apical portion* of the fibre. There is a low correlation between the point of break and strength indicating that there is a tendency for the comparatively weak fibres to break near their apical ends.

8. The percentage differences between base and apex mean values of the various fibre-properties are different for different cottons. The following table gives in a summary form the mean values and the percentage differences for the 8 cottons which formed the subject of this investigation:—

Cotton		Fibre-length			Fibre-weight			Fibre-strength		
		A	B	(A-B/B) ×100	A	B	(A-B/B) ×100	A	B	(A-B/B) ×100
Surat 1027 A.L.F...	28-29	0·83	0·92	− 9·8	3·02	1·61	+87·6	5·26	3·16	+66·5
P.A.4F	29-30	0·67	0·80	−16·3	2·94	1·78	+65·2	6·11	4·25	+43·8
Gadag I.	27-28	0·72	0·81	−11·1	2·22	1·49	+49·0	4·83	3·59	+34·5
Verum-Nagpur ...	28-29	0·72	0·82	−12·2	2·52	2·06	+22·3	6·49	4·93	+31·6
Nandyal 14	29-30	0·76	0·97	−21·6	2·31	1·96	+17·9	7·16	5·48	+30·7
Gadag I.	28-29	0·71	0·80	−11·3	2·19	1·48	+48·0	4·76	3·79	+25·6
CA-9	29-30	0·75	0·90	−16·7	1·97	1·70	+15·9	5·41	5·16	+ 4·8
CA-9	28-29	0·78	0·92	−15·2	2·00	1·69	+18·3	5·75	5·57	+ 3·2

A = Apex mean.
B = Base mean.

Units = Length inches. Strength grams.
Fibre-weight 10^{-6} gm.

9. There is a distinct tendency for a high ginning percentage to be associated with low percentage difference between mean fibre-length of hairs taken from the apex and base of a seed.

The practical applications of this investigation are discussed in Section VII. It is pointed out that in selecting new strains the cotton breeder should pay attention, not only to the absolute values of the fibre-properties, but also to the percentage difference between the mean values of the properties of hairs growing on the base and the apex of the seed. An analysis on these lines will at once differentiate between two strains with respect to the regularity of their staple, thus enabling the breeder to select the particular strain which will yield a more uniform lint. Secondly, on account of the large differences in the base and apex mean values of some cottons, it is suggested that if a method of differential ginning could be devised which would remove the lint from the two flanks and the base of the seed separately from that on its apex, it would be possible to obtain from the same seed two lots of cotton, one lot being appreciably longer and finer than the other. Such a differential gin would act as a combined ginning and combing machine. The suggestion is made for the benefit of those who have a mechanical bend of mind. Thirdly, it is pointed out that in view of the unexpectedly large differences in the base and apex mean values of the various fibre-properties it is extremely necessary, wherever possible, to take a fairly large sample for the determination of any of the fibre-properties. Where, owing to the tedious and time-absorbing nature of the work, a fairly large sample is ruled out, the sample selected should be so constituted as to be thoroughly representative of the bulk, otherwise a preponderance of basal or apical hairs in the sample will introduce a large error in the result.

I—INTRODUCTION

It has been recognised for a long time that fibres of the same cotton display great variation in their physical properties. A detailed study of the nature and extent of variation of some of the fibre-properties was made in a previous paper[1] written by one of us in collaboration with Dr. A. James Turner. The causes of the asymmetrical distributions of fibre-strength and fibre-rigidity were discussed at length, and the following observations were made in this connection :[1] " The second possible explanation of the asymmetry is that it arises from differences in the conditions of growth to which different fibres may have been subjected. Even if the fibres on a single seed have normal frequency distribution for fibre-strength, yet a mixture of fibres from different seeds may have an asymmetrical distribution ; for instance, suppose the fibres on one seed have developed normally, whereas those on another seed have been subject to malnutrition during their thickening stage, and so are both thin and weak ; it is possible that if both types of fibres are present in a mixture the frequency distribution of fibre-strength will be asymmetrical owing to an excess of weak fibres. . . . It should be noted that an excess of weak fibres may be produced even on a single seed, if a change in the environment leads to differential nutrition of the fibres . . ." " Now, in the course of growth inside the boll, the fibre frequently jostles against neighbouring fibres, the false plancenta, or the wall of the boll . . . And as the fibres of every individual seed are subjected to this type of interference with their growth, it is to be expected in such a case that an asymmetrical distribution will be characteristic of the fibres from a single seed." It was primarily with the object of examining the explanation of asymmetry given above, that the experiments on a single seed of Surat 1027 A.L.F. were carried out, but as the subsequent analysis of the results of these experiments tended to throw considerable light on the variation of fibre-strength with regard to the position of the fibre on the seed, the scope of the experiment was widened to cover other fibre-properties, and groups of seeds obtained from six standard Indian cottons, two of which were also studied for two seasons.

A thorough investigation of the chief properties of the fibres taken from different parts of a seed has not been undertaken before, although several

investigators have mentioned the existence of variability in certain properties from a seed. Thus Clegg and Harland[3] state that " in examining cross sections of hair from the same seed, it is not unusual to find patches of one to two hundred hairs closely grouped together, characterised by thin walls." Calvert and Summers,[4] while discussing the importance of sampling say that " hairs of the same width often occur together in groups on a seed." Hilson[5] while discussing halo method of measuring length writes, " If the seed with its halo be likened to a clock face, the butt end of the median line will represent the central point, and the maximum length will lie between that point and from 3 to 9 o'clock. Most commonly the largest measurement will be obtained at from 4 to 5 or 7 to 8 o'clock." Some of the statements are evidently based on insufficient data and are mutually contradictory. Thus, Collings[6] says " As a general thing, the longest fibres are found at the top, or apex of the seed, these being the first to develop, while the shortest are found near the base." Hugh Monie[7] discussing the maturity of the fibres states, " Fibres produced on the crown of the seed are in every way more advanced and developed than those on the base : Johnson[8] opines that " the longest fibres are produced at the posterior end of the seed and the shortest at the anterior end." It will be seen that, as regards fibre-lengths alone, the different writers hold conflicting views. It is hoped that, in addition to the theoretical and practical implications of the results of this investigation, which will be fully discussed later on, it will dispel the mist of uncertainty which, at present, hangs over the problem of variation of fibre-properties on the surface of a cotton seed.

In order to appreciate the great variability of the raw material, it should be remembered that a bale of cotton contains lint obtained from several million seeds. Consequently, a small sample taken from it for testing purposes should contain fibres not only from different seeds, but also from different parts of the seeds if it is to be a representative sample. When such a sample is tested for any fibre-property it is found to show great variability among individual test-results—the *nature* and *extent* of which depend not only on the cotton selected, but also on the particular fibre-property studied. A complete picture of this variation is given by the frequency distribution of test-results, but it is usual to describe the sample in terms of two statistics derived from their frequency distribution, viz., the arithmetic mean and the standard deviation. Now the total variability is a complex quantity and may either be due to (*a*) variability contributed by fibres coming from different seeds and different parts of the same seed, or (*b*) it may be independent of the source from which the fibres have come. If (*a*) be true, then

(i) the means and standard deviations of samples obtained from single seeds of the same cotton should differ from seed to seed ;

(ii) the means and standard deviations of samples obtained from different regions of the same seed should differ among themselves.

If (*b*) be true, then the frequency distributions of test results for samples obtained from different seeds or different parts of the same seed should all be practically the same as that for the " bulk sample."

The experiments described in these pages were undertaken to find out whether the variability of any fibre-property is independent of the position of the fibres on the seed or depends upon it and in the latter case, the *extent* and *nature* of variation on each region of the seed.

II—EXPERIMENTAL

(a) Single seed

A small seed was picked at random from the kapas of Surat 1027 A.L.F. It was lightly combed and all the hairs removed with the comb were collected for subsequent testing—the hairs thus removed were designated " combed hairs," and the seed, after this process " combed seed." From the combed seed which now presented the appearance of a halo, tufts of hairs were plucked in the following order :—

1. Left flank.
2. Apex or micropylar end.
3. Right flank, and—
4. Base or butt end,

these divisions being made arbitrarily.

Fig. 1 shows an actual size photograph of a combed seed from which the basal and apical fibres have been removed and the division into the four regions has been indicated by crossed lines.

All the fibres were tested for length and strength. Each fibre was mounted between two small eyelets about 2 mm. of the fibre being embedded under wax at each end. The length of each fibre was determined by means of a small steel scale graduated in ½ mm. The strength of single fibres was determined by Barratt's Fibre Balance.[9] In this way, altogether about 4,700 fibres were tested for length and strength. These fibres were found to be distributed as follows :—

A—Combed Hairs	1,255	
B—Seed	3,445	
(*a*) Left Flank	706	
(*b*) Apex	756	3,445
(*c*) Right Flank	1,022	
(*d*) Base	961	

In order to locate the actual point of break in the single fibre-breaks, two types of eyelets (one made of brass and the other of aluminium) were used. About 2,000 fibres were tested in this way, aluminium eyelet being always used for mounting the *apex* of the fibre.

(b) Groups of seeds

(i) *Material :* The material used consisted of kapas of six standard Indian cottons, two of which were for two seasons ; their details are given in Table I.

Table I

Cotton	Season	Botanical species	Place of growth	Highest standard warp counts.
1. Surat 1027 A.L.F. ...	1928-29	*Gossypium herbaceum* ...	Bombay	32
2. Nandyal 14	1929-30	*Gossypium indicum* ...	Madras	35
3. Punjab-American 4F ...	1929-30	*Gossypium hirsutum* ...	Punjab	20
4. Gadag 1	1927-28	,, ,, ...	Bombay	38
5. Gadag 1	1928-29	,, ,, ...	Bombay	26
6. Cawnpore-American C.A. 9 ...	1928-29	,, ,, ...	United Provinces	40
7. Cawnpore-American C.A. 9 ...	1929-30	,, ,, ...	,,	34
8. Verum 262 (Nagpur) ...	1928-29	*Gossypium Neglectum (Verum)*	Central Provinces	26

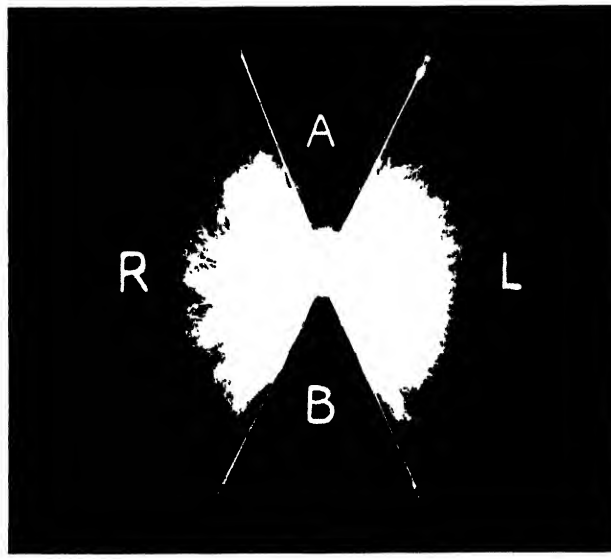


FIG 1

It will be seen from the table that most of the botanical species, and all the major cotton-growing provinces in India, are represented.

(ii) *Sampling:* The following procedure was adopted for obtaining a representative sample from the kapas. A pound of kapas (total quantity available) after being well mixed by hand was divided into approximately four equal parts, each of these parts were again divided into four parts, thus giving rise to sixteen sub-groups. From each of these sub-groups 12 to 13 seeds were picked at random. In this way about 200 seeds forming a representative sample were available for each cotton.

(iii) *Process of Delinting:* Each seed was lightly combed, first by hand, then by the broad side of a small comb and finally by its narrow side; the detached fibres were collected and the seed was ready for the next operation. Each "combed seed" was delinted separately at four parts—apex, base, right flank and left flank; the right and left flanks were distinguished by the following method:—Place the seed with the median line (see Fig. 1) *downwards*, and the apex or pointed end facing you, the flank to your left hand is the left flank and the other the right. The same convention was followed for all cottons and for all seeds.

(iv) *Ginning percentage and distribution of lint on the surface of the seed:* Before preparing the sliver for determination of fibre-properties, the total lint obtained from different regions of the 200 seeds was weighed separately. These weighings give the distribution of lint on the surface of a cotton seed. In the case of some cottons, the weighings were also made for groups of 50 seeds in the order of sampling. The delinted seeds of each variety were weighed separately and from these weighings the weight of seed, the lint per seed, and the ginning percentage were calculated for each cotton. Table II gives the results obtained.

Table II

Weight of seed, lint per seed, ginning percentage, and distribution of lint on the surface of the seed for some of the standard Indian cottons.

Seed and lint particulars	Surat 1027 A.L.F. (1928-1929)	Nandyal 14 (1929-1930)	Gadag 1 (1927-1928)	Gadag 1 (1928-1929)	C. A. 9 (1928-1929)	C. A. 9 (1929-1930)	Verum 262 (Nagpur) (1928-1929)	P. A 4F (1929-1930)
Weight of seed (milligrammes) ...	60·0	50·0	101·2	95·7	88·4	88·6	49·3	80·5
Weight of lint per seed (milligrammes)	34·1	16·5	47·5	44·6	33·6	37·8	29·5	39·4
Ginning percentage ...	36·2	24·8	32·0	31·8	27·6	30·0	37·4	32·8
Lint distribution (percentages):								
(*a*) Apex	10	16	10	10	11	9	14	8
(*b*) Base	19	30	28	19	29	19	28	17
(*c*) Right flank ...	29	23	24	30	23	31	25	32
(*d*) Left flank ...	28	24	21	30	22	33	24	30
(*e*) Combed hairs...	14	7	17	11	15	8	9	13

(v) *Preparation of sliver for fibre-properties:* The tufts of fibres removed from different parts of the seeds were opened and mixed carefully by hand so as to get a "mass" of cotton. From this, hand-slivers were prepared by the usual process of repeated mixing and doubling. For the determination of fibre-strength, the fibres were taken directly from this hand-sliver, but in the case of fibre-length and fibre-weight the hand-sliver was passed

a few times through draw-box, in order to ensure greater uniformity and parallelisation.

(vi) *Experimental Procedure:*

(*a*) *Fibre-Lengths:* Balls Sledge Sorter was used to determine the mean fibre-length and fibre-length distribution. Two draw-box slivers were used and the mean of the two results represent the mean fibre-length and fibre-length distribution for hairs taken from different parts of the seed.

(*b*) *Fibre-Weight:* The mean fibre-weight was determined by weighing bunches of whole fibres on a quartz-micro-balance. In all essential respects the method is the same as described in the Technological Reports on Standard Indian Cottons, 1931,[10] with this exception, that all the weighings were carried out within a narrow range of relative humidity (55-65). Consequently, the necessity for applying the correction for change of fibre-weight with change of humidity did not arise. For each section (base, apex, etc.) about 2,000 fibres (1,000 from each sliver) were weighed in appropriate groups equivalent to 0·5 mg. weight.

(*c*) *Fibre-Strength:* Fibre-strength was determined by Barratt's Fibre Balance for the apical and basal fibres only. For each section 200 fibres were tested, this number having been found adequate from an analysis of 500 tests on basal and an equal number on apical fibres of Nandyal 14. In the case of two cottons, viz., Nandyal 14, 1929-30 and Cawnpore-American C.A. 9, 1928-29, strength tests were also made on right and left flank fibres. The results showed that there is no appreciable difference in the mean-results for right and left flank; moreover, the results of fibre-length and fibre-weight determinations also indicated that any appreciable difference is not to be expected. Consequently, so far as the strength results are concerned only base and apex regions were examined. As in the case of single seed, the length of a fibre between two eyelets was also measured just before the breaking test.

Barritt[11] has pointed out that "as it was found that hairs mounted over-night gave higher results than hairs soon after mounting, the drying effect of the hot wax was corrected by wetting each hair after mounting by means of a camel hair brush." In the present experiments, instead of adopting any arbitrary process of wetting, the drying effect of the hot wax was corrected by keeping the mounted fibres overnight.

III—MEAN FIBRE-LENGTH AND FIBRE-LENGTH DISTRIBUTION

(a) Single seed

Table III

Frequency Distributions of Fibre-Length for fibres taken from a single seed.

Class interval (cms.)	Seed					Combed hairs	Whole seed
	Left flank	Apex	Right flank	Base	Total		
0·1-0·3	0	1	0	0	1	0	1
0·4-0·6	6	9	2	1	18	1	19
0·7-0·9	13	43	13	10	79	14	93
1·0-1·2	26	107	31	40	204	21	225
1·3-1·5	68	180	98	83	429	113	542
1·6-1·8	145	219	233	167	764	254	1,018
1·9-2·1	156	134	339	256	885	385	1,270
2·2-2·4	182	49	213	239	683	339	1,022
2·5-2·7	82	11	78	127	298	106	404
2·8-3·0	21	3	9	33	66	16	82
3·1-3·3	6	0	4	5	15	5	20
3·4-3·6	1	0	2	0	3	1	4
Total No. of tests ...	706	756	1,022	961	3,445	1,255	4,700

In Table III are given the frequency distributions for fibre-length for different parts of the seed; the last column gives the combined frequency distribution for the whole seed including the combed hairs.

From these figures it is evident that the general character of the frequency distribution is the same in each region of the seed, although the place where the frequency density is the highest is different for apex, base, etc. The percentage of fibres below 0·9 cms. and above 2·5 cms. present in different regions of the seed are given below :—

	Percentage of fibres	
	Below 0·9 cms.	Above 2·5 cms.
Apex	7·0	1·8
Base	1·1	17·5
Right flank	1·4	9·3
Left Flank	2·7	15·5

We thus see at once that in respect of fibre-length there is a great difference between the apex and the base. The figures show clearly that, on the whole the fibres at the apex are generally short, while those at the base are generally long.

In Table IV are given the frequency constants for the frequency distributions given in Table III.

TABLE IV

Frequency constants of frequency-distributions of fibre-length for fibres taken from a seed of Surat 1927 A.L.F.

Frequency constant	Seed					Combed hairs	Whole seed
	Left flank	Apex	Right flank	Base	Total		
Arithmetic mean ...	2·00	1·59	1·95	2·04	1·90	2·00	1·93
Upper Quartile ...	2·34	1·87	2·22	2·36	2·24	2·29	2·25
Lower Quartile ...	1·68	1·30	1·69	1·74	1·60	1·74	1·64
Standard Deviation	0·475	0·419	0·395	0·441	0·463	0·383	0·446
Coefficient of variation (%) ...	24	26	20	22	24	19	23
β_1	0·137	0·002	0·039	0·106	0·050	0·089	0·077
β_2	3·351	3·035	3·868	2·988	3·088	3·659	3·240
Skewness	−0·169	−0·023	−0·067	−0·184	−0·111	−0·114	−0·129
κ_2	0·365	0·027	0·019	−0·239	1·461	0·066	0·241
ε_1	0·32	0·29	0·26	0·30	0·30	0·26	0·29
ε_2	0·34	0·28	0·27	0·32	0·34	0·29	0·32
Q	0·33	0·29	0·27	0·31	0·32	0·28	0·31
P.E.	0·32	0·28	0·27	0·30	0·31	0·26	0·31

*Although this value of κ_2 is high, yet the curve is normal, for " The branch of the cubic with which we are concerned passes through the gaussian point at which $p = \infty$, and along this branch p is always > 5 "—Tables for Statisticians and Biometricians.[12]

Now p for Type V is given by [13] $-p = 4 + \frac{8 + 4\sqrt{4 + \beta_1}}{\beta_1}$; from our data $p = 4 + \frac{8 + 4\sqrt{4 \cdot 050}}{\cdot 050} = 325$, a very high value indeed. Hence the curve can be regarded as normal, reference to Table XLIII (Tables for Statisticians and Biometricians)[14] shows that the probable error of κ_2 is indeterminate and hence no reliance can be placed either on the sign or the magnitude of κ_2.

Many interesting points are revealed from the study of this Table; some of them are discussed below.

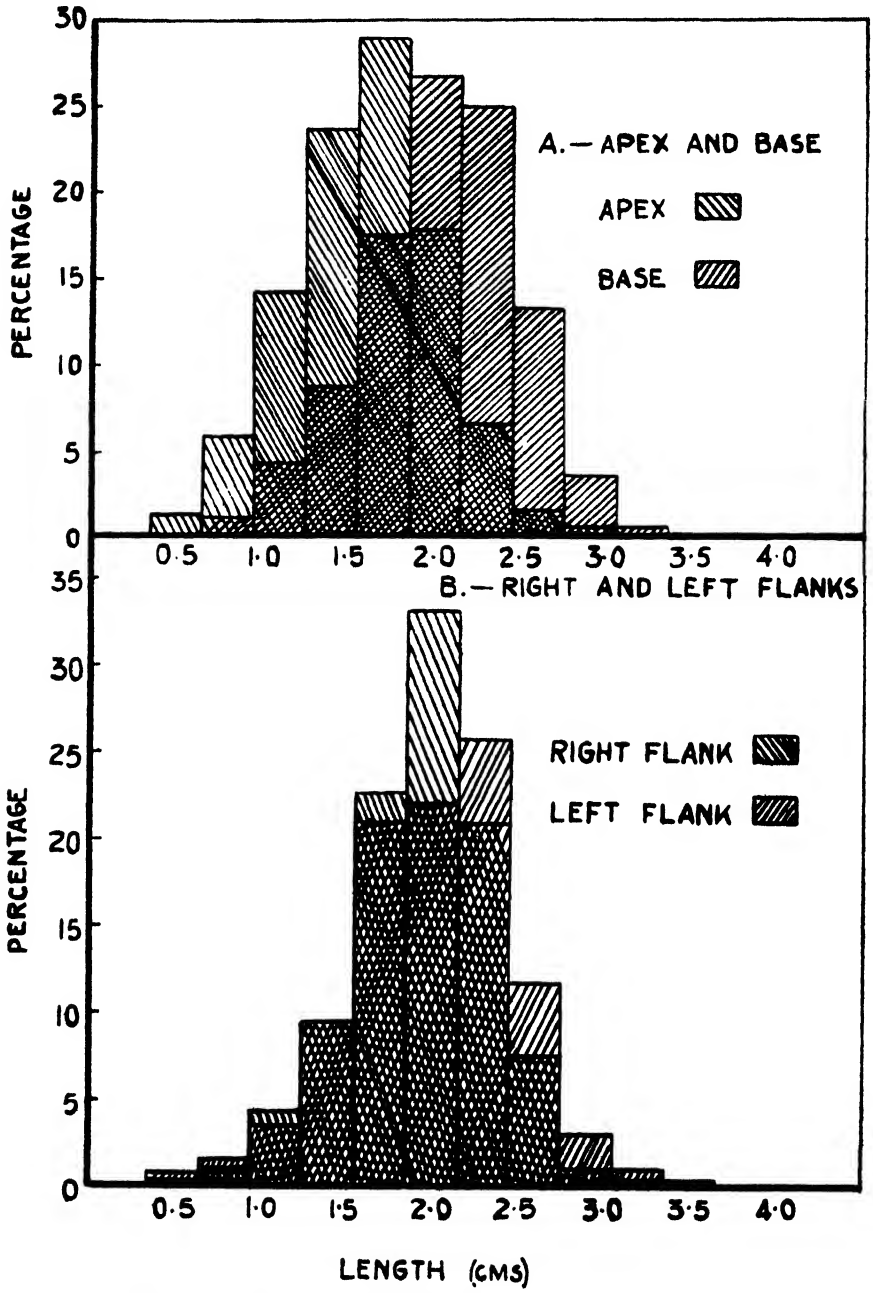


FIG. 2. Percentage distribution of fibres for different grades of Length—Surat 1027 A.L.F. (Single Seed).

(1) From the values of the arithmetic mean and upper and lower quartiles it is evident that there is a large difference between the lengths of fibres at the apex and at the base of a seed. The upper quartile for the former

(1·87) is less than the mean value (2·04) for the latter, showing that in general, long fibres are developed at the base and short fibres at the apex. This is also clear from Fig. 2A, which gives the percentage distribution of fibres of different grades of length. It is interesting to note that below 1·8 cms. in *every grade of length* the apex fibres are in excess, the shortest grade being exclusively theirs, while above 1·8 cms. reverse is the case, i.e., for every length grade the base fibres are in excess, the longest grade being formed exclusively of these fibres. In the case of the seed under discussion 74 per cent. of the apex fibres are below 1·8 cms. in length, while about 69 per cent. of the base fibres are above this length.

(2) The values of the arithmetic mean and the quartiles are practically the same for the right and the left flank, showing that there is no difference in length of fibres developed on the flanks of a seed—a fact, which can also be seen from Fig. 2B, showing the percentage distribution of fibres for different length grades.

(3) The values of β_1 and β_2 indicate that for different regions as well as for the whole seed, the frequency distribution is approximately symmetrical and normal. This is also evident from the study of the last four rows, for we find that the condition for normal distribution,[15] viz.,

$$\varepsilon_1 = \varepsilon_2 = Q = P.E.$$

is satisfied not only by the whole seed, but also by its different parts. Hence we conclude that fibres are distributed normally so far as length is concerned, not only on the seed as a whole, but also on its different parts.

(4) The values of skewness, though small, are negative throughout, indicating that there is a small preponderance of long fibres. This is also reflected in the sorter diagrams where the mode is always to the right (towards the giant side) of the mean.

(*b*) **Groups of Seeds**

As already stated on page T216, two slivers were used for the determination of mean length and length distribution for lint obtained from each region of the seed. The results are embodied in Tables 1-8 given in the Appendix. In each table is given the percentage fibre-length distribution for different parts of the seeds—apex, base, right flank, left flank, combed hairs. From these values, the percentage distribution of fibre-length for the whole seed is derived both by the " straight " mean and the " weighted " mean method. According to the first method the percentages corresponding to any given length grade are simply added up and their arithmetic mean is found; while according to the second method each percentage value is multiplied by the corresponding value of percentage lint distribution, given in Table II, the products are added up and the arithmetic mean is obtained. Finally, the values of the percentage fibre-length distribution obtained by testing lint, given in the Technological Reports[16] are also given for comparison. It will be seen that, on the whole, the weighted percentages agree more closely with the values given in the Technological Reports; this is also true of the values of mean fibre-length given at the bottom of each column.

When we examine the last rows of the tables giving the mean fibre-length for different regions of the seed we find:

(i) the apex mean-length is the smallest.

(ii) the base mean-length is the highest except for the cottons, Gadag I, Verum 262 and Surat 1027 A.L.F.

(iii) the right and the left flanks have practically given the same mean-lengths.

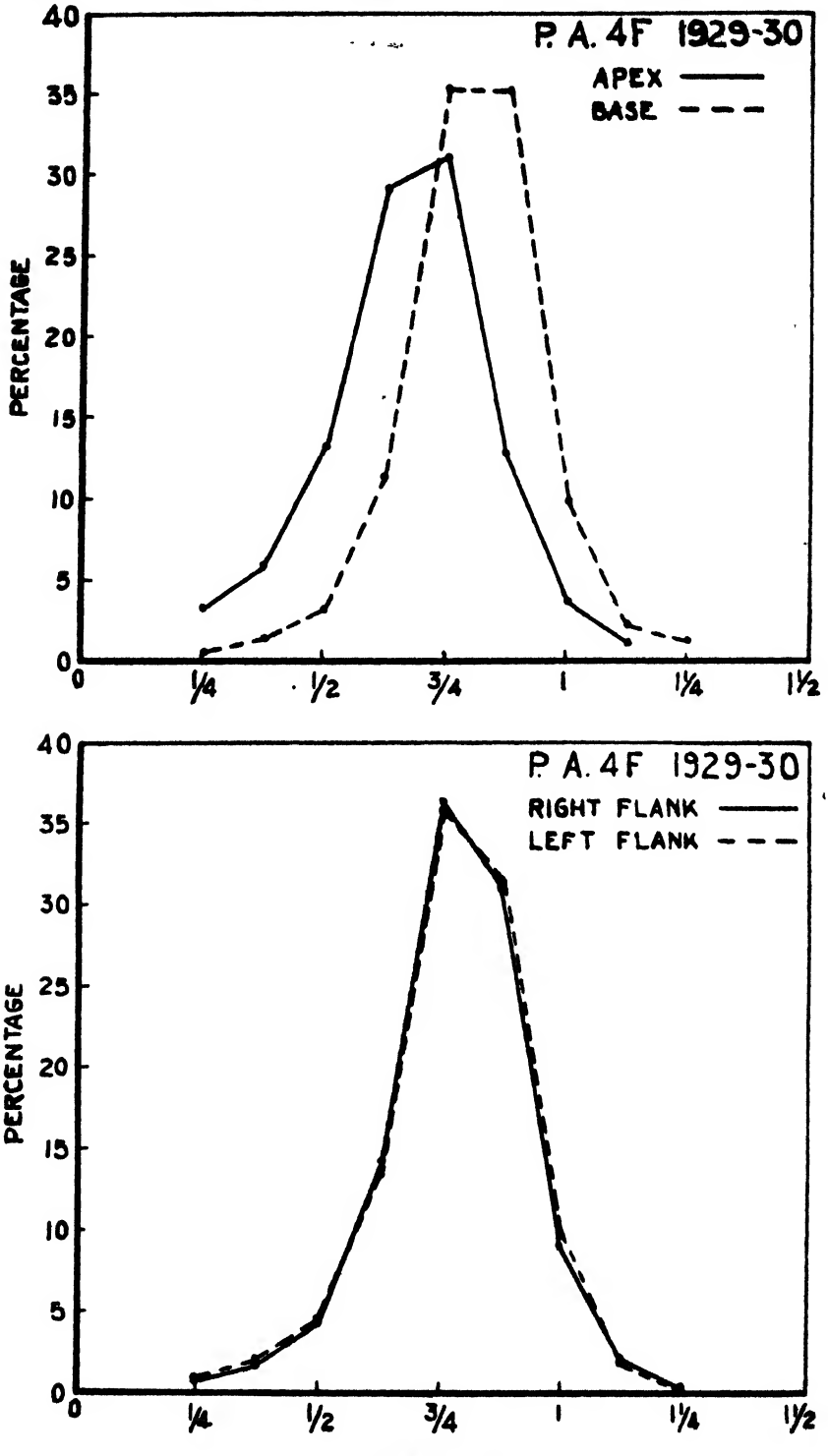


FIG. 3. Sorter Diagrams for P.A.4F (1929-30)

Table V

Section : (eighths of an inch)	C. A. 9 (1928-29)			C. A. 9 (1929-30)			Nandyal 14 (1929-30)			P. A. 4F (1929-30					
	A	B	A-B	A	B	A-B	A	B	A-B	A	B	A-B	R	L	R-L
2	1·6	—	+1·6	1·4	—	+1·4	2·1	—	+2·1	3·1	0·5	+2·6	0·7	0·8	−0·1
3	3·6	0·8	+2·8	3·6	1·5	+2·1	5·0	0·8	+4·2	5·8	1·4	+4·4	1·6	1·8	−0·2
4	6·2	2·1	+4·1	8·1	2·8	+5·3	10·4	1·4	+9·0	13·1	3·0	+10·1	4·2	4·4	−0·2
5	13·8	4·4	+9·4	17·3	5·9	+11·4	16·1	3·5	+12·6	29·1	11·3	+17·8	14·3	13·4	+0·9
6	25·8	13·1	+12·7	33·9	12·8	+21·1	23·1	8·1	+15·0	31·1	35·3	−4·2	36·4	36·1	+0·3
7	29·9	31·6	−1·7	26·7	31·2	−4·5	25·3	22·0	+3·3	12·9	35·2	−22·3	31·0	31·4	−0·4
8	15·7	34·6	−18·9	7·6	33·8	−26·2	14·1	38·2	−24·1	3·7	9·8	−6·1	9·1	9·7	−0·6
9	3·4	11·2	−7·8	1·4	10·5	−9·1	3·1	20·9	−17·8	1·2	2·2	−1·0	2·2	2·1	+0·1
10	—	2·2	−2·2	—	1·5	−1·5	0·8	4·2	−3·4	—	1·3	−1·3	0·5	0·3	+0·2
11	—	—	—	—	—	—	—	0·9	−0·9	—	—	—	—	—	—
d	—	—	61·2	—	—	82·6	—	—	92·4	—	—	69·8	—	—	3·0

A = Apex B = Base R = Right Flank L = Left Flank

These points will be made clearer by examining Table V and Figs. 3 and 4. In Table V, a comparison is made between the percentage distribution of length for apex and base fibres of C.A.9, P.A.4F, and Nandyal 14; in the case of one cotton (P.A.4F) the values of percentage length distribution for right and left flanks are also given. At the bottom of the table the values of d^{17} representing the total percentage divergence between the two distributions are also given. On examining the columns A and B it will be seen that in the case of all cottons—the differences in the first five rows are all positive, while in the last five rows they are all negative—showing that in the apex region there are relatively larger numbers of short length grade fibres, while in the base region reverse is the case. This is also evident from Fig. 3 in which the ordinates of the curve - - - showing the distribution for the base fibres are less than those of the curve——for apex fibres on the left-half, and continuously *in advance* of those on the right-half.

For all cottons the value of d the total percentage deviation between apex and base is large and considerably greater than the deviation between either two apex or two base slivers; for example d for C.A. 9 1928-29 (which is the least between these four cottons), is 61·2 as against 7·2 and 5·2 for two apex and two base slivers respectively. In the case of the right and the left flanks (4F) it will be seen that the value of d is very small as compared with its value for base and apex and is of the same order of magnitude as obtained with either two apex or two base slivers. Furthermore the differences in the R-L column (corresponding to A-B column) are sometimes positive and sometimes negative. Both these results show that the small differences observed between the right flank and the left flank are entirely due to sampling alone.

This will also be seen from Fig. 3 where the two sorter curves for the flanks overlap, but the base curve is bodily shifted as compared with the apex curve towards the right in the direction of the giant side of the mean. Fig. 4 gives the sorter diagrams for apex and base fibres for all the cottons tested. It will be seen from this that in all cases the percentage of short fibres is less at the base and greater at the apex while reverse is the case with long fibres.

As has been pointed out before it is only in the case of four cottons that the base-mean value is the highest, in the case of the other four cottons the highest mean-value is given either by one of the flanks or the combed hairs. The apex fibres, however, give the lowest mean-value in each and every case. In the following table the percentage length distribution of fibres from the region which has given the highest mean-value has been compared with the apex-percentage distribution and the corresponding values of d have been evaluated (see Table VI).

From the numerous mean fibre-length determinations made year by year at the Technological Laboratory it is known that the difference between the results for two slivers, due to sampling, rarely exceeds 0·04 ins. Table VI. shows that in the case of all cottons studied the difference between base and apex mean values is considerably higher than 0·04 ins., the minimum value being 0·09. We must therefore, conclude that the large differences between the base and the apex fibres are real and significant, and must be attributed to some other cause than random sampling fluctuations. The slight differences between the right and the left flank

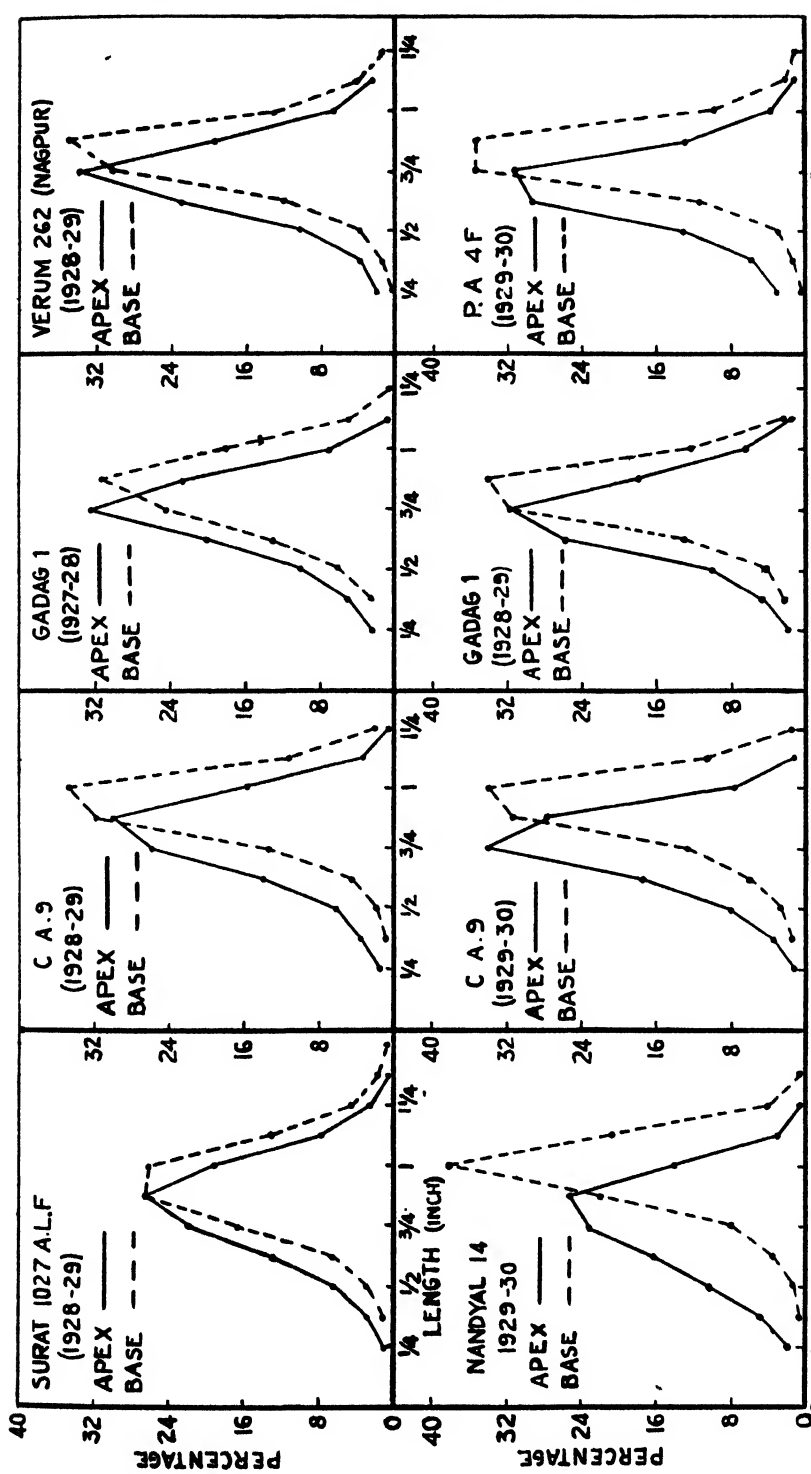

SURAT 1027 A.L.F
(1928-29)
APEX
BASE
C A.9
(1928-29)
APEX
BASE
GADAG 1
(1927-28)
APEX
BASE
VERUM 262 (NAGPUR)
(1928-29)
APEX
BASE
NANDYAL 14
1929-30
APEX
BASE
C A.9
(1929-30)
APEX
BASE
GADAG 1
(1928-29)
APEX
BASE
P.A 4F
(1929-30)
APEX
BASE
PERCENTAGE
LENGTH (INCH)
0
8
16
24
32
40
¼
½
¾
1
1¼

FIG. 4.

Table VI

Cotton	Apex-Mean (inches) A	Base-Mean (inches) B	A-B (inches)	$\frac{A-B}{B}\times 100$	d	Highest mean (inches) H	A-H	$\frac{A-H}{H}\times 100$	d_H
C. A. 9 (1928-29)	0·78	0·92	−0·14	−15·2	61·2	—	—	—	—
P. A. 4F (1929-30)	0·67	0·80	−0·13	−16·3	69·8	—	—	—	—
C. A. 9 (1929-30)	0·75	0·90	−0·15	−16·7	82·6	—	—	—	—
Nandyal 14 (1929-30)...	0·76	0·97	−0·21	−23·7	92·4	—	—	—	—
Gadag 1 (1927-28)	0·72	0·81	−0·09	−11·1	48·2	0·88	−0·16	−18·2	85·8
Verum 262, Nagpur (1928-29) ...	0·72	0·82	−0·10	−12·2	49·6	0·87	−0·15	−17·2	80·0
Gadag 1 (1928-29)	0·71	0·80	−0·09	−11·3	45·8	0·83	−0·12	−14·4	72·8
Surat 1027 A. L. F. (1928-29) ...	0·83	0·92	−0·09	−9·8	34·0	0·99	−0·16	−16·1	72·6

are, on the other hand, entirely due to sampling. Our latter conclusion does not agree with a result of Messrs. V. R. Ayyar and C. Jagannatha Rao, who state[18] " the lint length on the right side of the seed is greater than that on the left."

IV—UNIT FIBRE-WEIGHT AND MEAN FIBRE-WEIGHT PER UNIT LENGTH

(*a*) *Single seed :* A seed of Surat 1027 A.L.F. was taken at random, and fibres from its different regions were weighed in appropriate groups of 0·5 mgm. each. All weighings were carried out between 55-65 per cent. relative humidity. The results are shown in Table VII, and graphically represented in Fig. 5.

Table VII

Variation of unit fibre-weight on the surface of the seed. Surat 1027 A.L.F.

Group Number	Apex	Base	Right Flank	Left Flank	Combed Hairs
1	5·72	3·03	5·14	5·40	3·29
2	5·43	2·95	5·59	5·63	2·95
3	5·66	2·90	5·19	5·86	2·92
4	5·25	2·90	5·05	6·04	2·52
5	5·20	2·99	5·46	5·17	2·98
6	5·31	2·93	5·23	5·49	2·89
7	5·31	2·87	5·19	5·90	2·84
8	5·70	2·59	5·59	5·54	2·72
9	—	2·71	5·68	5·40	2·84
10	—	2·93	5·50	4·94	2·98
11	—	2·96	5·01	4·80	2·84
12	—	2·99	5·19	4·85	2·85
13	—	3·12	5·28	4·99	—
14	—	2·81	5·37	4·48	—
15	—	—	5·23	4·90	—
16	—	—	5·10	4·58	—
17	—	—	4·83	4·90	—
18	—	—	5·01	5·26	—
19	—	—	5·47	4·85	—
20	—	—	—	4·49	—
No. of fibres per group ...	75 ; last group 80	140 ; last group 182	100 ; last group 108	100 ; last group 102	150 ; last group 86
Total No. of fibres	605	2,002	1,908	2,002	1,736
Unit fibre-weight 10^{-6} gm....	5·448	2·906	5·270	5·174	2·885

The figures corresponding to each group, represent the unit fibre-weight (i.e., the average weight per whole fibre) obtained by weighing 75-150 fibres, the exact number being shown, in each case, at the foot of the column. The variation in fibre-weight for each region has been graphically represented in Fig. 5. The figures given in Table VII are re-arranged in decreasing order of magnitude of fibre-weight, so that the first group for each region of the seed indicates the highest value of fibre-weight obtained in that region, and the last group the lowest value. These group numbers are indicated along the x-axis in Fig. 5. The length of the apex curve is the shortest on account of the small number of groups available for it, as will be seen from Table VII. From the figure it is clear that the curves for apex and base are far apart ; the lowest value 5·20 for the former being considerably greater than the highest value 3·12 for the latter. The curves for the right and the left flank cross each other. The curve for the combed hairs is at the bottom

of the figure, showing that these have given the lowest fibre-weight. The mean values for the different regions are discussed below :—

Apex A	Base B	$\frac{A-B}{B} \times 100$	Right flank R	Left flank L	$\frac{R-L}{R} \times 100$	Base B	Combed Hairs C	$\frac{C-B}{B} \times 100$
5·448	2·906	87·5	5·270	5·174	1·8	2·906	2·885	−0·8

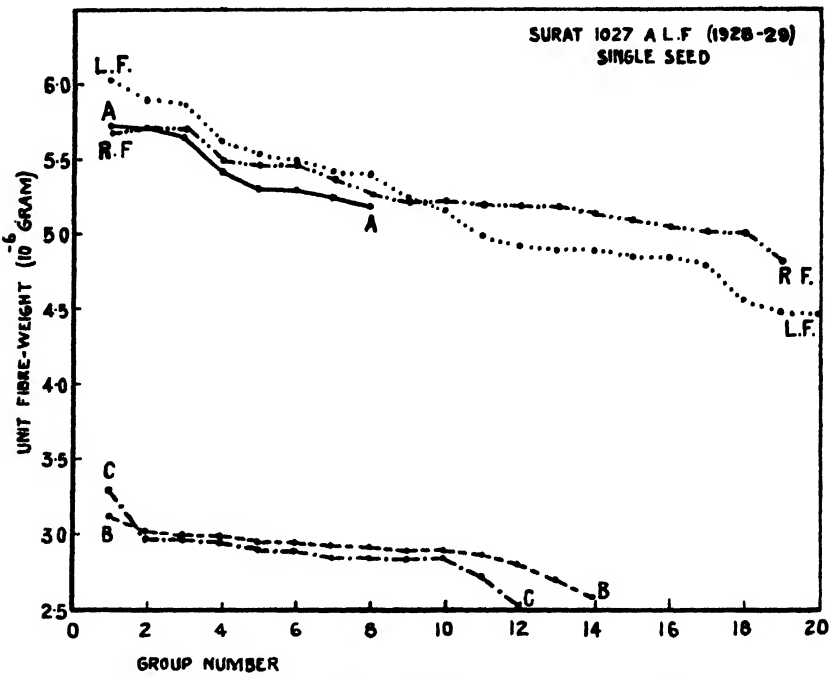


FIG. 5. Variation of Unit Fibre-Weight on the Surface of the Seed.

A = Apex
B = Base.
R.F. = Right Flank.
R.F. = Left Flank.
C. = Combed Hairs.

From the study of these values, Table VII and Fig. 5, the following conclusions are drawn :—

(1) The apex and the two flanks have given high values of unit fibre-weight.

(2) The base and the combed hairs have given low values of unit fibre-weight.

(3) There is no difference in unit fibre-weight values of hairs belonging to the right and the left flank, the slight difference observed between them is well within the sampling error.

(4) The apex fibres have given considerably higher values of unit fibre-weight, as compared with the base fibres—the difference being as high as 87 per cent. is highly significant and clearly outside the domain of random sampling.

(5) The hairs which are removed during the process of combing are generally those which have got the least fibre-weight.

(*b*) *Groups of seeds :* For the determination of fibre-weight 1,000 fibres taken from each of the Balls Sorter slivers were weighed in appropriate groups weighing 0·5 mg. each. The values of unit fibre-weight (fibre-weight per whole fibre) calculated from these groups are given in Tables 9-16 in the Appendix. The values for the apex and the base regions are graphically shown in Fig. 6. At the bottom of each column in each table are given the values of mean unit fibre-weight for each sliver. From the study of these figures it will be seen that with the exception of Gadag 1, the mean values for the combed hairs are the lowest. In the case of Gadag 1, the difference between the combed hairs and the base hairs which have given the lowest value is small and within the errors of random sampling. Consequently we can conclude that in the combing process these hairs are removed from the seed which have the least fibre-weight. This is in accordance with the result obtained for the single seed.

It is interesting to note that C.A. 9, particularly in the season 1928-29, has shown practically no difference in the mean-values of unit fibre-weight for the different regions. When the figures given in Table 11 are analysed by the " Method of Variance,"[19] it is found that the variance between regions is not significantly different from the variance within regions ; the value of z obtained is 0·204 which is smaller than 0·638 required for 1 per cent. point. However, as will be shown later on when the length of the fibres is taken into consideration, the value of fibre-weight per unit length is significantly greater for the apex than for the base fibres.

The values for apex and base in Tables 9-16 have been analysed separately for each cotton by the " Method of Variance " ; in order to find out whether the differences are real or due to random sampling. For the purpose of this analysis and for graphical representation in Fig. VI, the values for the two slivers for each region are taken together (e.g., for apex, 4F, 1929-30, 19 groups are considered irrespective of the sliver from which each group was obtained). The results are given in Table VIII :—

Table VIII

Significance of the difference between apex and base : Unit fibre-weight. Application of Analysis of Variance.

Cotton	n_1	n_2	z	Value of z for 1 per cent. point	Remarks
Surat 1027 A. L. F. (1928-29) ...	1	28	3·318	1·02	Significant
Nandyal 14 (1929-30)	1	36	1·436	1·01	Non-significant
C. A. 9 (1928-29)	28	1	1·475	4·37	Non-significant
C. A. 9 (1929-30)	1	33	1·024	1·01	Non-significant
Gadag 1 (1927-28)	1	28	2·690	1·02	Significant
Gadag 1 (1928-29)	1	27	2·891	1·02	Significant
Verum 262, Nagpur (1928-29) ...	1	28	2·390	1·02	Significant
P. A. 4F (1929-30)	1	32	3·405	1·01	Significant

From this table it is clear that with the exception of two cottons, Nandyal 14, and C.A.9 (both seasons), the difference between apex and base is significant—a fact which can also be seen from Fig. 6, where in the case of these two cottons the curves intersect, while in the case of all the other cottons the curve for the apex is distinctly apart from that for the base. The significance of the difference between the mean unit fibre-weight for

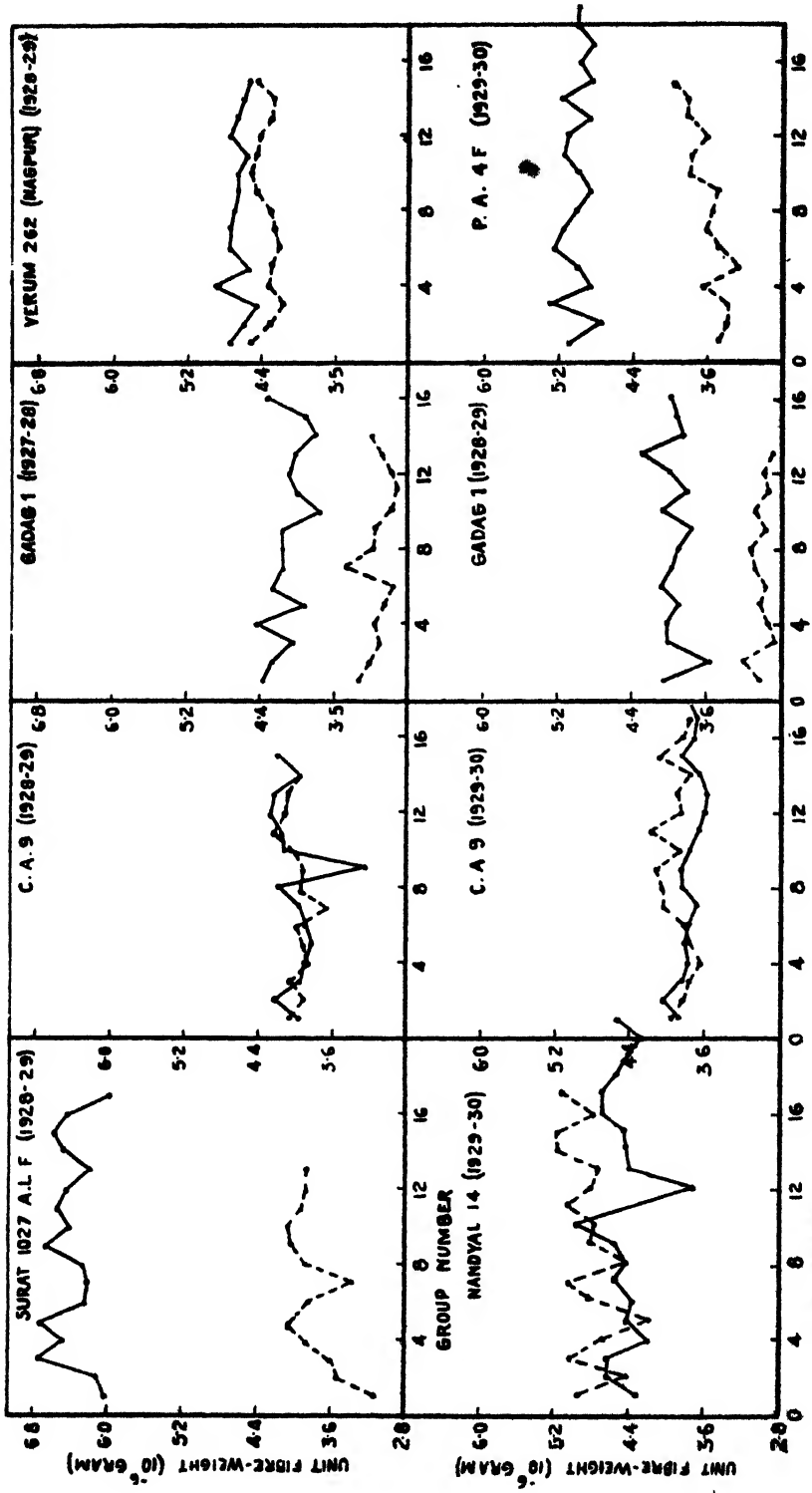

SURAT 1027 A.L F (1928-29)
C.A.9 (1928-29)
GADAG 1 (1927-28)
VERUM 262 (NAGPUR) (1928-29)
NANDYAL 14 (1929-30)
C.A 9 (1929-30)
GADAG 1 (1928-29)
P. A. 4 F (1929-30)
UNIT FIBRE-WEIGHT (10⁻⁶ GRAM)
GROUP NUMBER

FIG. 6.

apex and base regions for all cottons can also be judged by the "t" method.[10] The results are given in Table IX :—

Table IX

Significance of mean-values, apex and base—Unit Fibre-Weight

Cotton	Apex mean 10^{-6} gm.	Base mean 10^{-6} gm.	t	n	t for p = ·01	Remarks
Surat 1027 A.L.F. (1928-29) ...	6·37	3·77	27·54	28	2·76	Significant
Nandyal 14 (1929-30) ...	4·46	4·82	4·23	36	2·72	Significant
C.A. 9 (1928-29) ...	3·97	3·95	0·265	28	2·76	Non-significant
C.A. 9 (1929-30) ...	3·76	3·89	2·82	33	2·73	Non-significant
Gadag 1 (1927-28) ...	4·05	2·86	17·41	28	2·76	Significant
Gadag 1 (1928-29) ...	3·94	3·00	17·48	27	2·77	Significant
Verum 262, Nagpur (1928-29) ...	4·61	4·29	8·32	28	2·76	Significant
P.A. 4F (1929-30) ...	4·99	3·60	18·06	32	2·74	Significant

It will be seen that according to this test as well, the difference in base and apex mean values in the case of C.A.9 of both seasons is non-significant, while it is significant in the case of all the other cottons. There is an interesting point which should be mentioned. In the case of Nandyal 14 the difference is certainly significant but unlike all the other cottons, it is the *base* value which is *higher* than the apex value. It cannot therefore be laid down as universally true that the unit fibre-weight of hairs removed from the apex of a seed is always significantly higher than that of the basal fibres.

When we take into consideration the length of the fibres, the peculiarities noted in the case of Nandyal 14 and C.A.9 are removed. For this purpose the values for apex and base given in Tables 10-12 have been divided by the corresponding mean-fibre length given in Table XI; the resulting values representing fibre-weights per unit length have been analysed both by the method of variance and the "t" method. The results are given in Table X :—

Table X

Significance of the difference between apex and base Fibre-Weight per unit length.

Cotton	Analysis of Variance				
	n_1	n_2	z	z for 1 per cent. point	Remarks
Nandyal 14	1	36	2·197	1·01	Significant
C. A. 9 (1928-29)	1	28	2·108	1·02	Significant
C A. 9 (1929-30)	1	33	2·517	1·01	Significant

Cotton	Significance of Means					
	Apex mean 10^{-6} gm.	Base mean 10^{-6} gm.	n	t	t for p = ·01	Remarks
Nandyal 14	2·31	1·96	36	9·00	2·72	Significant
C.A. 9 (1928-29)	2·01	1·69	28	8·19	2·76	Significant
C.A. 9 (1929-30)	1·97	1·70	33	12·41	2·73	Significant

It will be seen that according to both tests the differences in means are significant for all the three cottons. As previously stated the mean-length for the apex fibres is always less than for the base fibres, it follows therefore that those cottons which have shown significant difference in unit fibre-weight will evidently show a much more significant difference in the values of fibre-weight per unit length. Consequently, it may be definitely stated that, in the case of these six cottons, the mean fibre-weight per unit length is significantly greater for the apex fibres as compared with the base fibres.

Table XI gives the mean-values of fibre-length, unit fibre-weight, and fibre-weight per unit length for fibres taken from different regions of the seed. The mean results obtained both by the straight mean and weighted mean method, together with the corresponding values taken from the Technological Reports are also given at the bottom of the table :—

Table XI

Region of the seed	Surat 1027 A.L.F. (28-29)			P.A. 4F (29-30)			Gadag 1 (27-28)		
	L	F.W.	F.W/L	L	F.W.	F.W/L	L	F.W.	F.W/L
Apex	2·11	6·37	3·02	1·70	4·99	2·94	1·83	4·05	2·21
Base	2·34	3·77	1·61	2·03	3·60	1·77	2·06	2·86	1·39
Right Flank	2·46	5·44	2·21	1·98	4·16	2·10	2·11	3·83	1·82
Left Flank	2·51	5·71	2·27	2·01	4·09	2·03	2·06	3·66	1·78
Combed hairs	2·39	3·61	1·51	2·06	3·38	1·64	2·24	3·13	1·40
MEAN RESULTS :									
Present experiments — Straight Mean ...	2,36	—	2·12	1·96	—	2·10	2·06	—	1·72
Present experiments — Weighted Mean ...	2·39	—	2·12	1·98	—	2·03	2·08	—	1·66
Technological Reports	2·44	—	2·28	2·06	—	1·73	2·18	—	1·87

Region of the seed	Gadag 1 (28-29)			Nandyal 14 (29-30)			Verum 262 (28-29)		
	L	F.W.	F.W/L	L	F.W.	F.W/L	L	F.W.	F.W/L
Apex	1·80	3·94	2·19	1·93	4·46	2·31	1·83	4·61	2·52
Base	2·03	3·00	1·48	2·46	4·82	1·96	2·08	4·29	2·06
Right Flank	2·11	3·56	1·69	2·51	5·32	2·12	2·21	4·72	2·14
Left Flank	2·08	3·68	1·77	2·49	5·08	2·04	2·21	4·72	2·14
Combed hairs	2·11	3·25	1·54	2·39	3·63	1·52	2·21	3·76	1·70
MEAN RESULTS :									
Present experiments — Straight Mean ...	2·03	—	1·73	2·36	—	1·99	2·11	—	2·11
Present experiments — Weighted Mean ...	2·06	—	1·71	2·39	—	2·06	2·13	—	2·13
Technological Reports	2·11	—	1·82	2·34	—	1·89	2·18	—	2·40

Table XI—*Continued*

Region of the seed	C. A. 9 (28-29)			C. A. 9 (29-30)		
	L	F.W.	F.W/L	L	F.W.	F.W/L
Apex	1·98	3·97	2·01	1·91	3·76	1·97
Base	2·34	3·95	1·69	2·29	3·89	1·70
Right Flank	2·29	4·02	1·76	2·24	3·93	1·75
Left Flank	2·24	3·99	1·78	2·26	4·07	1·80
Combed hairs	2·31	3·88	1·68	2·11	3·70	1·75
MEAN RESULTS :						
Present experiments — Straight Mean ...	2·24	—	1·78	2·16	—	1·79
Present experiments — Weighted Mean ...	2·26	—	1·86	2·21	—	1·78
Technological Reports	2·26	—	1·86	2·18	—	1·84

The following interesting points with respect to fibre-weight per unit length emerge from a study of this table :—

(1) The apex fibres give the highest values.

(2) The combed hairs give the lowest values except in the case of Gadag 1, 1927-28, and C.A.9, 1929-30 ; even in these cases the differences between the values for combed hairs and base fibres (which gives the lowest value) are small.

(3) The right and the left flanks have invariably given the same mean value.

(4) The mean values given at the bottom of the table agree generally with the corresponding values given in the Technological Reports ; the only two exceptions are (i) P.A.4F for which the present value is a little high, and (ii) Verum 262 for which it is rather low as compared with the Technological Report values.

The values for the right and the left flank are further analysed in Table XII :—

Table XII

Fibre-Weight—Right and Left Flanks

Cotton	Unit Fibre-Weight				Fibre-Weight per unit length			
	R 10^{-6} grams	L 10^{-6} grams	R-L	$\frac{R-L}{L}\times 100$	R 10^{-6} grams	L 10^{-6} grams	R-L	$\frac{R-L}{L}\times 100$
Surat 1027 A.L.F. ...	5·44	5·71	−0·27	−4·7	2·21	2·27	−0·06	−2·6
P. A. 4F	4·16	4·09	+0·07	+1·7	2·10	2·03	+0·07	+3·4
Gadag 1 1927-28 ...	3·83	3·66	+0·17	+4·6	1·82	1·78	+0·04	+2·2
Gadag 1 1928-29 ...	3·56	3·68	−0·12	−3·3	1·69	1·77	−0·08	−4·5
Nandyal 14	5·32	5·08	+0·24	+4·7	2·12	2·04	+0·08	+3·9
Verum 262	4·72	4·72	—	—	2·14	2·14	—	—
C. A. 9 1928-29	4·02	3·99	+0·03	+0·8	1·76	1·78	−0·02	−1·1
C. A. 9 1929-30	3·93	4·07	−0·14	−3·4	1·75	1·80	−0·05	−2·8

This table clearly shows that the small differences between the two flanks are entirely due to sampling, for not only are the percentage differences small, but they are positive in some cases and negative in the others ; moreover, the highest percentage difference 4·7 is well within the sampling error

as will be seen from the Tables 9-16 in the Appendix, where in some cases the difference between the means of two slivers from the same flank is about 5 per cent. or even more. Hence we conclude that whether we consider the weight of the whole fibre or its weight per unit length, there is no difference between the fibres taken from the right and the left flanks.

V—MEAN FIBRE-STRENGTH AND FIBRE-STRENGTH DISTRIBUTION

(a) Single seed

In Table XIII are given the frequency distributions of fibre-strength for fibres taken from different parts of the seed; the last column gives the combined frequency distribution for the whole seed including the combed hairs :—

Table XIII

Frequency Distributions of Fibre-Strength for fibres taken from a seed (Surat 1027 A.L.F., 1928-29).

Class Interval (grams)	Seed					Combed hairs	Whole seed including combed hairs
	Left flank	Apex	Right flank	Base	Total		
0·1-0·9	12	7	13	191	223	265	488
1·0-1·9	47	52	71	246	416	354	770
2·0-2·9	110	107	158	132	507	199	706
3·0-3·9	77	89	152	98	416	121	537
4·0-4·9	88	94	177	76	435	94	529
5·0-5·9	88	109	159	86	442	89	531
6·0-6·9	110	116	125	49	400	63	463
7·0-7·9	80	78	80	55	293	39	332
8·0-8·9	32	27	33	9	101	11	112
9·0-9·9	36	46	31	14	127	14	141
10·0-10·0	10	6	9	4	29	4	33
11·0-11·9	11	16	11	1	39	2	41
12·0-12·9	2	0	1	0	3	0	3
13·0-13·9	2	4	2	0	8	0	8
14·0-14·9	1	3	0	0	4	0	4
15·0-15·9	0	1	0	0	1	0	1
16·0-16·9	0	1	0	0	1	0	1
Total No. of tests	706	756	1,022	961	3,445	1,255	4,700

From the general run of these figures it is evident that all the frequency distributions are asymmetrical, while some of them are irregular—showing that not only is the asymmetrical distribution a characteristic of *all* the fibres of a single seed, but even in the different regions of the *same* seed the distribution is definitely skew.

Table XIV gives the frequency constants for the frequency distributions given in Table XIII :—

Table XIV

Frequency constants for frequency distributions of fibre-strength for fibres taken from a seed

Frequency constants	Seed					Combed hairs	Whole seed
	Left Flank	Apex	Right Flank	Base	Total		
Mean	5·231	5·327	4·802	3·016	4·507	2·731	4·033
Upper Quartile	6·927	6·890	6·242	4·657	6·312	3·974	5·882
Lower Quartile	3·047	3·208	3·039	1·150	2·388	1·088	1·842
Standard deviation ...	2·567	2·638	2·272	2·366	2·621	2·204	2·686

Table XIV—*Continued*

Frequency constants	Seed					Combed hairs	Whole Seed
	Left Flank	Apex	Right Flank	Base	Total		
Coefficient of Variation (%)	49	49	47	79	58	81	65
β_1	0·166	0·442	0·361	0·810	0·237	1·284	0·432
β_2	2·804	3·617	3·282	2·994	3·063	3·758	3·048
Skewness	0·294	0·342	0·360	—	0·318	—	0·545
K_2	−0·147	−3·945	−0·569	−0·312	−0·322	−0·561	−0·302
Type	I	I	I	IJ	I	IJ	I
ε_1	2·184	2·119	1·763	1·866	2·119	1·643	2·191
ε_2	1·696	1·563	1·440	1·641	1·805	1·243	1·849
Q	1·940	1·841	1·602	1·754	1·967	1·443	2·020
P.E.	1·731	1·779	1·532	1·596	1·768	1·487	1·778

Some of the interesting points revealed by a study of this table are discussed below :—

(1) The mean strength for the apex fibres (5·231 grams) is much higher than for the base fibres (3·016 grams). It is even greater than the Upper Quartile (4·657 grams) for the latter, showing that there is a general tendency for the development of strong fibres at the apex of the seed, and for weak fibres at its base. This is also clear from the graphical representation in Fig. 7 of the percentage distribution of fibres of different grades of strength in apex and base hairs. It will be seen that for low grades of strength, the base fibres are in excess while for high grades of strength the apex fibres are in excess.

(2) The value of the coefficient of variation (65) is high but it is of the same order as obtained previously for lint of this very cotton of another season.[21] It should, however, be noted that this high value is mainly due to the influence of base and combed hairs, for which the coefficient of variation is as large as 80 per cent. ; this high value may possibly be due to the fact that in these cases the variability among individual fibres is really large. It should be noted that the frequency distributions being strongly J-shaped, standard deviation may no longer be an efficient and satisfactory criterion of dispersion.

(3) From the values of β_1 and β_2 given in the table we see that the frequency distribution of fibres from the whole of the seed belongs to Pearsonian Type I, while the frequency distribution for different regions of the seed is either Type I or Type IJ. This confirms a possible explanation of the asymmetry of fibre-strength distribution given in Technological Bulletin, Series B. No. 6—" that it arises from differences in the condition of growth to which different fibres may have been subjected."

(4) At the bottom of the table are given values of ε_1, ε_2, Q, P.E., for each frequency distribution. A glance at these figures will show that the values of ε_1, ε_2, Q, and P.E., are not equal to one another. They form in this respect a marked contrast to the corresponding values for fibre-length given in Table IV. From these values alone it is clear that whereas in the case of fibre-length the frequency distribution for each region of the seed is symmetrical and practically normal, in the case of fibre-strength, each frequency distribution is asymmetrical and definitely skew.

(5) The mean, the two quartiles (upper and lower) and coefficient of variation are practically the same for the two flanks, showing that there is no appreciable difference between them—a fact also brought out by Fig. 7

which gives the percentage distribution of fibres of different strength grades. Unlike base and apex, the right and left flanks show no definite excess in percentage of fibres for either high or low strength grades. The slight differences observed between them must be attributed to sampling.

(b) Groups of seeds

In Table XV are given the frequency distributions of fibre-strength for hairs taken from apex and base for all cottons as well as the frequency distributions of fibre-strength for hairs taken from the two flanks in the case of seeds of Nandyal 14 and C.A. 9 (1928-29).

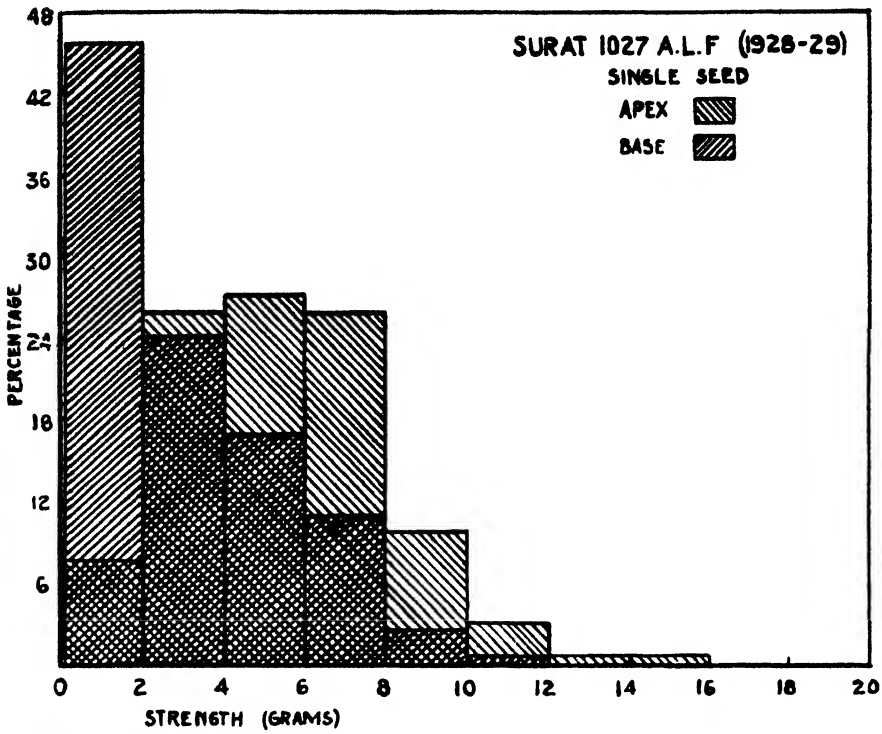
Table XV

Frequency Distributions of fibre-strength for cotton from different regions of the seed, for some of the standard Indian cottons.

Class Interval (grams)	Nandyal 14 1929-30					Surat 1027 A.L.F.	
	Apex	Base	Right Flank	Left Flank	Total	Apex	Base
Below 2 grams	7	9	22	12	50	11	54
2·0–3·9	23	63	74	72	232	60	93
4·0–5·9	39	46	84	84	253	50	27
6·0–7·9	59	42	78	92	271	33	16
8·0–9·9	34	25	61	39	159	23	7
10·0–11·9	20	14	34	41	109	9	1
12·0–13·9	11	3	24	23	61	2	0
14·0–15·9	3	—	3	4	10	2	—
16.0–17.9	1	—	1	1	3	—	—
Total No. of Tests ...	197	202	381	368	1,148	190	198

Class Interval (grams)	C. A. 9 1928-29					Gadag 1 1927-28	
	Apex	Base	Right Flank	Left Flank	Total	Apex	Base
Below 2 grams	6	5	20	23	54	8	25
2·0–3·9	42	51	77	67	237	64	100
4·0–5·9	48	59	113	119	339	63	48
6·0–7·9	69	73	79	108	329	38	20
8·0–9·9	16	26	43	37	122	18	1
10·0–11·9	10	4	4	8	26	1	—
12·0–13·9	1	—	—	—	1	—	—
14·0–15·9	—	—	—	—	—	—	—
16·0–17·9	—	—	—	—	—	—	—
Total No. of Tests ...	192	218	336	362	1,108	192	194

Class Interval (grams)	P. A. 4F 1929-30		Verum 262 1928-29		C. A. 9 1929-30		Gadag 1 1928-29	
	Apex	Base	Apex	Base	Apex	Base	Apex	Base
Below 2 grams	2	21	3	17	1	6	8	27
2·0–3·9	45	78	35	67	61	59	77	85
4·0–5·9	42	47	42	47	47	58	54	54
6·0–7·9	55	34	59	46	54	59	28	21
8·0–9·9	37	7	34	17	14	13	23	7
10·0–11·9	8	2	13	6	8	2	4	—
12·0–13·9	3	1	4	1	3	—	1	—
14·0–15·9	2	—	2	—	—	—	—	—
16·0–17·9	—	—	—	—	—	—	—	—
Total No. of Tests ...	194	190	192	201	188	197	195	194



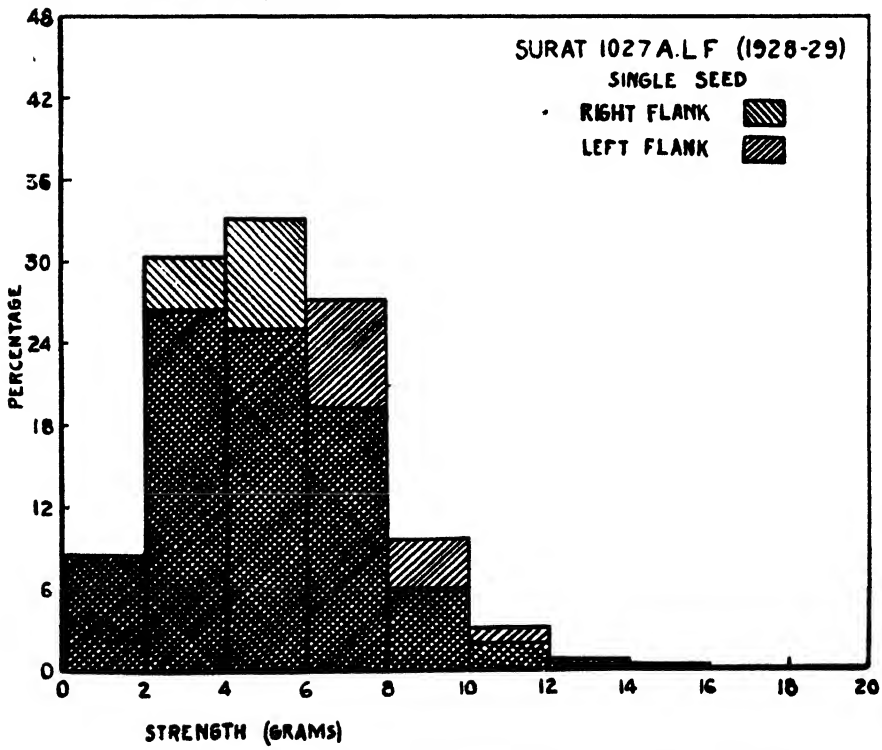


FIG. 7. Percentage Distribution of Fibres of different grades of Strength.

It will be observed that all the frequency distributions are asymmetrical—the degree of asymmetry being more prominent for the basal than for the apical fibres and that there is practically no difference in the frequency distributions of fibres taken from the right and the left flank. The percentage of fibres of each grade of strength is graphically shown in Fig. 8. It will be seen that, with the exception of C.A.9, there is in all cases a greater percentage of weak fibres at the base and a greater percentage of strong fibres at the apex, a conclusion which is reverse of that obtained for the fibre-length distribution. It should be mentioned that with the exception of Nyandal 14 and C.A.9 (1928-29) the other distributions embrace comparatively few tests, and therefore their actual form is subject to considerable sampling errors, which are presumably responsible for some of the irregularities observed in these distributions. The value of β_1 (= ·2091) and β_2 (= 2·6749) for Nandyal 14 based on 1148 tests show that not only is the distribution skew, but that the type of Pearson's curves which is likely to give the best fit is Type I, which it will be remembered was found most suitable to describe the fibre-strength distribution of hairs from a single seed of Surat 1027 A.L.F. Similarly the values of β_1 (= ·039) and β_2 (= 2·486) for C.A.9 (1928-29) show that this distribution based on 1,108 tests also belongs to Pearson's Type I.

In Table XVI are given the statistical constants of frequency distributions for right and left flanks of Nandyal 14 and C.A.9 (1928-29).

It will be seen that within the limits of experimental and sampling errors not only the mean strength results but also the other frequency constants are equal for the right and the left flank. This result was to be expected from the trend of values already discussed for fibre-length and fibre-weight which show no difference for the flanks. Consequently it was decided to test the basal and apical portions only for fibre-strength in the case of the other cottons. (The inequality of the figures in the last four columns shows that in both the cases the frequency distribution is asymmetrical—a conclusion already arrived at by the study of the single seed of Surat 1027 A.L.F.)

In Table XVII are given the various constants for frequency distributions of fibre strength for apex and base regions.

A close study of this table brings out the following interesting points :—

(1) The mean-strength for basal fibres is definitely less than for apical fibres ; the extent of this difference expressed as a percentage of the mean-strength for basal fibres, is given in column (4). It may be mentioned that C.A.9 in both the seasons has formed an exception as it has shown practically no difference in the apex and basal mean-strengths. The differences observed for other cottons are much too large to be due to sampling errors. The cottons may be divided into three classes according to the extent of difference between strength results for basal and apical fibres :—

% Difference between mean-apex strength and mean-base strength $\frac{A-B}{B} \times 100$	Cottons.
(a) Less than 20% (slightly variable)	C.A.9
(b) 20—40% (Variable)	Nandyal 14, Gadag 1, Verum 262
(c) Above 40% (Very variable)	P.A. 4F ; and Surat 1027 A.L.F.

Table XVI

Frequency constants for frequency distributions—Right and Left Flanks—Nandyal 14, and C. A. 9 (1928-29)

Cotton		Mean grams	Median grams	Standard deviation grams	Coefficient of variation	Lower Quartile grams Q_1	Upper Quartile grams Q_3	Distance of Q_1 from mean : grams.	Distance of Q_3 from mean : grams.	Quartile deviation grams	Probable error grams
Nandyal 14	Right Flank	6·43	6·22	3·29	51·1	3·93	8·86	2·50	2·43	2·46	2·22
,,	Left Flank	6·56	6·30	3·20	48·8	4·14	8·77	2·42	2·21	2·31	2·16
C. A. 9 (1928-29)	Right Flank	5·21	5·20	2·27	43·6	3·61	7·01	1·60	1·80	1·70	1·53
,,	Left Flank	5·33	5·48	2·26	42·4	3·96	7·11	1·37	1·78	1·58	1·53

Table XVII

Frequency constants for frequency distributions for fibre-strength of apical and basal regions of some of the standard Indian cottons

Cotton	Region of the seed	Mean grams	$\frac{A-B}{B} \times 100$	Standard deviation grams	Coefficient of variation	Lower Quartile Q_1 grams	Upper Quartile Q_3 grams	Distance of Q_3 from the mean : grams	Distance of Q_1 from the mean : grams	Quartile deviation	Probable error
Nandyal 14	Apex	7·16	30·7	2·79	39·0	4·94	9·11	2·22	1·95	2·09	1·88
	Base	5·48		2·76	50·4	3·27	7·55	2·21	2·07	2·14	1·86
Surat 1027 A.L.F.	Apex	5·26	67·3	2·74	51·9	3·17	7·25	2·11	1·97	2·04	1·85
	Base	3·16		1·96	62·1	1·81	4·06	1·35	0·90	1·12	1·32
C. A. 9 (1928-29)	Apex	5·75	3·2	2·28	39·7	3·95	7·34	1·80	1·59	1·70	1·54
	Base	5·57		2·09	37·5	3·89	7·28	1·68	1·71	1·70	1·41
Gadag 1 (1927-28)	Apex	4·83	34·7	1·73	35·8	3·20	6·42	1·63	1·59	1·61	1·17
	Base	3·59		1·69	47·0	2·42	4·80	1·17	1·21	1·19	1·14
P.A. 4F	Apex	6·11	43·8	2·78	45·5	4·02	8·03	2·22	1·92	2·00	1·88
	Base	4·25		2·26	53·2	2·63	5·80	1·62	1·55	1·59	1·52
Verum 262	Apex	6·49	31·7	2·71	41·8	4·43	8·24	2·06	1·75	1·90	1·83
	Base	4·93		2·51	50·9	2·94	6·81	1·99	1·88	1·94	1·69
C. A. 9 (1929-30)	Apex	5·41	4·8	2·50	46·2	3·46	7·13	1·95	1·72	1·84	1·69
	Base	5·16		2·36	45·7	3·42	6·79	1·74	1·63	1·69	1·59
Gadag 1 (1928-29)	Apex	4·76	25·7	2·39	50·2	3·01	6·47	1·75	1·71	1·73	1·61
	Base	3·79		1·92	50·7	2·46	5·19	1·33	1·40	1·37	1·30

A = Mean for apex fibres.
B = Mean for base fibres.

This difference in fibre-strength is so marked in the case of cottons belonging to classes (b) and (c) that even the means of 20 tests in the order of sampling, are enough to show it as will be seen from the following table :—

Table XVIII
Means of groups of 20 tests each in the order of sampling

Groups of 20 Fibres	Suart 1027 A.L.F.		Nandyal 14		P.A.4F		Verum 262		Gadag 1 (1927-28)	
	Apex	Base	Apex	Base	Apex	Base	Apex	Base	Apex	Base
1st	6·21	3·52	6·54	4·86	6·30	3·85	7·00	5·14	4·61	3·55
2nd	5·10	3·11	7·96	5·13	6·04	4·72	6·58	4·68	4·50	3·88
3rd	4·27	3·33	6·82	5·77	5·85	4·19	6·68	4·90	4·77	3·32
4th	4·53	3·48	6·85	5·76	6·43	4·69	6·99	4·50	4·24	3·49
5th	5·20	2·90	6·83	5·95	5·68	3·70	6·44	3·78	5·33	3·50
6th	6·49	3·02	7·36	5·26	5·69	4·26	6·19	4·52	5·06	3·52
7th	5·76	2·97	6·38	6·00	6·06	4·27	6·90	5·86	5·58	3·65
8th	5·29	4·00	7·27	5·85	6·22	4·72	6·72	5·65	5·24	3·82
9th	4·71	2·96	7·09	5·15	7·13	4·13	4·67*	4·06	4·66	3·67
10th	—	—	—	5·03	—	—	—	—	—	—
Total No. of Tests ...	190	198	197	202	194	190	192	201	192	194
Grand Mean ...	5·28	3·16	7·16	5·48	6·11	4·25	6·49	4·93	4·83	3·59
$\frac{A-B}{B} \times 100$	67·3		30·7		43·8		31·7		34·7	

A = Mean for apex fibres.
B = Mean for base fibres.

It will be seen that in all cases except the one marked with an asterisk even lowest values in the apical groups are greater than the highest values in the basal groups. This shows clearly that for all these cottons there is a marked tendency for the development of strong fibres at the apical region of the seed and weak fibres at the basal region. Brown[22] in his book on " Cotton " has pointed out that " The actual strength shown by the fibres varies considerably, depending on....., the part of the seed from which the fibre came (the fibres are weaker towards the pointed end of the seed)." This conclusion of Brown is not borne out by experiments on Indian cottons described here, if by " pointed end " we are to understand the apex of the seed, for we have seen that the apical fibres are generally stronger than the basal fibres. Even in the case of C.A.9, although the difference between base and apex mean-strengths is within the sampling error, yet it is interesting to note that in both seasons (1928-29 and 1929-30), the base mean-strength is less than the apex mean-strength. It can therefore be definitely stated that the fibres at the apex of a seed are stronger than those on its base, a conclusion which is in harmony with that obtained from the study of a single seed of Surat 1027 A.L.F.

(2) In column (6) of Table XVII are given the values of coefficient of variation to serve as a measure of dispersion of individual results of fibre-strength tests. It will be seen that with the exception of C.A.9, and Gadag 1 (1928-29) the dispersion is greater for the basal than for the apical fibres.

(3) In columns (7) and (8) of the same table are given the values of lower and upper quartiles. Like the mean values the quartiles are less for the base than for the apex fibres. It is interesting to note that in the case of cottons belonging to class (c) of page T226, viz., Surat 1027 A.L.F. and P.A. 4F, for which the difference between base and apex mean-strengths is highest, even the upper quartile for the basal fibres is less than the mean-strength for the apical fibres—a result already seen to hold good for the single seed of Surat 1027 A.L.F.

(4) In the last four columns of Tables XVII are given the values of the distances of the upper and lower quartiles from the mean, quartile deviation and probable error. The inequality of these four quantities in each row of the table shows that all the frequency distributions are asymmetrical.

(5) In the case of C.A.9, of both seasons (1928-29 and 1929-30) the frequency constants—mean, coefficient, of variation and quartiles are *smaller* for the basal than for the apical fibres. Although the differences are arithmetically small, they are in the *same* direction, showing that even in this cotton there is a slight tendency for the development of comparatively weaker fibres at the base and stronger fibres at the apex.

The percentages of fibres of different strength grades (below 2 grams, 2-4 grams, 4-6 grams, etc.) derived from Table XV are graphically shown in Fig. 8. For each strength grade the percentage is represented by a rectangle of appropriate height drawn on the corresponding class interval of strength. To facilitate comparison the apex region is throughout shown as  and the base region  consequently the crossed region  represents the area common to the base and apex fibres.

From a study of these graphs it will be seen that the percentage of the base fibres in the lower strength grades is greater than that of the apex fibres but that the difference between the two percentages decreases as the mean fibre-strength increases until a limit is reached beyond which the conditions are reversed, i.e., the percentage of apical fibres becomes greater than that of the basal fibres, the last few sections being almost exclusively formed of apical fibres. The limit at which reversal takes place is different for different cottons, and its exact value depends upon the mean fibre-strength of a cotton. Thus in Surat 1027 A.L.F., below 4 grams base fibres are more numerous while above it the apex fibres—the last two sections being exclusively formed of apex fibres; in 4F similar behaviour is noticeable except that reversal takes place at 6 grams. Even in C.A.9 where no definite line of demarcation is possible the numbers of base fibres are greater in the first few groups while apex fibres dominate in the last few groups. Hence the general conclusion may be drawn that there is a greater percentage of strong fibres at the apical region of the seed, and of weak fibres at its basal region.

The above conclusion which has been derived from a study of the graphs can be corroborated statistically by calculating the quantity $d = \Sigma\delta$ or the

percentage deviation (without regard to sign). Values of this quantity derived from data given in Table XV are embodied in the following table :—

Table XIX

Percentage frequency distributions of fibre-strength

Strength grades	Nandyal 14						Surat 1027 A.L.F.		
	A	B	A – B	R.F.	L.F.	R.F. – L.F.	A	B	A – B
Below 2 grams	3·6	4·4	−0·8	5·8	3·3	2·5	5·8	27·3	−21·5
2·0–3·9 ...	11·7	31·2	−19·5	19·4	19·6	−0·2	31·6	47·0	−15·4
4·0–5·9 ...	19·8	22·8	−3·0	22·0	22·8	−0·8	26·3	13·6	12·7
6·0–7·9 ...	29·9	20·8	9·1	20·5	25·0	−4·5	17·4	8·1	9·3
8·0–9·9 ...	17·3	12·4	4·9	16·0	10·6	5·4	12·1	3·5	8·6
10·0–11·9 ...	10·1	6·9	3·2	8·9	11·1	−2·2	4·7	0·5	4·2
12·0–13·9 ...	5·6	1·5	4·1	6·3	6·2	0·1	1·1	—	1·1
14·0–15·9 ...	1·5	—	1·5	0·8	1·1	−0·3	1·0	—	1·0
16·0–17·9 ...	0·5	—	0·5	0·3	0·3	—	—	—	—
d	46·3			16·0			73·8		

Strength grades	C. A. 9 1928-29			Gadag 1 1927-27			P. A. 4F 1929-30		
	A	B	A – B	A	B	A – B	A	B	A – B
Below 2 grams	3·1	2·3	0·8	4·2	12·9	−8·7	1·0	11·0	−10·0
2·0–3·9 ...	21·9	23·4	−1·5	33·3	51·6	−18·3	23·2	41·1	−17·9
4·0–5·9 ...	25·0	27·1	−2·1	32·8	24·7	8·1	21·6	24·7	−3·1
6·0–7·9 ...	36·0	33·5	2·5	19·8	10·3	9·5	28·4	17·9	10·5
8·0–9·9 ...	8·3	11·9	−3·6	9·4	0·5	8·9	19·1	3·7	15·4
10·0–11·9 ...	5·2	1·8	3·4	0·5	—	0·5	4·1	1·1	3·0
12·0–13·9 ...	0·5	—	0·5	—	—	—	1·6	0·5	1·1
14·0–15·9 ...	—	—	—	—	—	—	1·0	—	1·0
16·0–17·9 ...	—	—	—	—	—	—	—	—	—
d	14·4			54·0			62·0		

Strength grades	Verum 262 (Nagpur)			Gadag 1 1928-29			C. A. 9 1929-30		
	A	B	A – B	A	B	A – B	A	B	A – B
Below 2 grams	1·6	8·5	−6·9	4·1	13·9	−9·8	0·5	3·1	−2·6
2·0–3·9 ...	18·2	33·3	−15·1	39·5	43·8	−4·3	32·5	29·9	2·6
4·0–5·9 ...	21·9	23·4	−1·5	27·7	27·8	−0·1	25·0	29·5	−4·5
6·0–7·9 ...	30·7	22·9	7·8	14·4	10·9	3·5	28·7	29·9	−1·2
8·0 – 9·9 ...	17·7	8·4	9·3	11·8	3·6	8·2	7·4	6·6	0·8
10·0–11·9 ...	6·8	3·0	3·8	2·0	—	2·0	4·3	1·0	3·3
12·0–13·9 ...	2·1	0·5	1·6	0·5	—	0·5	1·6	—	1·6
14·0–15·9 ...	1·0	—	1·0	—	—	—	—	—	—
16·0–17·9 ...	—	—	—	—	—	—	—	—	—
d	47·0			28·4			16·6		

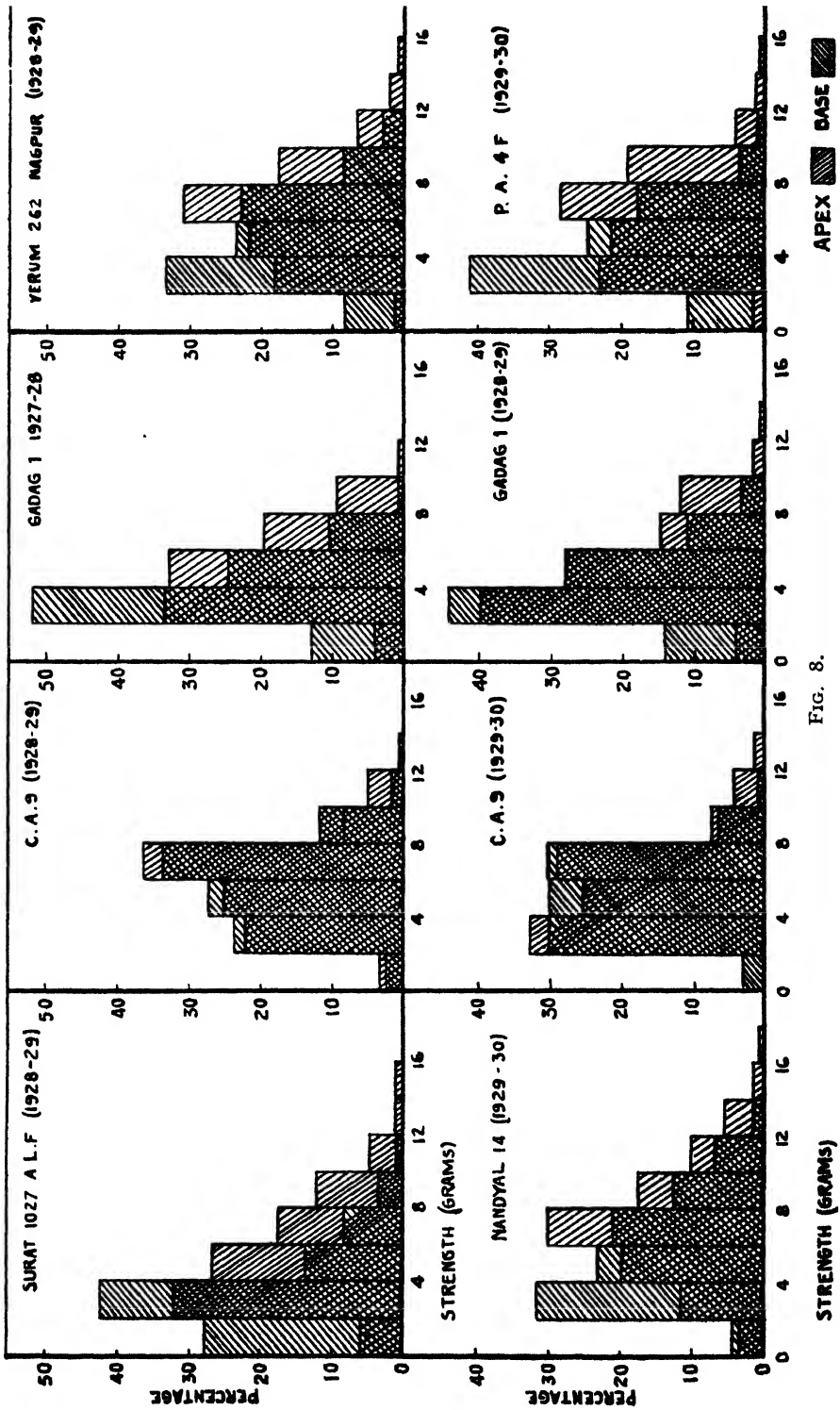

SURAT 1027 A L.F (1928-29)
C.A.9 (1928-29)
GADAG 1 1927-28
VERUM 262 NAGPUR (1928-29)
NANDYAL 14 (1929-30)
C.A.9 (1929-30)
GADAG 1 (1928-29)
P. A. 4 F (1929-30)
PERCENTAGE
STRENGTH (GRAMS)
APEX
BASE

FIG. 8.

If the difference between two samples with respect to any one fibre-property be due to random sampling, then not only should the total percentage deviation be small, but the individual deviations (δ) among various classes should be alternately positive and negative. On examining Table XIX we find that neither of these conditions is satisfied except in the case of right and left flanks. In all cases except C.A.9 the difference δ is at first negative and then positive, showing again that in lower strength-grades the base fibres are in excess, while in higher strength-grades, the apex fibres are predominant. In C.A.9 especially in 1929-30 season, it is interesting to note that although the total percentage deviation is comparatively small yet the deviation (δ) among the various classes is not alternately negative and positive, the last three values being all positive and the first four, with the exception of one, all negative, indicating that the *tendency*, though considerably weakened, is still in the *same* direction as in other cottons. It is interesting to note that the value of d for Surat 1027 A.L.F. derived from experiments on groups of seed, is practically the same as that obtained for a single seed—the actual values being 73·8 and 75·4 respectively.

The existence of variability in fibre-strength of hairs taken from different regions of the seed has been sufficiently demonstrated but to leave no room for doubt, another criterion, known as the Chi-Square Test[23] can also be applied to show that the conditions of development of fibres are " localised " at the base and the apex of the seed. The values of χ^2 together with η^1 (number of classes) and P (the probability that they are random samples from the same population) calculated according to this method are given in Table XX :—

Table XX

The Chi-Square Test—Fibre-Strength. Apex and Base

Cotton	χ^2	η^1	P
Surat 1027 A.L.F.	67	8	$5{\cdot}954 \times 10^{-13}$
P.A.4F	57	8	$5{\cdot}978 \times 10^{-10}$
Gadag 1 (1927-28)	41	6	$9{\cdot}644 \times 10^{-8}$
Verum 262	33·5	8	·00006
Nandyal 14	33·0	9	·00014
Gadag 1 (1928-29)	25·0	7	·00035
C.A.9 (1929-30)	11·8	7	·066
C.A.9 (1928-29)	6·5	7	·37

It will be seen that the probability that, as regards strength, the fibres from the apex and the base belong to the same population is extremely small for all cottons except C.A.9, its range being from nearly one part in a billion for Surat1027 A.L.F. to 3 parts in 10,000 for Gadag 1. In the face of this evidence there should be no doubt whatever that the fibres from the apex and base of seed behave so far as strength tests are concerned as if they belonged to different populations. We may now summarise the results

of three criteria, viz., (1) $\frac{A-B}{B} \times 100$, (2) d, and (3) χ^2, P used above for distinguishing between apex and base fibre-strengths :—

Cotton	$\frac{A-B}{B} \times 100$	d.	χ^2	P
1. Surat 1027 A.L.F.	67·3	73·8	67	$5{\cdot}954 \times 10^{-13}$
P.A.4F	43·8	62·0	57	$5{\cdot}978 \times 10^{-10}$
3. Gadag 1 (1927-28)	34·7	54·0	41	$9{\cdot}644 \times 10^{-6}$
4. Verum 262	31·7	47·0	33·5	·00006
5. Nandyal 14	30·7	46·3	33·0	·00014
6. Gadag 1 (1928-29)	25·7	28·4	25·0	·00035
7. C.A.9 (1929-30)	4·8	16·6	·11·8	·066
8. C.A.9 (1928-29)	3·2	14·4	6·5	·37

VI—THE REGION OF RUPTURE IN SINGLE HAIR BREAKS

As mentioned on page 4 while determining fibre-strength of hairs taken from the right flank and the base of a single seed of Surat 1027 A.L.F., about 2,000 fibres were mounted between two types of eyelets, one made of brass and the other of aluminium, the former always supporting the basal portion (the end attached to the seed) of the fibre ; and a count was made of the number of fibres which broke in the apical portion, the basal portion, and the middle portion of the fibre. For the purpose of these experiments the apical portion extended from the tip of the fibre to about 5 mms. and similarly the basal portion extended to an equal distance from the root of the fibre. The distribution of fibres for three arbitrary grades of strength, low, medium, and high are given in Table XXI :—

Table XXI

		Below 5 grams	Between 5 and 8 grams	8 grams and above	Total	Percentage of Fibres
Right Flank	Apical portion ...	505	252	60	817	80
	Middle ,, ...	52	39	12	103	10
	Basal ,,	27	61	14	102	10
	Total	584	352	86	1,022	—
Base ...	Apical portion ...	602	142	19	763	79·4
	Middle ,, ...	81	14	6	101	10·5
	Basal ,, ...	74	20	3	97	10·1
	Total	757	176	28	961	—

From this table it will be seen that about 80 per cent. of the fibres broke in the apical portion, 10 per cent, in the basal and nearly equal number in the middle portion. This result confirms the conclusion drawn by several workers that the cotton fibre is not regular in cross section along its length but tapers somewhat towards the apical end. It should be noted, however, that although in both cases the total percentage of fibres which broke in the apical portion is nearly the same, the percentage for less than 5 grams is higher for the basal fibres than for the right flank. The figures given in Table XXI have further been analysed by constructing 2 × 2 fold tables—apex and non-apex, low and high strength ; and from these four-fold tables two coefficients of association—The Yule's Coefficient of Association[24] Q and Pearson's Coefficient[25] Q_5 have been calculated. The results are given in Table XXII :—

Table XXII

Coefficients of Association between region of break and strength

	Q	Q_5
Right Flank	0·422±0·044	0·357
Base	0·018±0·065	0·014
Total	0·257±0·036	0·197

It will be noticed that the value of Q for the right flank is 0·422, which being ten times its probable error[26] is statistically significant, while the value of Q for the basal fibres is even less than its probable error. On the whole the value of Q though small is statistically significant. Hence we may conclude that on the whole there is greater tendency for the weak fibres (breaking load <5 grams) to rupture in the apical rather than the middle or the basal portion, and that this rendency is more marked in the fibres which grow on the right and possibly the left flank of the seed than in those which grow on its base.

In order to bring out these tendencies in a clearer manner, the number of fibres broken in the apical, basal, and middle portions are further analysed in finer grades of strengths. The results are given in Table XXIII ; the figures in italics indicate the percentage of fibres broken for each grade of strength :—

Table XXIII

	Portion	Below 2 gms.	2·0–3·9	4·0–5·9	6·0–7·9	8·0–9·9	10·0–11·9	12·0–13·9	Total
Right Flank	Apical portion ...	76 *90·4*	263 *84·8*	277 *82·4*	140 *68·3*	47 *73·4*	13 *65·0*	1 *33·3*	817
	Middle ,, ...	4 *4·8*	33 *10·7*	29 *8·6*	25 *12·2*	7 *11·0*	3 *15·0*	2 *66·7*	103
	Basal ,, ...	4 *4·8*	14 *4·5*	30 *9·0*	40 *19·5*	10 *15·6*	4 *20·0*	—	102
	Total	84	310	336	205	64	20	3	1,022

Table XXIII—*continued*

	Portion	Below 2 gms.	2.0–3.9	4.0–5.9	6·0–7.9	8·0–9·9	10·0–11.9	12·0–13·9	Total
Base ...	Apical portion ...	357 *81·7*	174 *75·7*	129 *79·6*	84 *80·8*	16 *69·6*	3 *60·0*	—	763
	Middle ,, ...	37 *8·5*	32 *13·9*	18 *11·1*	8 *7·7*	4 *17·4*	2 *40·0*	—	101
	Basal ,, ...	43 *9·8*	24 *10·4*	15 *9·3*	12 *11·5*	3 *13·0*	—	—	97
	Total	437	230	162	104	23	5	—	961
Total	Apical portion ...	433 *83·1*	437 *80·9*	406 *81·5*	224 *72·5*	63 *72·4*	16 *64·0*	1 *33·3*	1,580
	Non-apical ,, ...	88 *16·9*	103 *19·1*	92 *18·5*	85 *27·5*	24 *27·6*	9 *36·0*	2 *66·7*	403
	Total	521	540	498	309	87	25	3	1,983

From Table XXIII the following inferences are drawn :—

(1) In almost all grades of strength, and both for the right flank and the basal fibres, the percentage is much higher for the hairs breaking in the apical portion than for those snapping in the non-apical portion.

(2) As the breaking load increases the percentage of hairs belonging to the right flank of the seed which broke in the apical portion shows a progressive decrease ; at the same time the percentage of hairs breaking in the non-apical portion registers a small but persistent increase. Thus for breaking loads below 4 grams 86 per cent. of the hairs break near the apex and only 14 per cent. in the non-apical portion. On the other hand, for breaking load above 8 grams the percentage of the former is reduced to 70 per cent., that of the latter is raised to 30 per cent. This shows in an unmistakable manner that there is a tendency for the weak fibres to break near the apical portion, which is also borne out by the fact that the value of biserial coefficient of correlation[27] γ_b = ·275, though small is significant with respect to its probable error[28] ±·029. For the basal fibres the tendency is not so marked as for the right flank fibres. It is, however, interesting to note that in all the three portions viz., apical, middle and basal, the distribution of strength is J-shaped. This is no doubt due to the predominance of weak fibres which probably masks the effect of association of strength with region of break which was noticed in the right flank. Finally the values for all the fibres (1983) are grouped into apex and non-apex, in the lower part of Table XXIII, from which we can see that there is a tendency for the comparatively weak fibres to break near their apical ends.

VII—PRACTICAL APPLICATION

The results of this investigation which we have considered above, are primarily of theoretical importance. They are, however, not quite devoid of practical significance as will be seen from the following discussion.

(i) *Selection of new strains :* As is well known cotton breeders in different parts of the world are trying to improve the quality of the growths in their

respective areas by evolving new strains which, on the whole, should prove more satisfactory and give better monetary return. Very often the object of the breeder is to evolve new varieties which should have longer and finer staple than those which he intends to replace. In selection work of this nature the breeder has so far been guided mainly by considerations of mean fibre-length and, to a less extent, mean fibre-weight and mean fibre-strength. Other factors being nearly equal he would, if improvement of staple is his object, naturally be drawn towards a strain which possesses a long fine and silky staple. We know, however, that all the fibres of any cotton are neither equally long nor equally fine. Length variation is at once revealed by Sorter diagrams, fibre-weight variation by weighing equal numbers of fibres. Similarly as regards strength the fibres of the self same cotton show great variability. Some of them may break under a load of 1 g.m or even less, while others may resist a breaking load of 10 gms. or even more. This lack of uniformity in the fibres belonging to the same cotton has important ramifications in cotton spinning. In the eyes of a practical spinner a cotton A whose fibres are more uniform in their chief fibre-properties is very much more desirable than another cotton B which is less uniform. Now we have seen that, to a considerable extent, lack of uniformity in fibre-properties is caused by the fact that the fibres growing on the apex of a seed are very dissimilar to those growing on its base. We have seen that the apical fibres are comparatively shorter and coarser, albeit somewhat stronger, than the basal fibres, while the fibres developed on the two flanks of a seed closely resemble the basal fibres as regards length and the apical fibres as regards fibre-weight and fibre-strength. When all the fibres, growing on different regions of the seed are mixed together, as is ordinarily the case, the irregularity is enhanced. Furthermore we have seen that percentage differences in properties of fibres taken from different parts of a seed are not equal in the case of all cottons, but that in some cases these differences are small, in others, relatively large. The former cottons are consequently more uniform in their fibre-properties than the latter. It follows, therefore, that if, in the selection of new strains, attention is paid not only to the absolute values of the fibre-properties but also to the extent to which the properties of the fibres, which grow on the base and the apex of a seed, differ, then it will be possible to evolve strains which will be more uniform in their fibre-properties. This may be achieved either by pure line selection from cottons in which experiments of this nature reveal comparatively small differences in fibre-properties of apical and basal fibres, or by crossing such cottons with others which may not be so uniform but which possess certain other desirable characters. By repeating the latter process in several generations a strain will be ultimately evolved in which the disparity between the apical and the basal fibres, say with respect to length, will be reduced to a minimum. We take as an example, the case of two cottons which have been thoroughly studied in these experiments, viz., Nandyal 14 and C.A.9. The mean fibre-length for these two cottons is 0·91 and 0·88 inches respectively, which shows that so far as staple length is concerned, the two cottons are very much alike, the former being slightly longer. However, when we examine the percentage difference between the mean fibre-lengths of the apical and basal fibres, we find that it is nearly 24 per cent. in the case of Nandyal 14 but only 16 per cent. in the case of C.A.9. There is no doubt, therefore, that although C.A.9 is slightly shorter of the two, from the point

of view of regularity of staple it is easier to process and, therefore, more desirable. We conclude, therefore, as a practical consequence of this work, that whereas in the case of strains which differ considerably in their mean fibre-properties due regard will have to be paid as in the past to the absolute values, in the case of those strains which resemble each other a further analysis of the basal and the apical fibres will be distinctly advantageous. Such an analysis will at once differentiate between two strains with respect to the regularity of their staple, thus enabling the breeder to decide which of them will yield more uniform lint.

(ii) *Sampling of Cotton.* In most of the laboratory tests on the properties of cotton fibre it is possible to handle a small sample of cotton. In order that the values obtained for the small sample may lie reasonably close to the true values for the bulk, it is imperative that the sample drawn for the fibre tests should be representative of the whole. This point has been emphasised by different workers, but its importance is brought out from a new point of view by the results of these experiments. We have seen that the fibres removed from the apex and the base of a seed may differ considerably in their fibre-properties, such as length, fineness, and strength. We also know that fibres have a tendency to cling together, especially if the cotton has been ginned in a roller gin which at any instant pulls out bunches of fibres from the same part of the seed. If, therefore, a small sample of cotton is taken at random from a bale as representing the bulk, it is possible that a considerable portion of this sample may contain fibres either from the apex or from the base of a single seed. Fibre tests on this sample will consequently give either a too high or too low value depending upon the fibre property under investigation. Thus it is extremely necessary in fibre tests that initially a fairly large quantity of cotton should be taken which should be divided into 64 or at least 32 lots. From each lot a small bunch should be picked out at random, and all the bunches should then be combined, and doubled several times, removing the inequalities which exist between the fibres growing on different parts of the seed. The adoption of this precaution cannot be over-emphasised, especially for such experiments in which the ultimate sample of cotton weighs a few mgms.

(iii) *Differential Ginning.* Hitherto we have considered such practical consequences of these experiments as can find immediate application either in an experimental Farm or in a Laboratory. We shall now consider application of a different nature which has not yet seen the light of the day and which is offered as suggestion to future workers. It is not anticipated that this suggestion can readily be put into practice as it is realised that considerable practical difficulties exist in the way of realising it. We have seen above that in the case of some cottons the hairs growing on the apex and the base of a seed differ so radically in their fibre-properties that for all practical purposes the two may be regarded as belonging to different classes of cotton. Taking fibre-length as an example we have found that the basal fibres may be 10-20 per cent. longer than the apical fibres. We have also seen that the hairs developed on the two flanks of a seed have practically the same mean length as those on its base, If, therefore, a method of differential ginning could be devised which would make it possible to remove the lint grown on the two flanks and the base of the seed separately from that grown on its apex, it would be possible to obtain from the same seed two lots of cotton, one longer and finer than the other. We saw in

Table II that the lint grown on the two flanks and the base of a seed amounted to some 75 per cent. of the whole. From this it follows that the longer and finer lot would constitute by far the greater proportion of the ginned cotton. This longer and finer cotton could then be spun separately into much finer counts, especially it would be more uniform in its fibre-properties than the combined lint from the base and the apex. The proposed differential gin would in a way perform the function of a modern combing machine with this advantage that ginning and combing would be achieved simultaneously in one process. We are unable at the present moment to make any further suggestions as regards the mechanical construction of such a differential gin, but considering that very often advances in theoretical knowledge have found unexpected practical applications we feel that with mechanical difficulty of realisation as it may appear at the moment we should at least offer this suggestion for the benefit of those who have a mechanical bent of mind.

VIII—GENERAL DISCUSSION OF RESULTS

So far we have considered separately the results of tests on basal and apical fibres with respect to fibre-length, fibre-weight, and fibre-strength. We have seen that, in most cases, the mean values for the basal and the apical fibres are significantly different, and that the percentage differences between the mean values depend upon the cotton tested and the fibre property studied. We are now in a position to consider all the results, obtained for eight cottons and three fibre-properties, in order to ascertain whether the percentage differences observed for the three fibre-properties are mutually correlated, and whether these differences, for any one fibre-property, are related to the botanical species of the cottons, to their seasonal variation or to any of their plant characteristics.

(1) *Variability of Fibre-properties.* From the discussion of results in the main body of the paper it has been made clear that the fibres removed from the two flanks of a cotton seed do not differ by an appreciable amount in mean fibre-length, mean fibre-weight, or mean fibre-strength. Furthermore, it has been shown that the differences in mean fibre-length of fibres removed from either of the two flanks and the base are also insignificant. However, the basal and the apical fibres differ in a marked manner from one another in their mean values for length, fibre-weight and strength. We have seen that, as a rule, the apical fibres are shorter and coarser but stronger than the basal fibres. It will be quite sufficient, therefore, for the purposes of a general discussion if we confine our attention to the apical and basal fibres only, since these have given the most divergent results. Table XXIV gives in summary form the mean fibre properites for these fibres for the eight cottons which formed the subject of this investigation.

It will be seen from this table that in all cases, except a few, the percentage differences between the mean values are quite large. These, however, are neither equal nor even of the same order of magnitude for all cottons, being very much greater for some than for others. This is specially so in the case of fibre-weight for which the percentage differences between the apical and the basal mean values range from 16 to 88 per cent. and fibre-strength for which the range is from 3 to 67 per cent. In the case of fibre length the differences in mean values lie within 10 per cent. and 24 per cent. For some cottons these differences are so large that, if the lint removed from the apex

Table XXIV

Cotton	Fibre-Length			Fibre-Weight			Fibre-Strength			Plant Particulars	
	A	B	$\frac{A-B}{B}\times 100$	A	B	$\frac{A-B}{B}\times 100$	A	B	$\frac{A-B}{B}\times 100$	Weight of Seed	Ginning per-centage
Surat 1027 A.L.F., 1928-29	0·83	0·92	− 9·8	3·02	1·61	+87·6	5·26	3·16	+66·5	63	35
P.A.4F, 1929-30	0·67	0·80	−16·3	2·94	1·78	+65·2	6·11	4·25	+43·8	80·5	32·5
Gadag 1, 1927-28	0·72	0·81	−11·1	2·22	1·49	+49·0	4·83	3·59	+34·5	97	34
Verum 262 (Nagpur), 1928-29	0·72	0·82	−12·2	2·52	2·06	+22·3	6·49	4·93	+31·6	65	33
Nandyal 14, 1929-30... ...	0·76	0·97	−21·6	2·31	1·96	+17·9	7·16	5·48	+30·7	46	25
Gadag 1, 1928-29	0·71	0·80	−11·3	2·19	1·48	+48·0	4·76	3·79	+25·6	97	34
C.A.9, 1929-30	0·75	0·90	−16·7	1·97	1·70	+15·9	5·41	5·16	+4·8	75	31·5
C.A.9, 1928-29	0·78	0·92	−15·2	2·00	1·69	+18·3	5·75	5·57	+3·2	75	31·5

A = Apex Mean.
B = Base Mean.

Units :
Length-inches.
Fibre-weight per cm. 10^{-6} gram.
Strength—grams.
Weight of seed—mgs.

and the base of the seed were to be examined separately, it would very much have the appearance of belonging to two different cottons. For instance, the average fibre-length of Nandyal 14 as given by the tests made at the Technological Laboratory during the last 7 seasons is 0·91 inch. On referring to the above table we find that the mean fibre-length of its basal fibres is 0·97 inch, while that of the apical fibres is only 0·76 inch. This latter value is not much different from the mean length of the basal fibres of P.A. 4F although this cotton is generally placed in a lower class and is used for spinning coarser counts. Similarly, Gadag 1 is ordinarily regarded as a fairly fine cotton, with mean fibre-weight per cm. equal to 1·87 (10^{-6} gms.). Nevertheless, the apical fibres of this very cotton in the season 1927-28 have a mean fibre-weight per cm. which is as high as 2·22 (10^{-6} grams) and are thus easily comparable with fibres of Verum 262 which is admittedly a coarser cotton than Gadag 1.

(2) *Relationship between variability of different fibre-properties.* If these eight cottons are arranged in descending order of magnitude as regards percentage difference between fibre-weight of basal and apical fibres, it is found that with only one exception they become similarly arranged with respect to fibre-strength as well. We thus find that cottons which show large differences between apical and basal mean fibre-weight also show considerable differences between apical and basal mean fibre-strength. The correlation coefficient between the percentage differences, for fibre-weight and fibre-strength, comes out to be + ·84, which is significant. It is interesting to note that the correlation coefficient between the apex mean values of fibre-weight and fibre-strength, or the base mean values of these two properties, are + 0·664 and + 0·116 respectively and are therefore insignificant. In other words, while the mean values for fibre-strength and fibre-weight either for apex or base are not correlated, their percentage differences between base and apex values are strongly correlated. No correlation has been found to hold between fibre-length on the one hand and fibre-weight or fibre-strength on the other, although there is a mild tendency for cottons possessing large percentage differences between apical and basal fibre-weight or fibre-strength to have small percentage differences between basal and apical mean fibre-length.

(3) *Variability and botanical species.* Owing to the tedious nature of these experiments, which apart from the usual time-absorbing fibre tests, involved careful delinting by hand of a large number of seeds, it was not possible to examine more than eight cottons belonging to four botanical species. This number is hardly sufficient to enable one to decide whether the variability observed in the properties of fibres with respect to the region of their growth on the seed is related to the botanical species of a cotton or is merely due to a coincidence. For this purpose it would be necessary to perform experiments on at least four cottons belonging to each species and to extend them to cover half a dozen different species. However, with such evidence as we have before us, it is interesting to see that the cotton belonging to the *indicum* family has given the largest difference in mean fibre-length values, while that belonging to the *herbaceum* family has given the least. For other cottons which, with the exception of Verum 262, belong to the *hirsutum* family, these differences lie round about 15 per cent. It has been mentioned above that, in the case of fibre-weight and fibre-strength, the general trend of percentage differences is opposite to that for fibre-length.

This is in harmony with the fact that the *herbaceum* cotton has shown the greatest divergence between base and apex mean values of fibre-weight and fibre-strength, while the *hirsutum* cottons, with the exception of C.A.9, have shown medium divergence.

(4) *Seasonal Variation.* As is well known most cottons are subject, to a greater or less extent, to seasonal fluctuation in their fibre-properties and spinning performance. These fluctuations are due to a number of causes such as different amounts of rainfall, range of temperature, condition of soil, condition of the seed, nature of the preceding crop, incidence of pests and disease, etc. Among the standard Indian cottons, Gadag 1 has at times given widely divergent results in the different seasons. Its spinning performance has suddenly risen or fallen without any apparent cause and even without a corresponding change in its fibre-properties. It was thought that this peculiar behaviour of Gadag 1 may possibly be due to a change either in the relative proportion of basal and apical fibres or in their fibre-properties. Accordingly Gadag 1 of two consecutive seasons in which it gave a widely different spinning test results was examined. In 1927-28 this cotton was found suitable for spinning up to 38's standard warp counts, while in the following season its performance fell sharply and unexpectedly to a maximum of 26's standard warp counts. This decline in spinning performance was unaccompanied by any large variation in its chief fibre-properties as may be seen by referring to pages 31-33 of the Technological Reports on Standard Indian Cottons, 1931[10]. The present tests on Gadag 1, however, have shown that the mean values both for ginning percentage and fibre-properties for the basal and the apical fibres are practically the same in the two seasons. With the same object in view tests were also made on C.A.9 of 1928-29 and 1929-30, since in the latter season it was found suitable for 34's standard warp counts as against 40's in the former season. These also failed to reveal any appreciable difference either in the ginning percentage or in the properties of basal and the apical fibres. Since in both cases these tests have given a negative result, it may be concluded that such fluctuation in the spinning performance of a cotton as we have noticed above is not due to upsetting of the normal equilibrium between the relative proportion of the basal and apical hairs or to a sudden variation in their fibre-properties.

(5) *Variation in fibre-length and ginning percentage.* From a study of the ginning percentage of these eight cottons given in the last column of Table XXIV, it will be readily seen that there is a distinct tendency for high ginning percentage to be associated with low percentage difference between mean fibre-length of hairs taken from the apex and the base of a seed. The correlation coefficient between these two quantities is found to be $-0{\cdot}963$; this is indeed a high value but as it is based on only eight pairs of results we must judge its significance before drawing conclusions from it. If we apply the severe test of 1 per cent. point of judging significance we find that values of correlation coefficient greater than 0·834 are significant. We thus arrive at the extremely interesting result that cottons which possess low ginning percentage have a distinct tendency to develop long fibres at the base and short fibres at the apex of the seed, while those which are characterised by high ginning percentage develop more uniform lint on their seed. In order to throw more light on this point the correlation coefficient between seed weight and percentage difference in fibre-length was

also calculated and was found to be −0·593. This value according to the test applied above, is non-significant. The correlation coefficient between lint per seed and percentage difference in fibre-length, works out to be −0·803, a value which is lower than −0·963, obtained for ginning percentage and fibre-length (percentage difference). The correlation coefficient, as given above for eight pairs of results, require adjustment in order that they may approximate to values which are most probably true for the universe. This can be done according to an equation given by Ezekiel.[19]

$$r^{-2}_{yx} = 1 - (1 - r^2_{yx})\left(\frac{n-1}{n-2}\right)$$

where n is the number of pairs of values between which correlation coefficient is calculated. When adjustments are made according to the above equation, we obtain the following values.

	Ginning percentage	Seed weight	Lint per seed
$\frac{A-B}{B} \times 100$	−·956	−·503	−·766

These show that greater irregularity in staple length does not depend so much on the weight of the seed as on the relative amount of nutrition available for the formation of lint, and that cottons which have a generous supply of nutrition for their fibres develop relatively more uniform lint than those which have a meagre supply.

(6) *Nutrition problems.* The results of this investigation raise a number of important points as regards the supply of food to fibres on different regions of the seed, but their consideration is postponed until the results of supplementary investigation on the remaining fibre-properties and the chemical composition of different parts of the coat and kernel of the seed are available. This investigation is in progress.

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APPENDIX.

PERCENTAGE DISTRIBUTION OF FIBRE-LENGTH FOR FIBRES TAKEN FROM DIFFERENT PARTS OF THE SEED.

Table 1. Cotton: Surat 1027 A.L.F. (1928-29).

Mean Group Length		Apex			Base				Right Flank			Left Flank			Combed Hairs			Mean Results		
																		Present Experiments		
In eighths of an inch	Inches	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	3rd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	Straight mean	Wtd. mean	Tech. Reports
2	1/4	1·2	0·8	1·0	—	—	—	—	—	—	—	—	—	—	—	—	—	0·2	0·1	—
3	3/8	2·5	3·1	2·8	1·6	1·2	0·9	1·2	—	0·4	0·2	0·6	0·8	0·7	1·4	1·2	1·3	1·2	0·9	1·2
4	1/2	6·0	6·7	6·4	3·3	3·3	2·3	3·0	2·3	1·1	1·7	1·6	1·6	1·6	1·9	2·3	2·1	3·0	2·5	2·4
5	5/8	12·3	13·2	12·7	7·8	7·2	4·9	6·6	4·0	3·2	3·6	2·9	2·9	2·9	3·7	5·3	4·5	6·1	5·0	5·4
6	3/4	21·4	21·7	21·6	19·3	18·2	13·3	16·9	10·3	8·7	9·5	6·2	7·9	7·1	10·3	11·1	10·7	13·2	11·6	10·2
7	7/8	27·4	25·4	26·4	25·1	26·0	27·5	26·2	22·5	24·2	23·3	19·1	25·5	22·3	28·6	27·5	28·0	25·2	24·5	19·1
8	1	18·2	19·2	18·7	23·9	25·5	29·0	26·1	31·2	37·3	34·3	32·8	34·5	33·6	32·8	32·1	32·5	29·0	30·7	29·8
9	1 1/8	7·8	7·3	7·6	12·7	12·1	15·1	13·3	19·2	17·1	18·2	25·7	18·6	22·2	15·9	15·8	15·8	15·4	17·0	22·1
10	1 1/4	2·4	2·1	2·2	4·2	4·2	4·9	4·5	6·6	5·2	5·9	8·2	5·8	7·0	4·2	3·5	3·9	4·7	5·3	7·9
11	1 3/8	0·8	0·5	0·6	1·3	1·4	2·1	1·6	2·6	2·0	2·3	1·9	1·6	1·7	1·2	1·2	1·2	1·5	1·7	1·9
12	1 1/2	—	—	—	0·8	0·9	—	0·6	1·3	0·8	1·0	1·0	0·8	0·9	—	—	—	0·5	0·7	—
Mean Length		0·83	0·82	0·83	0·90	0·91	0·94	0·92	0·98	0·97	0·97	1·00	0·97	0·99	0·94	0·93	0·94	0·93	0·95	0·96

Table 2. Nandyal 14 (1929-30)

Mean Group Length		Apex			Base			Right Flank			Left Flank			Combed Hairs			Mean Results		
																	Present Experiments		
In eighths of an inch	Inches	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	Straight Mean	Wtd. Mean	Tech. Reports
2	¼	2·4	1·8	2·1	—	—	—	—	—	—	—	—	—	—	0·5	0·2	0·5	0·3	0·5
3	⅜	5·3	4·7	5·0	0·7	1·0	0·8	0·4	0·4	0·4	0·5	0·4	0·4	0·7	1·0	0·9	1·5	1·3	1·3
4	½	9·6	11·2	10·4	1·3	1·5	1·4	1·8	1·2	1·5	1·1	1·0	1·1	3·3	1·7	2·5	3·4	2·9	2·6
5	⅝	15·0	17·1	16·1	3·3	3·6	3·5	3·5	2·9	3·2	2·7	2·1	2·4	5·5	3·4	4·4	5·9	5·2	6·0
6	¾	23·4	22·9	23·1	8·5	7·7	8·1	6·5	6·9	6·7	6·3	6·4	6·3	11·3	8·7	10·0	10·8	9·9	12·0
7	⅞	26·4	24·1	25·3	24·5	19·5	22·0	19·1	19·3	19·2	19·6	21·5	20·6	20·8	25·2	23·0	22·0	21·6	24·8
8	1	14·8	13·5	14·1	41·5	35·0	38·2	37·0	36·1	36·6	44·4	41·2	42·8	37·2	42·0	39·6	34·3	35·2	33·7
9	1⅛	2·6	3·5	3·1	16·6	25·1	20·9	25·2	26·6	25·9	20·4	22·7	21·6	17·9	15·5	16·7	17·6	19·1	13·1
10	1¼	0·5	1·2	0·8	2·9	5·6	4·2	6·5	6·6	6·5	5·0	4·7	4·8	3·3	2·0	2·7	3·8	4·2	4·4
11	1⅜	—	—	—	0·7	1·0	0·9	—	—	—	—	—	—	—	—	—	0·2	0·3	1·6
Mean Length ...		0·76	0·76	0·76	0·96	0·98	0·97	0·98	0·99	0·99	0·98	0·98	0·98	0·94	0·95	0·94	0·93	0·94	0·92

Table 3. C.A.9 (1928-29).

Mean Group Length		Apex			Base			Right Flank			Left Flank			Combed Hairs			Mean Results		
																	Present Experiments		
In eighths of an inch	Inches	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	Straight Mean	Wtd. Mean	Tech. Reports
2	¼	1·8	1·4	1·6	—	—	—	—	—	—	—	—	—	—	—	—	0·3	0·2	0·7
3	⅜	3·5	3·6	3·6	0·9	0·7	0·8	1·1	0·5	0·8	1·3	1·3	1·3	1·3	1·4	1·3	1·6	1·3	1·7
4	½	5·7	6·8	6·2	2·1	2·1	2·1	2·1	1·6	1·9	2·6	2·6	2·6	2·7	2·4	2·6	3·1	2·7	2·9
5	⅝	12·7	14·8	13·8	4·2	4·5	4·4	4·9	5·5	5·2	6·9	6·1	6·5	5·3	5·0	5·2	7·0	6·2	6·0
6	¾	26·1	25·6	25·8	12·7	13·6	13·1	15·4	15·3	15·3	18·6	18·0	18·3	15·3	13·1	14·2	17·4	16·3	14·5
7	⅞	30·7	29·1	29·9	30·9	32·3	31·6	33·6	36·9	35·2	34·0	32·5	33·2	28·0	29·8	28·9	31·7	32·2	30·5
8	1	16·3	15·1	15·7	34·8	34·3	34·6	32·5	31·0	31·8	28·1	28·5	28·3	32·7	33·5	33·1	28·7	30·3	33·3
9	1⅛	3·2	3·6	3·4	11·9	10·5	11·2	8·7	7·7	8·2	7·2	9·2	8·2	12·0	12·4	12·2	8·6	9·1	9·1
10	1¼	—	—	—	2·5	2·0	2·2	1·7	1·5	1·6	1·3	1·8	1·6	2·7	2·4	2·5	1·6	1·7	1·3
Mean Length ...		0·79	0·78	0·78	0·92	0·91	0·92	0·90	0·90	0·90	0·88	0·89	0·88	0·91	0·91	0·91	0·88	0·89	0·89

Table 4. Cotton—C.A.9—1929-30.

Mean Group Length		Apex			Base			Right Flank			Left Flank			Combed Hairs			Mean Results		
																	Present Experiments		
In eighths of an inch	Inches	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	Straight Mean	Wtd. Mean	Tech. Reports
2	¼	1·2	1·6	1·4	—	—	—	—	—	—	—	—	—	—	—	—	0·3	0·1	0·2
3	⅜	3·7	3·5	3·6	1·3	1·6	1·5	1·1	1·4	1·2	1·4	1·0	1·2	2·6	3·8	3·2	2·1	1·6	1·6
4	½	8·6	7·5	8·1	2·6	3·0	2·8	2·5	2·8	2·7	2·9	1·7	2·3	5·3	5·1	5·2	4·2	3·3	3·9
5	⅝	18·1	16·5	17·3	5·3	6·5	5·9	6·2	7·2	6·7	6·1	4·4	5·2	10·5	10·1	10·3	9·1	7·3	8·8
6	¾	34·8	33·0	33·9	11·8	13·8	12·8	16·9	18·5	17·7	16·5	14·8	15·7	23·0	22·8	22·9	20·6	18·0	20·0
7	⅞	25·4	28·0	26·7	32·9	29·5	31·2	36·0	35·2	35·6	33·0	39·6	36·3	30·3	29·8	30·1	32·0	33·7	33·3
8	1	7·0	8·3	7·6	34·2	33·4	33·8	27·6	25·8	26·7	28·0	29·1	28·6	19·7	20·2	19·9	23·3	26·4	24·6
9	1⅛	1·2	1·6	1·4	10·6	10·5	10·5	8·0	7·7	7·9	9·4	7·4	8·4	6·6	6·3	6·5	6·9	7·9	6·5
10	1¼	—	—	—	1·3	1·7	1·5	1·7	1·4	1·5	2·7	2·0	2·3	2·0	1·9	1·9	1·5	1·7	1·1
11	1⅜	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mean Length ...		0·74	0·75	0·75	0·90	0·90	0·90	0·88	0·87	0·88	0·89	0·90	0·89	0·84	0·83	0·83	0·85	0·87	0·86

Table 5. Cotton—Gadag I (1927-28).

Mean Group Length		Apex			Base			Right Flank			Left Flank			Combed Hairs			Mean Results		
																	Present Experiments		
In eighths of an inch	Inches	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	Straight Mean	Wtd. Mean	Tech. Reports
2	¼	2·4	2·6	2·5	—	—	—	0·9	0·4	0·6	1·2	0·7	0·9	—	—	—	0·8	0·6	0·4
3	⅜	5·2	4·6	4·9	2·5	2·7	2·6	1·7	1·9	1·8	4·0	2·0	3·0	1·5	2·1	1·8	2·8	2·6	1·7
4	½	10·9	9·5	10·2	5·7	6·4	6·0	3·8	3·8	3·8	6·4	4·1	5·3	2·6	4·2	3·4	5·8	5·3	3·7
5	⅝	21·3	18·7	20·0	13·4	12·5	13·0	7·6	9·5	8·6	12·0	10·5	11·2	5·5	7·8	6·6	11·9	11·2	7·2
6	¾	30·9	33·8	32·4	24·9	23·7	24·3	22·0	24·0	23·0	25·2	21·8	23·5	13·9	16·7	15·3	23·7	23·1	17·0
7	⅞	22·1	22·9	22·5	31·1	31·0	31·1	38·6	38·4	38·5	34·4	33·2	33·8	35·5	32·5	34·0	32·0	33·1	37·7
8	1	7·2	6·9	7·0	17·8	18·4	18·1	20·8	18·2	19·5	12·8	21·8	17·3	34·1	28·3	31·2	18·6	19·4	25·7
9	1⅛	—	1·0	0·5	4·6	4·8	4·7	4·2	3·8	4·0	3·2	5·9	4·6	6·2	7·3	6·8	4·1	4·4	6·0
10	1¼	—	—	—	—	0·5	0·2	0·4	—	0·2	0·8	—	0·4	0·7	1·1	0·9	0·3	0·3	0·6
11	1⅜	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mean Length ...		0·71	0·72	0·72	0·81	0·81	0·81	0·84	0·83	0·83	0·79	0·83	0·81	0·89	0·87	0·88	0·81	0·82	0·86

Table 6. Gadag I, 1928-29.

Mean Group Length		Apex			Base			Right Flank			Left Flank			Combed Hairs			Mean Results		
																	Present Experiments		
In eighths of an inch	Inches	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	Straight Mean	Wtd. Mean	Tech. Reports
2	¼	2·0	1·7	1·9	—	—	—	—	—	—	—	—	—	0·8	0·6	0·7	0·5	0·3	0·2
3	⅜	4·4	5·2	4·8	2·1	2·5	2·3	1·7	1·0	1·4	1·6	1·5	1·6	2·1	1·4	1·7	2·4	2·0	1·8
4	½	9·8	10·0	9·9	3·8	4·8	4·3	2·7	1·7	2·2	4·0	3·4	3·7	3·3	2·9	3·1	4·6	3·9	3·8
5	⅝	24·2	27·4	25·8	12·0	13·8	12·9	8·8	8·6	8·7	9·5	10·5	10·0	8·2	8·2	8·2	13·2	11·5	9·4
6	¾	32·5	30·9	31·7	29·4	34·0	31·7	25·4	27·7	26·6	29·6	28·2	28·9	24·1	23·9	24·0	28·6	28·5	24·4
7	⅞	18·7	17·4	18·0	36·3	31·8	34·0	41·1	41·8	41·4	38·5	39·5	39·0	40·5	42·4	41·5	34·8	36·9	37·6
8	1	6·9	5·7	6·3	13·7	10·8	12·3	16·6	16·1	16·3	13·8	14·3	14·0	17·4	17·3	17·3	13·2	14·0	18·4
9	1⅛	1·5	1·7	1·6	2·7	2·3	2·5	3·7	3·1	3·4	3·0	2·6	2·8	3·6	3·3	3·5	2·7	2·9	4·3
10	1¼	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0·1
Mean Length ...		0·72	0·71	0·71	0·81	0·79	0·80	0·83	0·82	0·83	0·81	0·82	0·82	0·83	0·83	0·83	0·80	0·81	0·83

Table 7. Cotton—Verum 262 (Nagpur), 1928-29.

Mean Group Length		Apex			Base			Right Flank			Left Flank			Combed Hairs			Mean Results		
																	Present Experiments		
In eighths of an inch	Inches	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	Straight Mean	Wtd. Mean	Tech. Reports
2	¼	1·9	1·7	1·8	—	0·3	0·2	0·4	0·4	0·4	0·3	—	0·1	—	—	—	0·5	0·4	—
3	⅜	3·9	3·7	3·8	1·5	1·4	1·4	1·1	0·9	1·0	0·7	0·8	0·8	—	1·1	0·5	1·5	1·4	1·5
4	½	10·2	10·1	10·1	3·6	3·9	3·8	2·6	1·7	2·1	1·7	1·5	1·6	2·6	2·7	2·7	4·1	3·6	3·8
5	⅝	21·8	23·5	22·7	11·5	12·2	11·8	9·0	5·7	7·4	4·8	5·7	5·2	6·9	7·5	7·2	10·9	10·2	7·5
6	¾	33·0	34·2	33·6	29·5	30·4	30·0	25·8	21·2	23·5	21·0	22·0	21·5	20·1	23·0	21·6	26·0	26·1	19·5
7	⅞	19·4	19·1	19·2	35·2	34·3	34·7	33·6	37·0	35·3	45·0	40·9	43·0	37·6	37·4	37·5	34·0	34·9	34·5
8	1	7·3	5·4	6·4	12·9	12·6	12·8	17·5	23·0	20·3	20·7	21·2	20·9	21·2	18·7	19·9	16·2	16·4	24·8
9	1⅛	2·5	2·3	2·4	4·3	3·5	3·9	6·7	7·5	7·1	4·8	6·0	5·4	7·9	6·4	7·2	5·2	5·2	6·8
10	1¼	—	—	—	1·5	1·4	1·4	2·2	1·7	1·9	0·7	1·3	1·0	2·6	2·1	2·3	1·3	1·3	1·6
11	1⅜	—	—	—	—	—	—	1·1	0·9	1·0	0·3	0·6	0·5	1·1	1·1	1·1	0·3	0·5	—
Mean Length ...		0·72	0·72	0·72	0·82	0·81	0·82	0·86	0·88	0·87	0·87	0·87	0·87	0·88	0·86	0·87	0·83	0·84	0·86

Table 8. Cotton—P.A., 4F 1929-30.

Mean Group Length		Apex			Base			Right Flank			Left Flank			Combed Hairs			Mean Results		
																	Present Experiments		
In eighths of an inch	Inches	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	1st sliver	2nd sliver	Mean	Straight Mean	Wtd. Mean	Tech. Reports
2	¼	3·2	3·1	3·1	0·5	0·5	0·5	0·5	0·8	0·7	0·8	0·9	0·8	0·6	1·0	0·8	1·2	0·9	0·8
3	⅜	5·8	5·7	5·8	1·2	1·6	1·4	1·5	1·6	1·6	1·6	2·0	1·8	1·4	2·1	1·7	2·4	2·0	1·9
4	½	12·6	13·6	13·1	2·9	3·2	3·0	4·2	4·2	4·2	3·5	5·2	4·4	2·7	3·6	3·2	5·6	4·6	4·6
5	⅝	29·2	29·0	29·1	10·9	11·6	11·3	14·5	14·2	14·3	11·3	15·6	13·4	10·9	11·7	11·3	15·9	14·3	11·4
6	¾	31·6	30·6	31·1	35·8	34·8	35·3	35·3	37·5	36·4	34·6	37·5	36·1	31·6	33·6	32·6	34·3	35·2	26·8
7	⅞	12·9	12·9	12·9	34·4	35·9	35·2	31·0	31·1	31·0	35·2	27·6	31·4	36·4	34·6	35·5	29·2	31·0	35·5
8	1	3·6	3·8	3·7	10·5	9·0	9·8	9·9	8·3	9·1	10·1	9·2	9·7	12·9	11·3	12·1	8·9	9·4	14·6
9	1⅛	1·1	1·3	1·2	2·4	2·1	2·2	2·1	2·2	2·2	2·2	2·0	2·1	3·1	2·1	2·6	2·1	2·1	4·2
10	1¼	—	—	—	1·4	1·3	1·3	1·0	—	0·5	0·6	—	0·3	0·4	—	0·2	0·4	0·5	0·2
Mean Length		0·67	0·67	0·67	0·81	0·80	0·80	0·79	0·78	0·78	0·80	0·77	0·79	0·81	0·80	0·81	0·77	0·78	0·81

VARIATION OF UNIT FIBRE-WEIGHT ON THE SURFACE OF THE SEED

Table 9
Surat 1027 A.L.F. (1928-29)

Group No.	Apex		Base		Right Flank		Left Flank		Combed hairs	
	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver
1	5·99	6·64	3·13	3·86	5·56	5·34	5·94	5·84	3·30	3·75
2	6·08	6·40	3·50	4·01	5·44	5·51	6·32	5·52	3·58	3·82
3	6·72	6·52	3·62	4·06	5·67	5·62	5·50	5·57	3·61	3·72
4	6·45	6·42	3·89	3·90	5·10	5·67	5·45	5·78	3·26	3·82
5	6·72	6·18	4·06	3·86	5·56	5·40	5·94	6·08	3·86	4·02
6	6·25	6·45	3·84	3·83	4·93	5·18	5·86	6·10	3·54	3·46
7	6·22	6·57	3·36	...	5·56	5·45	5·40	5·62	3·63	3·14
8	6·25	6·44	...	...	5·27	5·23	5·50	5·83	...	...
9	...	5·96	...	...	5·49	5·73	5·40	5·78	...	...
10	...	...	...	...	...	5·67	...	5·57	...	...
11	...	...	...	...	...	5·45	...	5·15	...	...
Mean ...	6·368		3·629	3·920	5·398	5·477	5·701	5·713	3·540	3·676

Table 10
Nandyal 14 (1929-30)

Group No.	Apex		Base		Right Flank		Left Flank		Combed hairs	
	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver
1	4·33	4·35	4·95	4·76	5·31	5·26	5·14	5·06	3·69	3·70
2	4·64	4·43	4·41	5·03	5·29	5·21	5·02	4·96	3·60	3·87
3	4·64	4·43	5·05	4·82	5·53	5·14	5·00	5·03	3·30	3·42
4	4·21	4·70	4·69	4·74	5·23	5·48	4·88	4·91	4·08	3·59
5	4·43	4·70	4·18	5·15	5·16	5·29	5·10	5·11	3·52	3·59
6	4·38	4·57	4·75	5·21	5·13	5·29	5·00	5·18	3·75	3·77
7	4·53	4·39	5·05	4·78	5·60	5·46	4·90	5·18	3·52	3·70
8	4·45	4·30	4·43	5·10	5·33	5·38	5·02	5·13	3·06	3·96
9	4·53	4·54	4·79	...	5·16	5·51	5·07	5·03	...	...
10	4·97	...	...	...	5·35	5·26	5·29	5·62	...	...
11	4·43	...	...	...	...	...	4·92	...	...	...
12	3·70	...	...	...	...	...	...	...	...	...
Mean ...	4·437	4·490	4·700	4·949	5·309	5·328	5·031	5·121	3·565	3·700

Table 11
C.A.9 (1928-29)

Group No.	Apex		Base		Right Flank		Left Flank		Combed hair	
	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver
1	3·91	3·19	4·04	3·90	4·09	4·00	3·78	4·02	3·53	4·06
2	4·22	4·08	3·89	3·88	3·96	4·14	3·81	4·04	3·84	3·97
3	3·91	4·13	4·02	3·99	3·98	3·96	3·85	4·33	4·00	4·04
4	3·87	4·23	3·85	4·19	4·16	3·92	4·07	4·11	4·00	3·97
5	3·80	4·20	3·87	4·08	4·07	3·80	3·94	3·93	3·91	3·95
6	3·84	3·92	3·96	4·06	4·16	3·89	4·03	4·00	3·84	3·97
7	3·91	4·15	3·64	3·93	4·09	4·01	3·78	3·98	3·78	3·83
8	4·17	3·95	...	...	4·07	3·99	4·18	3·90	3·62	3·79
9	...	...	...	...	...	...	3·95	...	...	...
Mean ...	3·954	3·981	3·896	4·004	4·073	3·964	3·932	4·039	3·815	3·948

Table 12
C.A.9 (1929-30)

Group No.	Apex		Base		Right Flank		Left Flank		Combed hair	
	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver
1	3·89	3·75	3·96	4·13	3·88	3·89	3·94	3·93	3·31	3·69
2	4·04	3·68	3·85	3·84	3·96	3·82	3·79	4·08	3·71	3·76
3	3·85	3·61	3·78	4·16	3·81	3·78	4·28	3·90	3·82	3·83
4	3·78	3·54	3·63	3·84	3·99	4·00	3·94	4·15	3·79	3·69
5	3·82	3·65	3·74	3·88	3·88	4·11	4·01	4·08	3·60	3·79
6	3·78	3·83	3·81	3·77	3·96	4·04	4·05	3·93	3·49	3·87
7	3·67	3·72	4·06	4·09	4·06	3·93	4·01	4·12	3·49	3·90
8	3·85	3·68	4·05	3·84	4·00	3·83	4·59	4·04	3·70	...
9	3·86	3·78	...	3·77	...	...	...	4·37	...	...
Mean ...	3·838	3·683	3·860	3·924	3·943	3·925	4·076	4·067	3·614	3·790

Table 13
Gadag I (1927-28)

Group No.	Apex		Base		Right Flank		Left Flank		Combed hairs	
	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver
1	4·31	3·71	3·30	3·12	4·07	3·80	3·66	3·63	3·43	3·08
2	4·25	3·96	2·82	2·97	4·01	4·02	3·44	3·84	3·17	3·24
3	3·98	4·06	3·07	2·90	4·17	4·07	3·69	3·82	3·05	3·27
4	4·39	3·98	3·12	2·93	3·99	3·46	3·50	3·63	3·38	3·30
5	3·88	3·76	3·02	3·07	3·86	3·52	3·60	3·68	3·58	3·32
6	4·23	3·88	2·92	3·17	4·21	3·40	3·58	3·86	2·80	3·14
7	4·14	4·28	3·44	...	3·63	3·46	3·49	3·81	...	3·12
8	4·12	...	3·14	...	3·64	...	3·74	3·51	...	...
9	4·14	...	...	...	4·30	...	...	...	...	...
Mean ...	4·160	3·947	3·104	3·027	3·987	3·676	3·588	3·723	3·235	3·210

Table 14
Gadag I (1928-29)

Group No.	Apex		Base		Right Flank		Left Flank		Combed hairs	
	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver
1	4·06	3·76	3·02	3·07	3·52	3·69	3·65	3·79	3·47	3·14
2	3·56	4·08	3·20	3·13	3·73	3·52	3·79	3·66	3·41	3·34
3	3·99	3·80	2·85	2·95	3·66	3·59	3·82	3·72	3·06	3·17
4	4·02	3·97	2·91	3·07	3·66	3·42	3·75	3·52	3·24	3·17
5	3·88	4·29	3·02	2·92	3·45	3·45	3·68	3·66	3·21	3·22
6	4·09	3·83	2·97	2·98	3·48	3·49	3·47	3·52	3·24	3·27
7	3·95	3·90	...	2·87	3·52	3·66	3·82	3·62	3·31	...
8	3·90	3·98	...	...	3·53	3·57	3·87	3·47	...	...
Mean ...	3·931	3·951	2·995	2·999	3·569	3·549	3·731	3·633	3·277	3·218

Table 15
Verum 262 (Nagpur) 1928-29

Group No.	Apex		Base		Right Flank		Left Flank		Combed hairs	
	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver
1	4·69	4·61	4·44	4·25	4·72	4·81	4·80	4·83	3·85	3·54
2	4·59	4·61	4·26	4·39	4·55	4·60	4·87	4·62	3·68	3·78
3	4·41	4·51	4·12	4·46	5·03	4·70	4·94	4·94	3·54	4·03
4	4·83	4·68	4·26	4·39	4·65	4·56	4·70	4·76	3·78	3·99
5	4·52	4·61	4·23	4·35	4·79	4·53	4·48	4·73	3·43	3·75
6	4·69	4·54	4·15	4·25	4·86	4·46	4·34	4·94	3·64	3·99
7	4·69	4·47	4·20	4·21	5·00	4·66	4·44	4·76	3·61	3·89
8	4·65	...	...	4·38	4·96	...	...	4·70	3·78	...
Mean ...	4·634	4·576	4·237	4·335	4·820	4·617	4·653	4·785	3·664	3·853

Table 16
Punjab-American 4F (1929-30)

Group No.	Apex		Base		Right Flank		Left Flank		Combed hairs	
	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver	1st sliver	2nd sliver
1	5·07	4·95	3·48	3·46	4·38	4·16	3·72	4·30	3·63	3·54
2	4·71	5·12	3·39	3·79	4·42	3·75	3·94	4·09	3·48	3·30
3	5·20	5·08	3·35	3·76	4·34	4·16	4·12	4·27	3·54	3·15
4	4·85	4·86	3·66	3·61	4·23	4·01	4·12	4·27	3·33	3·30
5	4·98	5·17	3·26	3·79	4·31	4·04	4·12	4·19	3·30	3·42
6	5·24	4·86	3·48	3·79	4·12	4·12	3·94	4·16	3·31	3·20
7	5·15	4·95	3·60	3·95	4·23	4·09	3·98	4·23	...	...
8	4·98	4·81	3·53	...	4·09	...	3·83	4·09	...	...
9	4·85	4·99	...	...	4·34	...	4·12	...	...	...
10	...	4·96	...	...	4·20	...	...	...	...	...
Mean ...	5·003	4·975	3·469	3·736	4·266	4·047	3·988	4·200	3·432	3·318

22—THE ANALYSIS OF SIZED COTTON: THE DETERMINATION OF ZINC AND MAGNESIUM, AND SOME QUALITATIVE TESTS

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I. INTRODUCTION AND SUMMARY.

Two common constituents of size mixings for cotton warps are the metals zinc and magnesium, generally in the form of their chlorides, the former being used chiefly for its antiseptic value, and the latter for the sake of its deliquescent properties. Determinations are often required of the amount of these sizing ingredients on a cotton warp, or in a cloth, and methods of analysis have been described by Neale[12] for this purpose. The accurate separation of the two metals, only present in small quantities, and mixed with organic materials, demands a critically tested analytical procedure, and Neale described a method of extraction, and a process of separation in which the metals were precipitated individually as double ammonium phosphates at different controlled hydrogen ion concentrations.

Since the date of Neale's work methods of analysis, due originally to Berg,[3] have been described in which oxine (8-hydroxyquinoline) is used as the precipitant for a number of metals. The methods appeared particularly attractive for the determination of zinc and magnesium in sized cotton goods, and this paper describes their adaptation to this end. Frequent use over a period of some years has shown them to be convenient, rapid, and sufficiently accurate, whilst they can also be applied to the analysis of the size paste or mixing itself.

An electrolytic method also appeared likely to furnish an accurate means for the determination of zinc in the presence of magnesium. A suitable adaptation of Slater Price's[15, 16] method was found to give reliable results, but in order to avoid disturbances caused by other ingredients of sized cotton a somewhat lengthy method was necessary for the extraction of the metals. It is not therefore recommended for routine use, but results by the oxine and electrolytic methods are shown in this paper to furnish mutual confirmation of reliability in the accurate determination of zinc.

When an estimate is required of the amount of magnesium added to an unbleached warp during sizing, the analytical figure requires correction for the magnesium present in the unsized cotton, and since sufficient data were not found in the literature, raw cottons of different origins were analysed. The results are given in Table III, a fair average for all classes of cotton

being 0·25 per cent. expressed as magnesium chloride ($MgCl_2$), and it is necessary to deduct this amount from analyses of grey sized cotton. In bleached materials a correction is unnecessary.

In a newly manufactured cloth the zinc chloride is found entirely on the sized warp, but after storage it is frequently found also on the weft. This migration of the zinc chloride from the warp to the weft is highly dependent on the conditions of storage, and in particular is greatly accelerated by increasing humidity. Analyses of the warp and weft therefore provide some information regarding storage conditions, and may help in deciding whether mildewing is to be ascribed to deficiency of zinc chloride, when this is used as the sole antiseptic, or to storage in an unreasonably damp condition.

In the last section of the paper several qualitative tests are described. The recent discoveries of organic reagents which give specific colour reactions with various metals has greatly facilitated qualitative analysis and tests based on published reactions of this type are described for zinc, magnesium, aluminium and china clay. The procedure in each case has been arranged so that a positive result will be obtained with the smallest amount of the substance that is of practical significance, and not so as to obtain the maximum sensitivity.

Sodium silicofluoride is occasionally added to size mixings for its antiseptic value, though the quantities recommended are very small, and correspond with a fluorine addition of the order of 0·1 per cent. of the weight of the cotton. When Tammann's[17] test for fluorine was applied to raw, unsized, cotton, amounts of this order are found to be present as a natural constituent, and purely qualitative tests are not therefore suitable for detecting the addition of small quantities of fluorine compounds to unbleached cotton.

II. ELECTROLYTIC METHOD FOR THE DETERMINATION OF ZINC.

The method used was that of Slater Price[15, 16] modified so as to determine with sufficient accuracy amounts of zinc of the order of 5 mg. The electrodes used were similar to his, but on a much smaller—semi-micro—scale, the cathode consisting of a cylinder of platinum gauze rotating within an annular anode in a specially designed electrolytic vessel of 15 c.c. capacity. The volume of electrolyte was 10 c.c, and it was prepared from the zinc solution by the addition of 0·4 g. each of anhydrous sodium sulphate and hydrated sodium acetate and of two or three drops of glacial acetic acid. Electrolysis was continued for one hour with a current of 50 milliamperes, requiring 3·0 to 3·2 volts, whilst the cathode was rotated at about 600 r.p.m.

Accurate results were obtained with a pure zinc sulphate solution, and with one containing a large excess of magnesium sulphate. When a solution was used that had been obtained by extracting a sized warp (starch—tallow) containing a known amount of added zinc with hot dilute acid, the results were low and irregular. This was due to the presence of organic substances extracted by the acid from the sized cotton, and accurate results could be obtained if the solution was first evaporated to dryness and the organic matter removed by " acid ashing " (Neumann),[18] that is, by oxidation with concentrated nitric acid in boiling concentrated sulphuric acid solution. The separation of mineral matter from organic constituents by ashing over a flame or in a furnace is open to the objection that losses of zinc by volatilisation can easily occur.

The necessity for an acid ashing process greatly detracts from the convenience of the method, and further experimental detail will not therefore

be recorded. In Section III a comparison is given, however, between results obtained by the electrolytic method on the acid ashed extracts of many cloths with those obtained by the oxine method to be described now in detail; the agreement is very good.

III. THE OXINE METHOD FOR THE DETERMINATION OF ZINC AND MAGNESIUM.

It has been shown by Berg[8], by Hahn and Vieweg[7] and by Kolthoff[11] that zinc and magnesium may be separated and determined by precipitating with oxine (8-hydroxyquinoline) under suitable conditions. In slightly acid solution zinc is precipitated but not magnesium, and the latter may then be precipitated from the filtrate by making this alkaline and adding a fresh quantity of oxine. Alternatively two aliquot portions of the solution may be taken, and the zinc precipitated from one in acid solution and the zinc and magnesium precipitated together from the other in alkaline solution; this latter method has been found more convenient because quicker. The precipitates are redissolved in acid and the oxine determined in these solutions by bromometric titration. From the amounts of oxine in the two precipitates the weights of zinc and magnesium are readily calculated. In order to obtain quantitative results it is necessary to control carefully not only the acidity or alkalinity of the solution but also the amount of oxine, as has also been stated by Hahn[6] in a paper which appeared after the completion of this work.

In applying the method to sized cotton goods the zinc and magnesium salts were at first extracted with acid and the extract acid-ashed as for the electrolytic method. It was then found that the acid-ashing could be omitted without affecting the result, and the metals extracted by the simple digestion procedure given below. By this procedure the starch is sufficiently hydrolysed to allow rapid filtration, and the organic substances remaining in the solution do not interfere with the determinations of zinc and magnesium.

Of the other metals stated by Kolthoff to be precipitated by oxine those most likely to be present are calcium, iron and aluminium. Calcium is present in the ash of raw cotton, and is precipitated by oxine along with magnesium from alkaline solutions. Kolthoff has shown, however, that it can be conveniently eliminated by adding ammonium oxalate before the oxine, it being unnecessary to filter off the calcium oxalate, and this procedure has been incorporated in the method. Iron is precipitated from both acid and alkaline solutions, but the oxinate is much more soluble in the latter. It may be present in cotton as rust stains or other accidental contamination, and if precipitated along with zinc or magnesium it is easily noticed because its oxinate is black whereas those of zinc and magnesium are pale greenish yellow. Occasionally the zinc oxinate precipitate has been dark, and in such cases the iron has been determined colorimetrically. Discolouration of the mixed zinc and magnesium oxinates obtained from alkaline solutions has not been observed. Aluminium is a constituent of china clay and is precipitated by oxine from acid solutions. Experiment has shown, however, that by the method given below no aluminium is extracted from china clay.

Detailed Procedure

A sample of yarn or cloth weighing about 10 g. and cut into small pieces, is weighed dry and digested for half an hour in a boiling water bath with 130 c.c. of water and 20 c.c. of *N*. hydrochloric acid. It is then filtered through

a Buchner funnel, well pressed, and the cotton washed repeatedly with 20 c.c. portions of water. The filtrate and washings are made up to 250 c.c. A fairly large quantity of material is preferred in order to reduce sampling errors, but less can be taken and the filtrate made up to a correspondingly smaller bulk.

Zinc. Fifty c.c. of the solution are transferred to a 100 c.c. conical flask and 4 c.c. of 2*N* acetic acid, 2·5 c.c. of *N* ammonium acetate, excess of fresh 5 per cent. alcoholic oxine, and 4 c.c. of *N* sodium hydroxide are added in succession. The volume of oxine solution should be about 1 c.c. in excess of the volume required to combine with the zinc; the sodium hydroxide neutralises the hydrochloric acid originally present. The mixture is raised to the boil and allowed to stand for half an hour, preferably hot. It is then filtered, the flask washed out three times with hot water, and the precipitate on the filter washed a further three times with hot water. The precipitate in the flask and filter is dissolved in 100 c.c. of hot 2*N* hydrochloric acid and the solution collected in a 250 c.c. measuring flask. After cooling, 1 c.c. of 0·005 per cent. Methyl Red is added, and a 0·1 *N* potassium bromate solution containing an excess of potassium bromide (2·784 g. of potassium bromate and 12 g. of potassium bromide per litre) is run in from a burette until the solution is sulphur yellow. The bromine which is liberated when the bromate and bromide are run into acid brominates the oxine and also destroys the colour of the Methyl Red by oxidation. The former reaction is considerably the more rapid but the difference in speed is not sufficient to enable the bromination to proceed to completion before oxidation of Methyl Red begins. It is therefore necessary to add a second 1 c.c. of the indicator and to run in further bromate and bromide until the solution is again yellow. Usually this requires only 1 or 2 c.c. but if more than a few c.c. are required the process must be repeated until this is no longer so. The burette is then adjusted to a convenient mark by running in a further portion of about 1 c.c. and excess of bromine is confirmed by adding a further 1 c.c. of Methyl Red, which should be rapidly decolourised. After standing for a half a minute to a minute the excess bromine is determined by adding 5 c.c. of 20 per cent. potassium iodide and starch and titrating the iodine liberated with 0·1*N* sodium thiosulphate. When no information is available as to the amount of zinc chloride to be expected a round value of 0·5 per cent. may be assumed, and this requires 1·7 c.c. of 5 per cent. oxine solution. If an error of 0·3 c.c. in the volume of oxine is allowed this amount is suitable for cloths containing between 0·3 and 0·7 per cent. of zinc chloride, and if the proportion should fall outside these limits the determination must be repeated with a fresh aliquot portion of the solution. The volume of 0·1*N* potassium bromate-bromide equivalent to 1 c.c. of 5 per cent. oxine is 13·8 c.c., and the correctness of the volume taken is therefore most easily checked by dividing the bromate-bromide titre by 13·8.

Magnesium. Twenty-five c.c. of the solution are diluted with 25 c.c. of water in a 100 c.c. conical flask; if the amount of magnesium is small 50 c.c. of the solution are taken. After raising to the boil, 1 c.c. of a saturated solution of ammonium oxalate is added and the solution is made just alkaline by the addition of 5 *N* ammonium hydroxide (about 0·4 c.c.) in the presence of Methyl Red. After digesting for a quarter of an hour on a water bath to precipitate calcium oxalate, 2 c.c. of 5 *N* ammonium hydroxide, excess of fresh 5 per cent. alcoholic oxine, and a further 2 c.c. of 5 *N* ammonium hydroxide are

added. The volume of oxine should be about 1 c.c. in excess of that required to combine with the zinc and magnesium. The mixture is digested on a water bath for an hour, when both the zinc and magnesium are precipitated. It is then filtered, the flask washed three times with hot 0·5 *N* ammonium hydroxide, and the precipitate in the filter washed a further three times. The oxine in the precipitate is then determined as given for zinc oxinate.

In its behaviour towards metals oxine reacts as a mono-basic acid (M.W. 145·07) and with bromine, which is liberated when the mixture of potassium bromate and bromide is run into acid, it forms a dibromide. Thus if M is a divalent metal

$$C_9H_6N{-}OH \longrightarrow (C_9H_6N{-}O)_2M$$

$$C_9H_6N{-}OH + 2Br_2 \longrightarrow C_9H_4Br_2N{-}OH + 2HBr$$

The weight of oxine which precipitates one gram-equivalent of metal reduces four gram-equivalents of bromine, and this renders the method especially suitable for small amounts. One c.c. of 0·1 *N* bromine is equivalent to 1·703 mg. of zinc chloride or to 1·191 mg. of magnesium chloride. Thus if

T_1 and T_2 are the titres of the two oxinate precipitates in c.c. of 0·1 *N* bromine,

W is the dry weight of material taken,

S is the percentage of size in the cloth,

then $ZnCl_2 = 0{\cdot}8515\ T_1/W\%$

$MgCl_2 = 1{\cdot}191\,(T_2 - \frac{1}{2}T_1)/W - 0{\cdot}25\,(100 - S)$

correcting for the magnesium content of the raw cotton.

If the zinc oxinate is dark in colour it is necessary to apply a correction for the iron present, and this is readily done by a colorimetric determination in an aliquot portion of the cotton extract.

Control Analyses

The method was tested with known amounts of zinc and magnesium both as pure solutions and added to grey cloth containing warp size. Zinc was used as recrystallised zinc sulphate of which the purity was checked both by ignition followed by weighing the residual oxide, and by precipitation and weighing as zinc ammonium phosphate. The former method gave 22·71, 22·69 per cent. zinc and the latter 22·73, 22·76 per cent., the calculated value being 22·74 per cent. Magnesium was used as a solution of A.R. magnesium sulphate which was analysed by Epperson's modification of the pyrophosphate method and found to contain 2·517, 2·521 grams of magnesium per litre.

Pure Solutions :—

Zinc alone: *Taken* mg. 6·01 ; *Found* mg. 6·09, 6·05.

Magnesium alone : *Taken* mg. 5.05 ; *Found* mg. 5·11, 5·11, 5·04, 5·14, 5·02, 5·00, 5·10, 5·13, 5·04, Mean 5·08.

Zinc and magnesium together ; Magnesium determined in filtrate from zinc oxinate : *Taken* mg. Zinc 6·01, Magnesium 5·04. *Found* mg. Zinc 5·90, 6·00, Magnesium 5·03, 5·01.

Zinc and magnesium precipitated together : *Taken* mg. Zinc 6·01, Magnesium 5·05, Zinc and magnesium calculated as zinc 19·58. *Found* mg. Zn and Mg calculated as Zn 19·58, 19·54, 19·69, 19·61. Mean 19·61.

Magnesium determined in the presence of zinc, aluminium, iron and calcium : The zinc, aluminium and iron were precipitated with oxine

from acid solution, and in the filtrate the calcium was precipitated as oxalate and the magnesium as oxinate in alkaline solution:

Taken mg. Zinc 6·01, Iron, aluminium and calcium each equivalent to 5·0 of magnesium. Magnesium 5·05.
Found mg. Magnesium 5·13, 5·15, 5·13.

Comparison of different methods of preparing extract:—

Extracts were prepared by different methods from a cloth (SC.66) containing zinc and magnesium in the warp size.

Acid ashing: $ZnCl_2$ 0·94, 0·94, 0·93, 0·94, 0·94. Mean 0·94 per cent.
$MgCl_2$ 2·67, 2·63, 2·69, 2·62, 2·59. Mean 2·64 per cent.

Extraction in Soxhlet with dilute nitric acid:
$ZnCl_2$ 0.94, 0.94, 0·935. Mean 0·94 per cent.
$MgCl_2$ 2·57, 2·60, 2·61, 2·63. Mean 2·60 per cent.

Standard digestion method:
$ZnCl_2$ 0·933, 0·935. Mean 0·934 per cent.
$MgCl_2$ 2·64, 2·64, 2·61. Mean 2·63 per cent.

In these magnesium determinations the calcium was not eliminated.

Zinc and magnesium added to grey cloth:—

Appreciable amounts of magnesium are always present in grey cotton and it was, therefore, not possible to take a grey cloth free from zinc and magnesium and add known amounts of these to it. To take a bleached cloth would have been to have omitted those substances most likely to interfere with the determinations. Conditions which gave reproducible results were, therefore, worked out on a grey cloth (SC.66) containing both zinc and magnesium. This procedure, which is given in detail above, was then applied to a grey cloth (258/3) containing no zinc or magnesium except the magnesium normal to grey cotton, and to this cloth after the addition of known amounts of the pure salts. The results are all expressed as the percentages of the chlorides in the grey cloth.

Cloth No. 258/3:
$ZnCl_2$ 0·004, 0·004, 0·003, 0·003, 0·004, 0·006, 0·003. Mean 0·004 per cent.
$MgCl_2$ 0·207, 0·208, 0·206, 0·209. Mean 0·208 per cent.

Cloth No. 258/3 *with added zinc and magnesium*:

Calculated	$ZnCl_2$	1·34	0.675	3·35 per cent.
	$MgCl_2$	2·84	5·49	1·26 per cent.
Found	$ZnCl_2$	1·32	0·64, 0·64	3·31, 3·31 per cent.
	$MgCl_2$	2·80, 2·81	5·58, 5·58	1·31, 1·32 per cent.

Determination of magnesium in the presence of calcium:
Cloth SC.66. *Found* $MgCl_2$, 2·54, 2·55, 2·55 per cent.
Cloth SC.66 + $CaCl_2$ equiv. to 2 per cent. $MgCl_2$. *Found* $MgCl_2$, 2·55, 2·56 per cent.

Comparison of Electrolytic and Oxine Methods:—

In one series of comparisons the zinc solution was prepared from the cotton by extraction and acid ashing and aliquot portions were used for determinations by the two methods.

Table I

Cloth No.	Zinc found in solution mg./c.c.		Cloth No.	Zinc found in solution mg /c.c.	
	Electrolytic.	Oxine.		Electrolytic.	Oxine.
SC.42/1	0·74	0·725	SC.66	0·88	0·873
SC.55/1	0·73	0·742	SC.47	0·36	0·372
SC.55/1	0·71	0·713	SC.71/1 with added zinc	0·49	0·491
SC.55/2	0·78	0·787		0·47	0·479
SC.55/2	0·78	0·793		0·48	0·491
Z.3	0·36	0·375		0·50	0·500
Z3	0·38	0·380	SC.72	0·21	0·233
Z,10	0·35	0·362	SC.47/T1/A5	0·03	0·001

In a second series of comparisons the two determinations were completely independent and the procedure for the oxine method was exactly as described on page 86.

Table II.

Cloth No.	Zinc chloride found in cloth %	
	Electrolytic.	Oxine.
SC.47/Z1/B1	0·73	0·76, 0·76
253C	1·12	1·15
253E	1·61	1·60
263	0·99	0·98, 1·00
257/4	0·79	0·76, 0·78
256I	2·26	2·28, 2·27
264	1·55	1·64, 1·61

Application of the Oxine Method to the Analysis of Size.

The method described on page 86 may be used for the analysis of size, but digestion for one hour on a water bath with 20 c.c. of *N* hydrochloric acid and 130 c.c. of water does not hydrolyse the starch sufficiently to enable the extract to be filtered easily. The procedure is, therefore, slightly modified. Sufficient size to contain about 0·1 g. of zinc chloride is weighed into a 250 c.c. beaker, 5 c.c. of 4*N* hydrochloric acid are added, and the mixture heated in a boiling water bath for an hour; 130 c.c. of hot water are then added, the solution filtered, the filtrate and washings made up to 250 c.c. and used for the determinations of zinc and magnesium as described on page T282.

The method was checked by adding known amounts of zinc and magnesium to a paste containing 8 per cent. of farina. Portions of about 15 g. were taken for each determination.

Paste alone:

$ZnCl_2$ 0·0040, 0·0031 per cent.
$MgCl_2$ 0·0015, 0·0022 per cent.

Paste with added zinc and magnesium.:

Taken	Zinc. 0·0299 g.	Magnesium. 0·0255 g.
Found	Zinc, 0·0298, 0·0295 g.	Magnesium, 0·0258, 0·0257 g.

IV. MAGNESIUM CONTENT OF RAW COTTONS.

Zinc and magnesium were determined in a collection of grey unsized yarns by the oxine methods. In most cases no trace of zinc was found, and the maximum amount, calculated as the chloride, was 0.007 per cent., which was not experimentally significant. The magnesium contents, expressed purely for convenience as percentages of magnesium chloride, are given in Table III, from which it is seen that 0·25 per cent. is a fair mean value for correcting analyses of sized material containing cotton of unknown origin (see next page).

V. DIFFUSION OF ZINC CHLORIDE FROM WARP TO WEFT DURING STORAGE.

Zinc chloride is added to cloth as a constituent of the size and is therefore at first entirely on the warp. When cloths are analysed after storage zinc is, however, frequently found in both warp and weft, as is illustrated by the analyses recorded in Table IV of a number of cloths taken at random.

Table III. Magnesium Contents of Raw Cottons.

Cotton.	Magnesium expressed as Magnesium chloride. %	Mean
American : Texas No. 149	0·200	
,, 168	0·212	
,, 188	0·187	0·208
,, 222	0·187	
Memphis No. 212	0·256	
Egyptian : Uppers No. 128	0·285	
,, 129	0·269	
Sakel No. 130	0·327	0·300
,, 229	0·318	
South American : Brazilian No. 152	0·278	
Peru Mitafifi No. 153	0·229	0·246
Tanguis No. 213	0·230	
Indian : Broach No. 141	0·281	
Punjab American No. 196	0·227	
East African No. 169	0·292	

Table IV.

Cloth No.	Zinc chloride %				Remarks.
	Cloth.	Warp.	Weft.	Weft/Warp	
SC.48	0·78	0·74	0·79	1·07	Mildewed ; storage conditions unknown.
SC.99	0·47	0·56	0·33	0·59	
SC.101/1	0·61	0·61	0·61	1·00	
SC.153	0·67	0·69	0·62	0·90	
SC.170	0·45	0·68	0·15	0·22	
SC.26/5	0·69	0·94	0·04	0·04	Not mildewed ; storage conditions unknown.
SC.101/2	0·59	0·60	0·57	0·95	
SC.42/1	0·77	1·17	0·03	0·03	Not mildewed ; stored in dry laboratory.
SC.42/2	0·82	1·24	0·02	0·02	
SC.42/3	0·84	1·16	0·05	0·04	
253E	1·62	2·56	0·10	0·04	
257/1	0·73	1·22	0·10	0·08	
257/3	0·79	1·23	0·08	0·07	
263	0·99	1·45	0·03	0·02	

In general the cloths in which the most diffusion of zinc chloride from the warp to the weft has occurred are those that have mildewed and have, therefore, probably been stored in a moist and warm atmosphere. The diffusion that takes place in a damp atmosphere was followed by exposing two of the above cloths, in which little diffusion had occurred, to outside humidities by hanging in a well ventilated and unheated hut, and the following table contains analyses made from time to time. The calculated values for the zinc chloride content of the cloth are checks on the accuracy of analysis, and are evaluated on the assumption that the ratio of sized warp to weft is not significantly affected by the diffusion.

Table V.

Time Days.	Successive periods in continuous experiments.			Zinc chloride %.			
	Length days.	Relative Humidity. %	Temp. °C.	Cloth Calculated.	Warp.	Weft	Weft/Warp
Cloth 257/3, 0·79% zinc chloride by analysis of the cloth.							
0	—	—	—	0·79	1·23	0·08	0·07
9	9	74	—	0·82	1·27	0·09	0·07
20	11	—	—	0·78	1·17	0·15	0·13
41	21	80	9	0·80	0·91	0·61	0·67
50	9	84	11	0·79	0·90	0·58	0·65
76	26	83	5	0·77	0·86	0·61	0·71
129	53	85	4	0·79	0·84	0·70	0·83
14	14	83	4	0·79	1·06	0·35	0·33
37	23	85	4	0·74	0·85	0·57	0·67
61	24	85	4	0·77	0·82	0·68	0·83
120	59	73	4	0·79	0·84	0·70	0·83
Cloth 263, 0·99 % zinc chloride by analysis of the cloth							
0	—	—	—	1·04	1·45	0·03	0·02
14	14	83	4	0·94	1·09	0·66	0·61
37	23	85	4	0·98	0·99	0·98	0·99

It is seen that under these conditions the zinc chloride content of the weft rises gradually whilst that of the warp falls, until the two are not greatly different. During the first experiment with cloth 257/3 little diffusion took place during the first twenty days when the humidity was low, but when the relative humidity rose to 80 per cent. and above the diffusion was rapid. This effect of humidity was confirmed by storing a cloth (No. 253E) at controlled temperatures and humidities for 23 days. The analytical data then obtained for the warp and weft are given in Table VI and show that the rate of diffusion depends greatly on the relative humidity in the region between 80 per cent. and 90 per cent., and on the temperature at a humidity of 80 per cent. That a high temperature is not essential for rapid diffusion is shown by the experiments under open air conditions, but it is probable that a high humidity is essential.

Table VI.

Cloth No. 253E, 1·62% zinc chloride by analysis of the cloth.

Time Days.	Relative Humidity %	Temp. °C.	Zinc chloride %.			
			Cloth Calculated.	Warp.	Weft.	Weft/Warp
0	—	—	1·69	2·56	0·10	0·04
23	92	20	1·60	1·67	1·47	0·88
23	87	20	1·73	1·76	1·65	0·94
23	80	20	1·63	2·33	0·38	0·16
23	80	25	1·67	1·93	1·20	0·62

In another experiment two tapes, similar in all respects except that No. 283 contained 1·15 per cent. of magnesium chloride added in the size

whereas No. 282 was free from magnesium chloride, were stored together at 87 per cent. relative humidity and 25° C. and analysed from time to time. The data are collected in Table VII and indicate that the presence of magnesium chloride does not affect the diffusion of the zinc chloride.

Table VII.

Time Days.	Zinc chloride %.							
	Tape No. 282, 1·14% $ZnCl_2$.				Tape No. 283, 1·11% $ZnCl_2$.			
	Cloth Calculated.	Warp.	Weft.	Weft/Warp	Cloth Calculated.	Warp.	Weft.	Weft/Warp
0	1·08	1·77	0·01	0·004	1·14	1·79	0·01	0·005
5	1·18	1·32	0·96	0·73	1·15	1·25	0·98	0·78
10	1·18	1·37	0·89	0·65	1·10	1·21	0·90	0·74
17	1·07	1·16	0·94	0·81	1·13	1·21	1.00	0·83
24	1·16	1·26	1·00	0·79	1·21	1·26	1·11	0·88
31	1·15	1·23	1·03	0·84	1·17	1·24	1·06	0·85
38	1·16	1·26	1·01	0·80	1·18	1·24	1·07	0·86

It appears that by the analysis of the warp and weft of a cloth containing zinc chloride some indication of the previous conditions under which it was stored might be gained.

VI. QUALITATIVE TESTS.

(a) Zinc

Of the three tests for zinc described below the first, in which the reagents are spotted directly on to the cloth, is the most easily carried out and does not necessitate cutting the material; it is not, however, very sensitive and the other two tests are therefore generally more useful, and, of these, the diethylaniline test is the more convenient.

Spotting test. The coloration given by the successive addition of diphenylamine acetate and potassium ferricyanide was first used as a qualitative test for zinc by Cone and Cady[8], and was adapted as a spotting test for the presence of zinc soaps in cloth by Kehren[9]. The test is as follows.

Solution No. 1 : 1 g. diphenylamine, 2 c.c. glacial acetic acid, 18 c.c. water, and 80 c.c. 96 per cent. alcohol.

Solution No. 2 : 0·5 per cent. aqueous potassium ferricyanide.

One drop of solution No. 1 is placed on the cloth, followed by one drop of solution No. 2. In the presence of zinc a violet-black to green coloration is produced, with a violet ring round the drop. Iron gives a blue-green colour, but not a violet colour. The test is not sensitive to less than about 0·25 per cent. of zinc chloride on the weight of the cloth.

Electrolytic test. Neumann[14] showed that very small quantities of zinc could be detected by electrolytic deposition on a fine copper wire from an alkaline bath, and his test is conveniently applied as follows.

One gram of the material is worked for half a minute with 5 c.c. of boiling 0.5*N* sulphuric acid in a large test-tube, and as much as possible of the extract pressed out into a smaller test-tube and centrifuged; 1·5 c.c. of the solution is then transferred to a tube about 2½ inches long by ½ inch internal diameter, and 0·5 c.c. 5*N* potassium hydroxide is added, making the solution about 0·9*N* in free alkali. This alkaline solution is electrolysed between an anode consisting of a small platinum sphere and a cathode which

is a clean, fine copper wire dipping a few mm. below the surface ; the E.M.F. is 6 volts and the cell should be kept cool in a bath of water. If zinc is present a silver-white coating is deposited on the copper wire. The test is somewhat more sensitive if the 1·5 c.c. of acid extract is boiled to dryness and charred but not ashed. It is again boiled to dryness with a few drops of dilute sulphuric acid, boiled for a few seconds with 1·5 c.c. 0·5*N* sulphuric acid, poured into the electrolytic cell, 0·5 c.c. of 5*N* potassium hydroxide added and the solution electrolysed. This procedure eliminates hydrochloric and nitric acids, which affect the sensitiveness of the test.

The test is not affected by aluminium or magnesium, and in the first and simpler form gives positive results with 0·05 per cent. of zinc chloride in the presence of 2 per cent. of magnesium chloride, after not more than half an hour's electrolysis.

Diethylaniline test. This test was devised by Eegriwe[4] and may be applied to sized cotton goods as follows.

One g. of the material is digested for half a minute with 20 c.c. of 0·2*N* acetic acid. One c.c. of this extract is added to a mixture of 1 c.c. of a 0·125 per cent. solution of diethylaniline in equal volumes of concentrated sulphuric acid and water and 1 c.c. of a fresh 3 per cent. aqueous solution of potassium ferricyanide. When the amount of zinc is greater than corresponds with 0·05 per cent. of zinc chloride in the original material the solution becomes redder than a control consisting of the two reagents and 1 c.c. of water. If the cloth extract is filtered before adding to the mixed reagents the appearance of a cloudiness is a very sensitive test for zinc, revealing about 0·01 per cent. of zinc chloride, but such an increased sensitiveness is usually of no practical value.

(b) Magnesium

A test for magnesium as a constituent of the size in a warp or grey cloth must be semi-quantitative since all raw cottons contain magnesium in amounts equivalent to about 0·25 per cent. of magnesium chloride. Of the various colour tests that have been published those using tetrahydroxyanthraquinone[8] and Titan Yellow 2GS[1], respectively, have been found suitable. Both tests require the elimination of zinc, and of the two the latter is preferred as the colour changes are clearer and cover a wider range. They may be applied as follows.

One g. of the sized cotton is digested for half a minute with 20 c.c. of 0·2*N* acetic acid. Five c.c. of the extract are diluted with 1 c.c. of a 2 per cent. solution of hydrated sodium sulphide and 19 c.c. of water ; the addition of the sulphide renders the zinc innocuous without filtration being necessary. One c.c. of the diluted and zinc free solution is added to (a) 5 c.c. of 0·004 per cent. Titan Yellow 2GS in 0·1*N* sodium hydroxide, or (b) 1 c.c. of 0·01 per cent. 1.2.5.8.-tetrahydroxyanthraquinone (Alizarine Bordeaux) and 4 c.c. of 0·1*N* sodium hydroxide, and the colour is compared with that given by adding 1 c.c. of a magnesium sulphate solution containing 6·0 mg. of magnesium per litre to (a) or (b), respectively. This amount of magnesium corresponds with the mean amount present in raw cotton, which is taken as 0·25 per cent., expressed as magnesium chloride, and magnesium is present in the size if the test solution is (a) redder, or (b) bluer, than the control.

These tests and the diethylaniline test for zinc are conveniently carried out with the same cotton extract. They have been applied to a large

number of cloths that have either been analysed quantitatively or for which known size mixings have been used, and the results have been uniformly correct. Slight colour differences between the magnesium test solution and the control are naturally to be expected on account of the variable magnesium content of raw cottons, but this does not introduce practical difficulties since if magnesium chloride is included in a size mixing the amount added to the cloth will be considerable. The tests are not affected by calcium.

The Titan Yellow 2GS test can be used for distinguishing between normal American and normal Egyptian cottons in the grey state, since the former contain about 0·2 per cent. and the latter about 0·3 per cent. of magnesium expressed as the chloride. In such a test it is best to use as a standard a cotton which contains an intermediate amount of magnesium.

(c) Aluminium

Aluminium may be present in cotton goods as mordants, and can be detected by a test due to Eegriwe[8] which is conveniently applied as follows.

One g. of the material is digested for half a minute with 20 c.c. of 0·2*N* acetic acid. To 1 c.c. of the extract 1 c.c. of 0·1 per cent. Eriochromcyanine R is added and then 2*N* sodium hydroxide drop by drop until the solution is alkaline, as shown by the appearance of a purple colour, and finally one drop in excess : 0·2*N* acetic acid is then added drop by drop ; when about neutral the colour becomes yellow, with another one or two drops of acetic acid a further colour change towards red occurs, after which one or two more drops are added. In the absence of aluminium the colour is orange-red ; with increasing amounts of aluminium the colour becomes deeper and then bluer, until a precipitate is formed. The colour of the test solution is best compared with those obtained by the same procedure starting with (a) 1 c.c. of 0·2*N* acetic acid, and (b) 1 c.c. of 0·2*N* acetic acid containing 0·001 mg. of aluminium. There is a very sharp colour change between 0·001 mg. and 0·005 mg. of aluminium, and 0·005 per cent. of aluminium in cotton is thus readily detected.

Negative results are given by grey cloths containing china clay and zinc and magnesium salts but no soluble aluminium compounds. Iron gives coloration somewhat similar to that given by aluminium but not so intense ; thus 0·1 per cent. of iron added to a cloth gave a colour corresponding with between 0·01 and 0·02 per cent. of aluminium.

(d) China Clay

China clay is essentially an aluminium silicate, and either the aluminium or the silicic acid can be used to detect its presence. Thus the test just given for aluminium may be utilised in the following form.

Aluminium test. One g. of the material is ashed in a platinum dish, the ash ignited for five minutes, boiled to dryness with a drop of concentrated hydrochloric acid, and taken up in 50 c.c. of 0·1*N* hydrochloric acid. One c.c. of this extract is then tested for aluminium with Eriochromcyanine R as described above. The colour given by a test solution from a cloth free from china clay is paler than that given by 1 c.c. of 0·1*N* hydrochloric acid containing 0·005 mg. of aluminium, whilst that given by a cloth containing 1 per cent. of clay is deeper than this control.

Silicic acid test. The silicic acid content of china clay may be utilised by means of the yellow colour which it gives with molybdic acid[10]. Half a gram of the material is cut up and heated in a platinum dish with about 2 g. of sodium carbonate and 1 g. of potassium (or sodium) nitrate ; when

combustion is completed the mass is heated strongly until it is clear. It is then boiled out with water, and the extract made up to 50 c.c. Five c.c. are transferred to a test-tube and 1 c.c. of 10 per cent. ammonium molybdate and 5 c.c. of *N* sulphuric acid are added. An appreciable yellow colour indicates the presence of china clay. For safety the colour is compared with that given by grey cotton with no added silica, and for this purpose the test may be carried out as above with such a grey cotton, in which case any silica in the reagents is allowed for. If the reagents are known to be free from silica the control may be 1 c.c. of a picric acid solution containing 0·004 g. per 100 c.c. diluted with 10 c.c. of water; this corresponds in colour with 0·35 per cent. of clay in cotton. Six grey yarns of American, Egyptian and Indian origins gave colours corresponding with 0·13 to 0·22 per cent. of clay, and a deeper colour than that of the picric acid standard therefore indicates the presence of china clay.

(e) Fluorine

With the object of testing qualitatively for the presence of fluosilicates Tammann's[17] test for fluorine was applied to cotton, and the following procedure was found suitable.

The cotton, in pastille form, is wetted with 2 c.c. of 2*N* sodium hydroxide in a small platinum dish, and dried and ashed over a Bunsen burner. The ash is mixed with about an equal weight of powdered silica, and the mixture placed in a 8·5 by 1·8 cm. test-tube provided with a three-holed rubber stopper carrying three 4 mm. external diameter tubes for entrance and exit of air and for addition of sulphuric acid from a dropping funnel, respectively. Replacing the flask, as used by Tammann, by a tube diminishes the dead-space above the reaction mixture. The air exit tube is bent downwards and joined by a short rubber connection to a glass tube of 0·4 mm. external diameter. The whole apparatus must be thoroughly dry. After the apparatus is connected up, air, dried by two sulphuric acid wash bottles, is passed in at the rate of two or three bubbles a second, and a small test-tube containing water is raised under the air exit tube until the end of the latter dips slightly below the surface of the water; the water in this tube is renewed for each test. Concentrated sulphuric acid is then added slowly through the dropping funnel until the material to be tested and the end of the air inlet tube are covered. When the evolution of carbon dioxide has ceased the mixture is gently warmed with a micro-burner, and, if fluorine is present, a gelatinous precipitate is formed as a ring round the inside of the end of the air exit tube. Concentrated sulphuric acid reacts with fluosilicates with the formation of gaseous silicon tetrafluoride, which is decomposed by water with the deposition of silicic acid.

In this form the test gave a positive result with 2 g. of bleached cotton to which 0·1 mg. (0·005 per cent.) of fluorine had been added either as potassium hydrogen fluoride or as sodium fluosilicate, and a negative result with half this amount of fluorine. Ten g. of the bleached cotton alone gave a negative result, and it was concluded that this contained less than 0·1 mg. of fluorine, that is less than 0·001 per cent. If cotton to which fluorine had been added was boiled with dilute sodium hydroxide and the extract evaporated to dryness and tested, the reaction was less sensitive, but gave a positive result with 0·2 mg. of fluorine. The sensitiveness of the test was not increased by replacing ordinary concentrated sulphuric acid

(about 93 per cent.) by 100 per cent. acid, but it was considerably diminished if the acid was diluted to 80 per cent.

The application of this test to grey, unsized, cotton showed that detectable amounts of fluorine were present. Faint positive results, indicating about 0·1 mg. of fluorine, were obtained with 0·1 g. of a Broach cotton, 0·25 g. of Sakel, Texas and Tanguis cottons, and 0·5 g. of a Memphis cotton, corresponding with 0·1 per cent. of fluorine in the Broach, 0·04 per cent. in the Sakel, Texas and Tanguis, and 0·02 per cent. in the Memphis cotton. The amounts of sodium fluosilicate which may be added for antiseptic purposes correspond with as little as 0·1 per cent of fluorine in the cotton, and it is therefore concluded that a purely qualitative test cannot be used to detect such an addition.

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23—THE BEHAVIOUR IN CHEMICKING OF MATERIALS DYED WITH SOME VAT AND INSOLUBLE AZO DYES

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INTRODUCTION

In the course of the past few years several cases of coloured border goods in which the dyed yarn has been excessively tender have been submitted for report, the undyed cross threads immediately beneath being comparatively sound. Other cases have occurred in which the coloured border, after laundering, has disappeared almost completely, leaving an open-work effect. Figure 1 shows part of a laundered linen cloth actually submitted for examination. The cotton warp yarns in the wide border were dyed with Cibanone Orange R and have almost completely disappeared, those in the weft border were dyed with Indanthrene Golden Orange 3G. Examination of the small amount of warp yarn left gave a solubility number[1] of 19·2, whereas the value for the cotton sewing thread was found to be 7·4.

It was noticed that such tendering was associated in general with yellow and orange vat dyes, though some reds were found to cause the trouble. The fact that the excessive tendering was in all cases confined to the dyed yarn suggested that the dyestuff was responsible and an investigation was undertaken of the conditions under which the trouble occurred, particularly from the point of view of the linen bleacher.

In the examination of many of the samples submitted the sewing thread was found to be comparatively sound and this suggested that most of the tendering of the dyed yarn occurred during the bleaching.

It has been shown[2] that in the bleaching of undyed cotton cellulose with hypochlorite solutions the greatest degradation is produced in the region of the neutral point and that in very alkaline solutions there is comparatively little degradation. It was reasonable to suppose that dyed cellulose might behave similarly, but the bleaching of linen goods may become inconveniently slow if very alkaline liquors are employed. In order to discover a safe lower limit of *p*H at which such goods woven with coloured borders could be bleached without undue degradation of the dyed yarn, experiments were carried out in which the yarns were treated with a range of chemics buffered at various *p*H values and the extent of degradation of the cellulose determined by the solubility number method.[1]

PREPARATION OF THE DYED SAMPLES

Since dyed cotton is largely used for the coloured borders of linen goods the present work was confined to cotton, but it is hoped to include linen yarn in later work. A range of vat and insoluble azo (Naphthol AS) dyes was tested.

Depth of Dyeing

Vat Colours. Since the concentration of the vat dye pastes supplied by the various colour makers varies according to the different dyestuffs from 5-15 per cent. or more, the yarn was dyed in the present work to a 15 per cent. shade calculated on a 10 per cent. dye paste.

Naphthol Colours. The depth of these was chosen to correspond as far as possible with the medium shades on the manufacturers' pattern cards.

2/24's grey cotton yarn was used and dyed throughout at a liquor ratio of 20 : 1. After dyeing the yarn was soaped at the boil for half an hour in the following solution :—

0·1 per cent. Soda Ash.

0·3 per cent. Soap (Textile Flakes).

This soaping treatment was given to both the vat and the naphthol dyed yarns.

The undyed yarn used as a control was given :

(*a*) the vat dye process ;

(*b*) the naphthol process.

Subsequent results indicated that yarn treated by either process behaved in the same way.

PREPARATION OF THE CHEMICS

Sodium hypochlorite stock liquor was diluted with water to give an *N*/25 or " 10 bottles "* solution. With the water was included a sufficient quantity of dilute sulphuric acid (0·181 *N*) to give as nearly as possible the same colour on the filter paper spot test,[8] using B.D.H.universal indicator, as that given by a standard buffer mixture of the required *p*H value. Another solution was then made up using the standard buffer mixture in place of water and the requisite amount of acid added. The buffered and unbuffered chemics were then compared by the spot test and the amount of acid adjusted if necessary (by making up fresh solutions) in order to give an exact colour match. The colour given by the buffered chemic was not altered by the addition or removal of small amounts of acid, whereas noticeable changes were produced in the colour given by the unbuffered chemic. Further it was shown that in cases where it was necessary to make a final adjustment of the amount of acid added in order to produce an exact colour match, this amount of acid when added separately to the same quantity of the respective buffer standard produced only a very small change in the *p*H value as measured by the B.D.H. capillator.

The following examples illustrate the method of procedure :—

Total volume of chemic = 500 c.c.

pH 7·0

Volume of 0·181 *N* sulphuric acid required to give a colour match on the spot test with Sörensen phosphate buffer *p*H 7·0 = 50 c.c.

The buffered and unbuffered chemics containing this volume of acid gave identical colours and therefore no final adjustment of the volume of acid was necessary.

pH 5·5

Volume of 0·181 *N* sulphuric acid required to give an approximate colour match on the spot test with Walpole's acetate buffer *p*H 5·5 = 72·5 c.c.

Total amount of acid required to produce a match between the buffered and the unbuffered chemics = 85 c.c.

∴ extra acid required = 12·5 c.c.

This volume of acid added to 500 c.c. of the standard buffer mixture *p*H 5·5 gave a solution of *p*H 5·35 measured by the B.D.H. capillator method.

pH 9·5

Volume of acid required to give an approximate match with Sorensen phosphate buffer *p*H 9·5 = 15-20 c.c.

Total volume of acid required to produce a match between the buffered and the unbuffered chemic = 17·5 c.c.

* It is convenient to refer to the strength of a chemic in " Bottles " (originally the number of carboys of stock liquor necessary to make a kieve up to the required strength) A chemic of one " Bottle " strength contains 0·142 grams of available chlorine per litre.

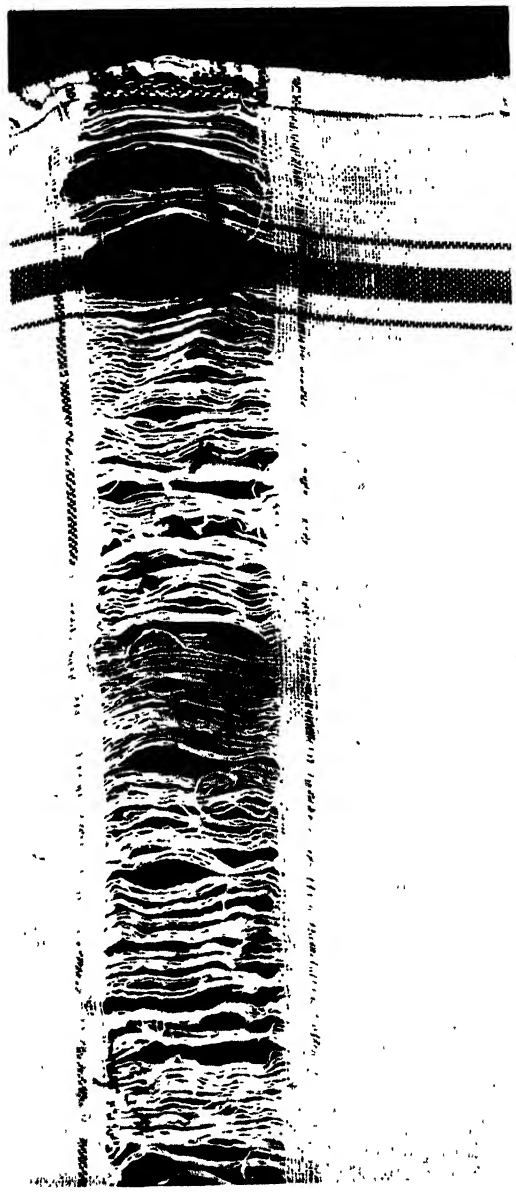

Fig. 1

5 c.c. of acid when added to 500 c.c. of the standard buffer mixture *p*H 9·5 gave a solution of *p*H 9·4-9·5 as measured by the capillator method.

The values for the total amounts of acid required plotted against *p*H values gave a smooth curve with an inflection characteristic of the neutralisation curve of a weak acid.

The determination of the *p*H of the diluted stock liquor, i.e., without the addition of acid, was found to be about 11·3 by the rate of discharge of Thymol Violet when added to the solution compared with chemics buffered in the region of 11·0-11·5.

The *p*H values employed were 4·5, 5·5, 7·0, 7·5, 8·0, 9·5, 10·5, 11·5.

The standard buffer mixtures employed are given in the following table.

Table I

*p*H	Buffer Mixture.
4·5 5·5	Walpole's Sodium Acetate—Acetic acid
7·0 7·5 8·0	Sörensen's Phosphate.
9·5 10·5 11·5	Sorensen's Borate—Caustic Soda.

DETAILS OF THE CHEMICKING

Two grams of the yarn were chemicked in 200 c.c. of solution at 20° C. for 4½ hours.

(*a*) in the dark in covered Thermos flasks ;

(*b*) in open dishes surrounded by water at 20° C. and illuminated by diffuse daylight in front of a window. Some preliminary experiments were made by chemicking the yarn in glass flasks suspended in water in a thermostat at 20° C. and illuminated by a Lamplough Daylight lamp run at a constant current. Certain vat-dyed yarns, however, showed very little tendering under this treatment while in diffuse daylight a noticeable effect was produced. Apparently the daylight lamp is deficient in certain of the necessary rays which are present in daylight and the lamp was therefore abandoned in favour of diffuse daylight.

The solubility numbers found at the various *p*H values in the dark and in daylight for some of the dyed yarns tested are given in the following tables and curves.

Table II—Indanthrene Rubine R.

Strength of Chemic = 10·2 Bottles.

*p*H	Solubility Number	
	Dark	Daylight
4·5	2·2	34·8
5·5	2·0	42·2
7·0	11·3	45·9
7·5	11·5	45·3
8·0	10·8	44·2
9·5	1·9	40·5
10·5	1·5	33·3
11·5	1·2	4·5

Unchemicked yarn = 0·9

These results are shown graphically in Fig. 2.

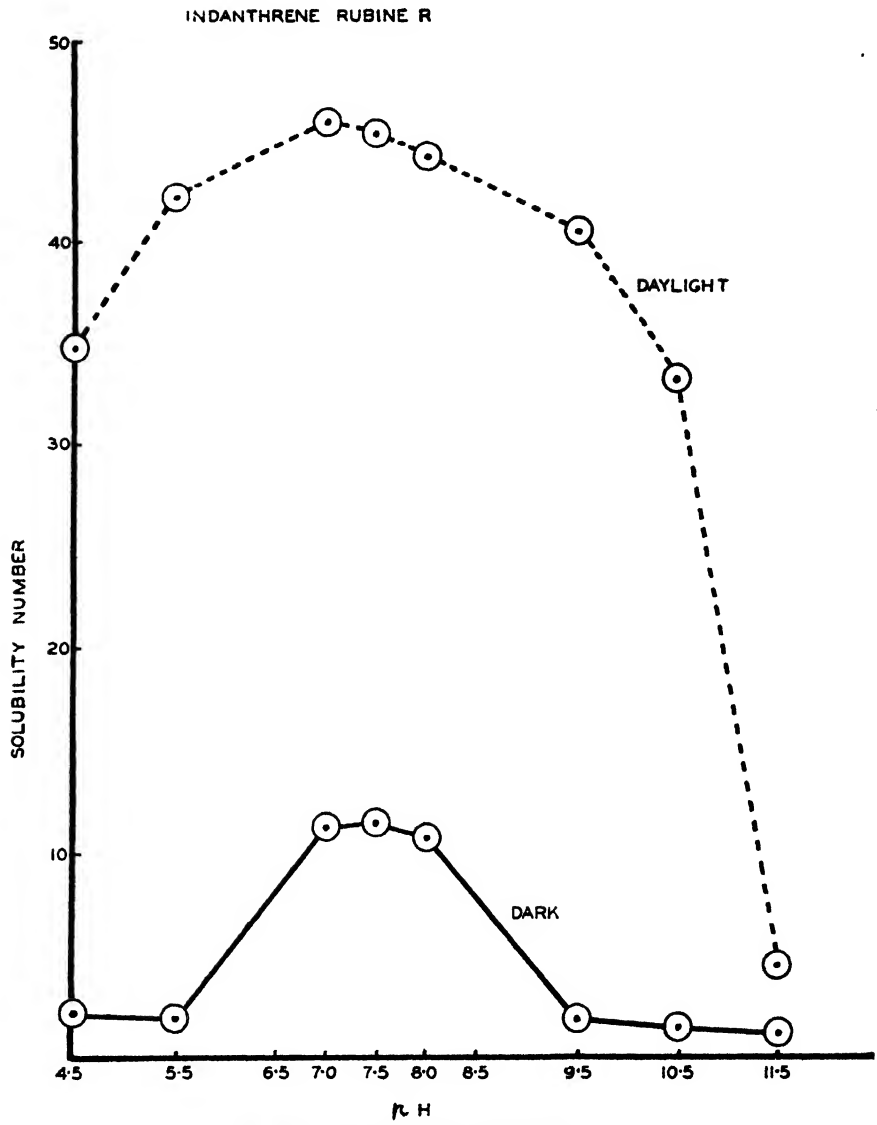

Fig. 2—Indanthrene Rubine R

Table III—Undyed

Strength of Chemic = 10·2 Bottles.

*p*H	Solubility Number	
	Dark	Daylight
4·5	1·9	4·5
5·5	2·0	4·6
7·0	12·0	15·5
7·5	11·8	14·5
8·0	8·4	10·7
9·5	1·5	1·4
10·5	1·2	1·3
11·5	1·0	1·1

Unchemicked yarn = 1·0

These results are shown graphically in Fig. 3.

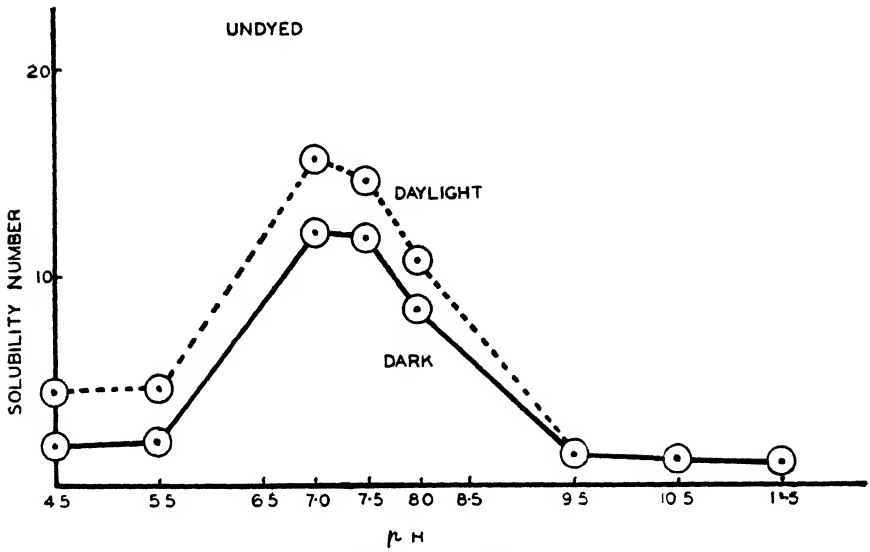

Fig. 3—Undyed

It was observed that while the *p*H values of the chemics after treating the yarns in daylight remained approximately constant up to *p*H 8·0, the remainder decreased somewhat owing to absorption of carbon dioxide by the caustic soda of the borate—caustic soda buffer mixtures used—*p*H 9·5 fell to between 9·0 and 9·5, 10·5 fell to 9·8-10·0, and 11·5 to 10·5-11·0.

Table IV—Indanthrene Golden Orange 3G.

Strength of Chemic = 10·1 Bottles.

*p*H	Solubility Number	
	Dark	Daylight
4·5	1·7	14·0
5·5	1·9	10·1
7·0	9·6	20·8
7·5	9·5	20·3
8·0	6·6	15·5
9·5	1·7	2·3
10·5	1·6	1·5
11·5	1·5	1·5

Unchemicked yarn = 1·1.

These results are shown graphically in Fig. 4.

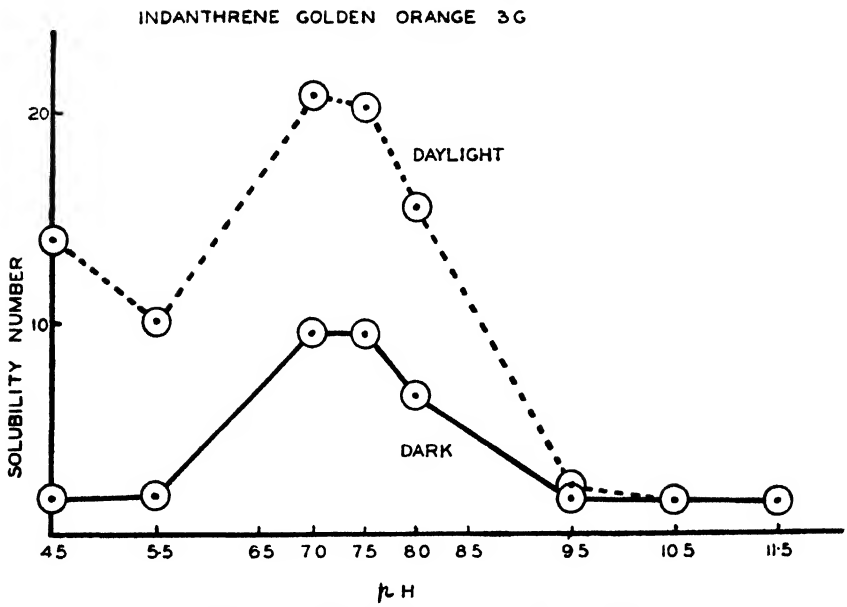

Fig. 4—Indanthrene Golden Orange 3G

Table V—Caledon Gold Orange GS.
Strength of Chemic = 10·2 Bottles.

*p*H	Solubility Number	
	Dark	Daylight
4·5	1·5	31·6
5·5	2·2	34·2
7·0	11·5	51·5
7·5	11·1	50·7
8·0	8·3	42·1
9·5	1·5	8·4
10·5	1·0	6·6
11·5	0·8	3·7

Unchemicked yarn = 0·8.

These results are shown graphically in Fig. 5.

Table VI—Gold Orange from Naphthol AS-G (2·0 g.p.l.) and Fast Red Salt (AL 5·0 g.p.l.)
Strength of Chemic = 10·2 Bottles.

*p*H	Solubility Number	
	Dark	Daylight
4·5	1·5	5·3
5·5	2·2	8·1
7·0	12·5	25·1
7·5	13·0	20·9
8·0	7·0	15·6
9·5	1·5	2·0
10·5	1·2	1·2
11·5	1·1	1·1

Unchemicked yarn = 1·1.

These results are shown graphically in Fig. 6.

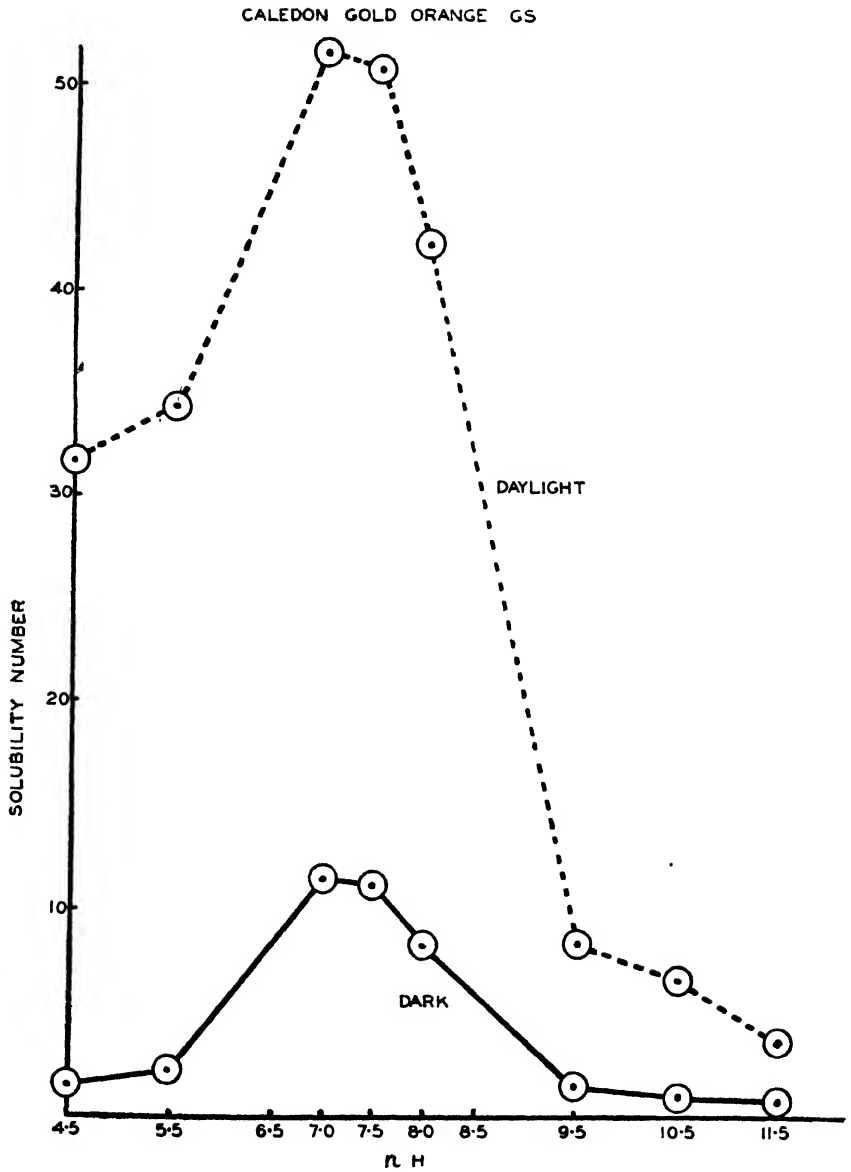

Fig. 5—Caledon Gold Orange GS

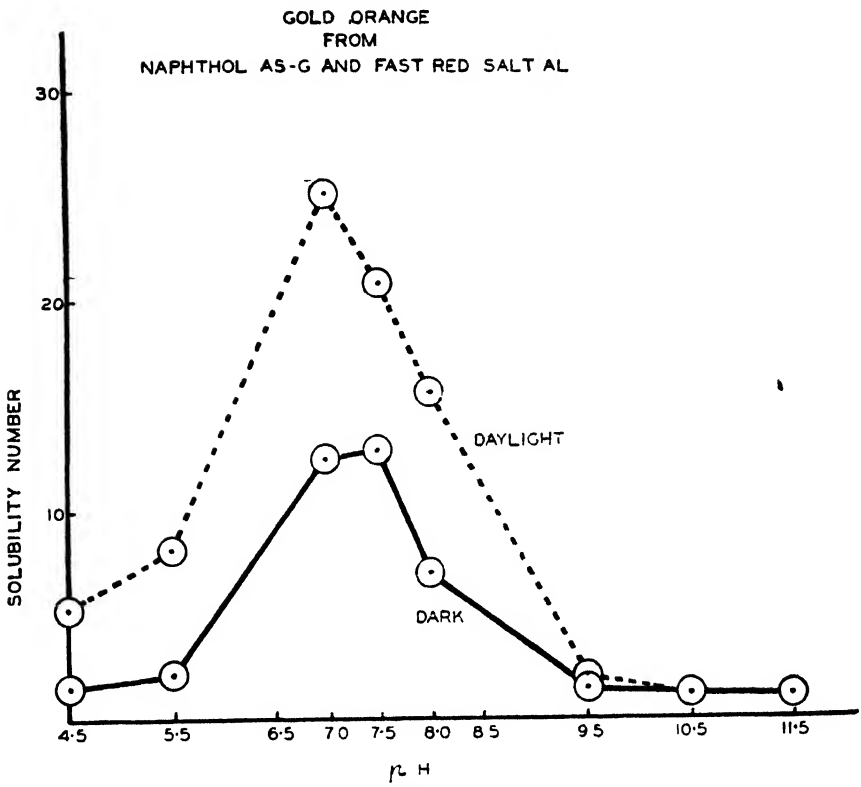

Fig. 6—Gold Orange from Naphthol AS-G and Fast Red Salt AL

Table VII—Caledon Yellow GS.
Strength of Chemic = 10·2 Bottles.

*p*H	Solubility Number	
	Dark	Daylight
4·5	1·5	37·1
5·5	1·9	44·6
7·0	12·7	47·9
7·5	12·3	41·7
8·0	10·5	36·5
9·5	1·7	12·7
10·5	1·2	7·0
11·5	1·0	2·4

Unchemicked yarn = 0·9.

These results are shown graphically in Fig. 7.

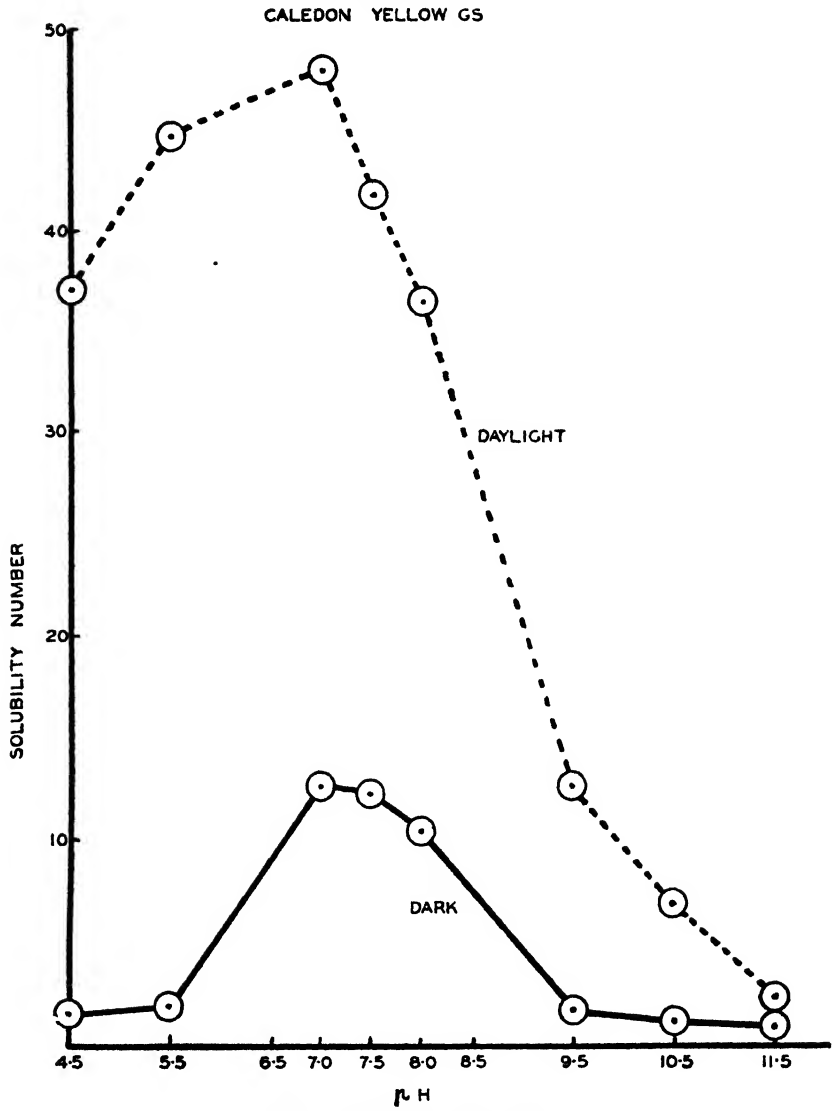

Fig. 7—Caledon Yellow GS

Table VIII—Cibanone Yellow R.
Strength of Chemic = 10·1 Bottles.

*p*H	Solubility Number Dark	Daylight
4·5	1·5	40·2
5·5	2·0	42·0
7·0	11·3	50·0
7·5	11·0	48·2
8·0	9·3	46·0
9·5	1·6	16·5
10·5	1·2	12·3
11·5	1·2	7·3

Unchemicked yarn = 1·2.

These results are shown graphically in Fig. 8.

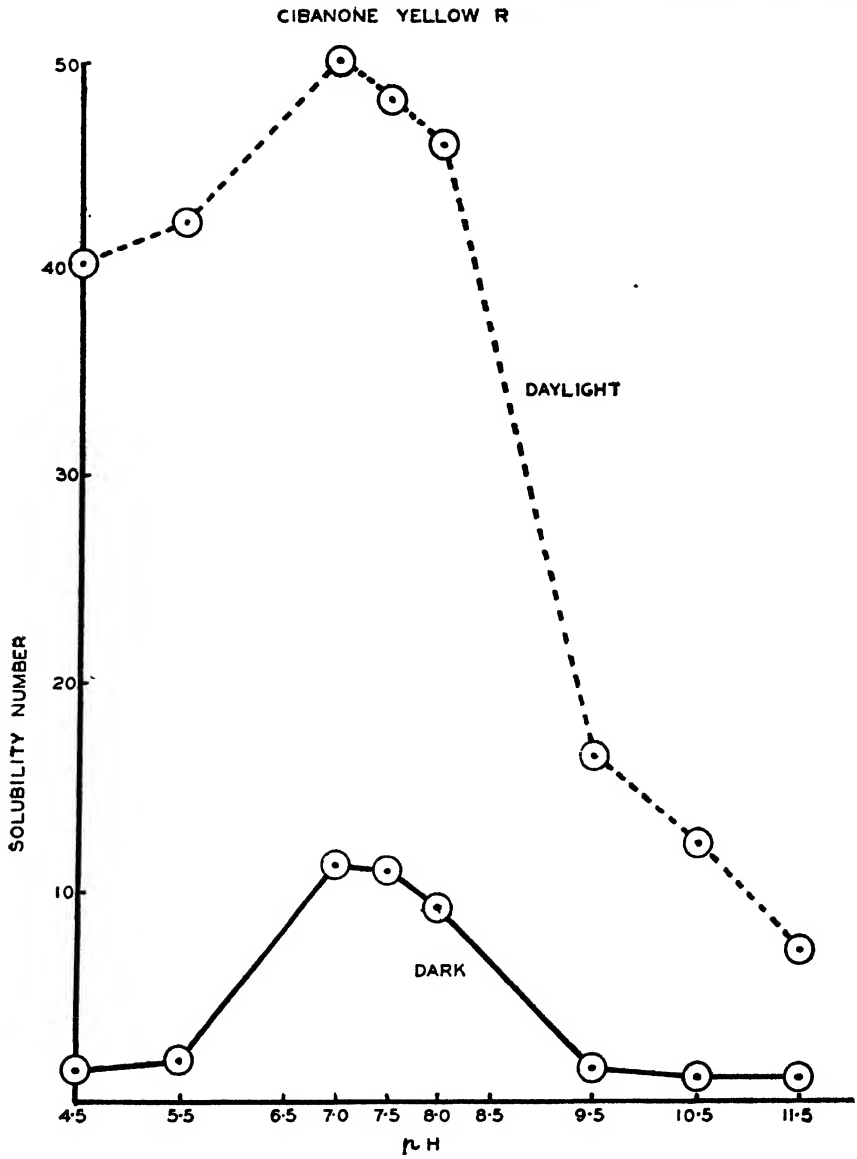

Fig. 8—Cibanone Yellow R

Table IX—Yellow from Naphthol AS-G (1·3 g.p.l.) and Fast Red KB Base (1·4 g.p.l.)

Strength of Chemic = 10·1 Bottles.

*p*H	Solubility Number	
	Dark	Daylight
4·5	1·2	3·2
5·5	1·2	2·5
7·0	10·5	11·7
7·5	11·3	11·8
8·0	7·1	7·1
9·5	1·0	1·2
10·5	0·8	0·8
11·5	0·8	0·8

Unchemicked yarn = 0·8.

These results are shown graphically in Fig. 9.

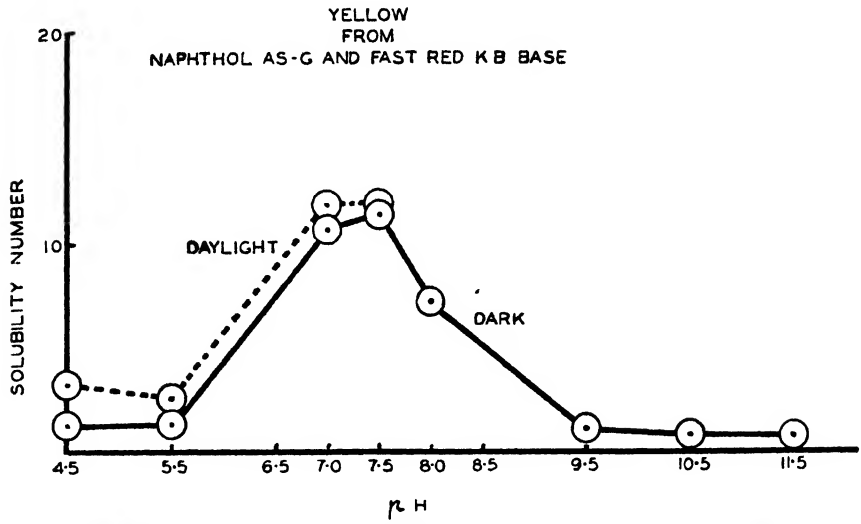

Fig. 9—Yellow from Naphthol AS-G and Fast Red KB Base

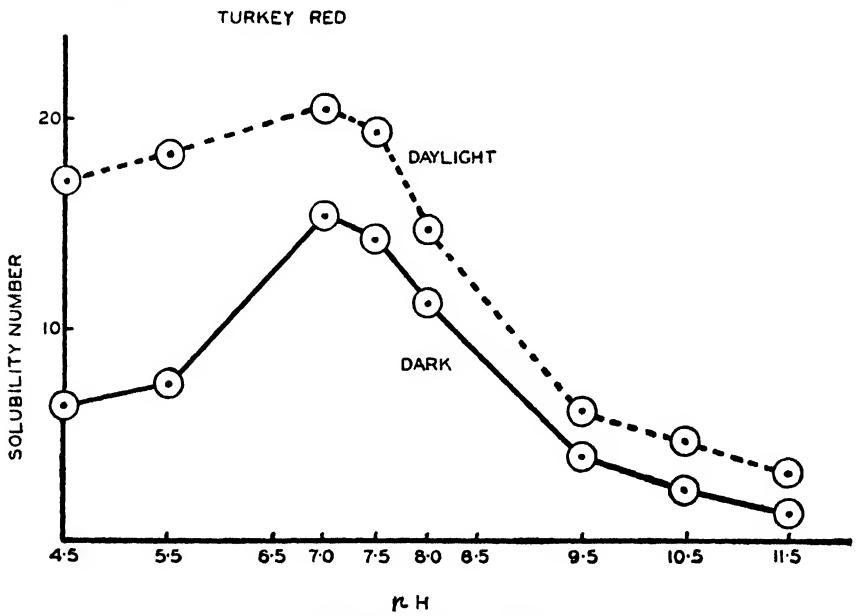

Fig. 10—Turkey Red

A sample of Turkey Red was also included dyed on the same yarn at the works. The colour was completely bleached both in the dark and in daylight at *p*H 4·5, 5·5 and 7·0 (somewhat more rapidly at *p*H 4·5 than at *p*H 7·0). The colour was very largely destroyed at *p*H 7·5 and was quite appreciably paler at *p*H 8·0. It was, however, practically unaltered at *p*H 9·5 and higher.

The results of the solubility number determinations are given in Table X.

Table X—Turkey Red

Strength of Chemic = 10·2 Bottles.

*p*H	Solubility Number	
	Dark	Daylight
4·5	6·3	17·0
5·5	7·5	18·3
7·0	15·4	20·5
7·5	14·3	19·4
8·0	11·3	14·7
9·5	4·0	6·1
10·5	2·4	4·7
11·5	1·3	3·2

Unchemicked yarn = 1·3.

These results are shown graphically in Fig. 10.

EFFECT OF DEPTH OF DYEING ON TENDERING

In order to determine the influence of the depth of dyeing on the tendering effect in daylight, a range of dyeings with Indanthrene Rubine R was made from ½ per cent. to 15 per cent. calculated on a 10 per cent. paste. These were chemicked at the neutral point together with the undyed yarn. The results are given in Table XI.

Table XI—Effect of Depth of Dyeing on the Tendering of Yarn dyed with Indanthrene Rubine R.

Strength of Chemic = 10·2 Bottles.

Depth of Dyeing.	Solubility Number
Undyed	14·4
0·5%	23·3
1·0%	26·3
1·5%	30·5
2·5%	39·6
5·0%	40·9
10·0%	42·7
15·0%	46·1

Owing to variation in intensity of the daylight on different days the foregoing dyestuffs cannot be compared strictly with one another. A number of dyes at different colours, therefore, were chemicked at *p*H 7·0 at the same time in daylight together with the undyed yarn and a sample of yarn dyed with Indanthrene Golden Orange 3G to act as an indicator dye.

The results are given in the following tables :—

Table XII—Red Dyestuffs

Strength of Chemic = 10·1 Bottles.

Dyestuff	Solubility Number
Caledon Red 2 GS	51·5
Indanthrene Rubine R	45·3
Turkey Red	23·0
Caledon Red BNS	17·7
Naphthol AS 3·75 g.p.l	11·5
Fast Red Salt AL 5·0 g.p.l.	

Table XII—*Continued*

Dyestuff	Solubility Number
Naphthol AS-TR 3·75 g.p.l. ... ... / Fast Red Salt TR 8·0 g p.l.	11·1
Naphthol AS-D 3·75 g.p.l. ... ... / Fast Bordeaux Salt GP 8·0 g p.l.	10·5
Naphthol AS-ITR 3·75 g.p.l. ... ... / Fast Red Base ITR 1·6 g p.l.	8·4
Undyed	15·6
Indanthrene Golden Orange 3G	22·9

Table XIII—Orange Dyestuffs

Strength of Chemic = 10·1 Bottles.

Dyestuff	Solubility Number
Cibanone Orange R	49·4
Caledon Gold Orange GS	49·3
Indanthrene Brill. Orange GK	48·4
Caledon Orange 4RS	42·2
Naphthol AS-G 2·0 g.p.l. ... ... / Fast Red Salt AL 5·0 g p l.	23·1
Naphthol AS-G 2·0 g p l. ... ... / Fast Bordeaux Salt GP 8·75 g p.l.	10·5
Naphthol AS 3·75 g p l. ... ... / Fast Orange Salt GC 5·5 g p.l.	9·5
Undyed	14·8
Indanthrene Golden Orange 3G	20·8

Table XIV—Yellow Dyestuffs

Strength of Chemic = 10·2 Bottles.

Dyestuff	Solubility Number
Cibanone Yellow R	51·0
Caledon Yellow GS	46·6
Anthraflavone GC	41·4
Indanthrene Yellow FFRK	39·2
Caledon Yellow 3GS	24·8
Naphthol AS-G 1·5 g.p.l. ... ... / Fast Scarlet Salt 2G 5·5 g.p l.	16·7
Chrysophenine (direct)	16·1
Naphthol AS-G 1·3 g p.l. ... ... / Fast Red KB Base 1·4 g.p.l....	14·4
Undyed	15·6
Indanthrene Golden Orange 3G	23·0

The direct dyestuff Chrysophenine (1 per cent. shade) was included for comparison purposes. Its shade is somewhat similar to that of Caledon Yellow GS.

Table XV—Green Dyestuffs
Strength of Chemic = 10·2 Bottles.
The three green mixtures were also chemicked in the dark, with the results shown.

Dyestuff	Solubility Number	
	Daylight	Dark
Caledon Jade Green XS 7½%... ...	43·4	13·9
Caledon Yellow GS 7½%		
Caledon Jade Green XS 7½%... ...	31·1	12·5
Indanthrene Yellow FFRK 7½% ...		
Anthraflavone GC 7½%...	14·0	6·8
Caledon Blue GCDS 7½%		
Naphthol AS-GR 1·1 g.p.l.	13·8	—
Fast Blue Salt 2B 1·0 g.p.l.		
Caledon Jade Green XS	13·3	—
Undyed	15·0	—
Indanthrene Golden Orange	21·6	—

All three green mixtures yellowed to approximately the same extent in the dark as in the light. Caledon Jade Green became appreciably paler and duller. Naphthol AS-GR — Fast Blue Salt 2B combination became considerably flatter and weaker.

Table XVI—Black Dyestuffs
Strength of Chemic = 10·2 Bottles.

Dyestuff	Solubility Number
Caledon Black 2BS	28·9
Naphthol AS-SG 4·8 g.p.l.	5·5
Fast Red B Salt 5·5 g.p.l.	
Undyed	15·0
Indanthrene Golden Orange 3G	21·6

Table XVII—Blue and Violet Dyestuffs
Strength of Chemic = 10·1 Bottles.

Dyestuff	Solubility Number
Naphthol AS 1·5 g.p.l....	17·1
Fast Blue Salt 2B 3·2 g.p.l.	
Caledon Blue GCDS	7·4
Caledon Blue RCS	7·4
Caledon Brilliant Purple 4RS	37·0
Naphthol AS 1·0 g.p.l....	10·5
Fast Violet B Salt 2·5 g.p.l.	
Undyed	13·6
Indanthrene Golden Orange 3G	19·2

Table XVIII—Brown Dyestuffs
Strength of Chemic = 10·1 Bottles.

Dyestuff	Solubility Number
Caledon Brown RS	18·1
Naphthol AS-LB 2·0 g.p.l.	9·3
Fast Scarlet Salt 2G 4·4 g.p.l.	
Naphthol AS-LB 2·0 g.p.l.	9·0
Fast Red Salt TR 4·5 g.p.l.	
Undyed	15·4
Indanthrene Golden Orange 3G	21·4

Reference to the yellow and orange dyeings chemicked through a range of *p*H values makes it clear that in the dark the tendering is of the same order as that shown by the undyed yarn. In order to verify this point in connection with some of the other colours tested and especially those naphthol combinations which in the light gave a lower solubility number than that given by the

undyed yarn, several of these dyeings were chemicked in the dark at *p*H 7·0 and the values obtained for the solubility number are given in the following table together with those already obtained in daylight.

Table XIX—Comparison of Effect of Chemicking at *p*H 7·0 in the dark and in daylight

Strength of Chemic = 10·1-10·2 Bottles.

Dyestuff	Solubility Number	
	Dark	Daylight
Caledon Brilliant Purple 4RS ...	15·6	37·0
Caledon Jade Green XS	12·4	13·3
Naphthol AS-ITR 3·75 g.p.l	7·1	8·4
Fast Red Base ITR 1·6 g.p.l ...		
Caledon Blue GCDS	7·1	7·4
Black from Naphthol AS-SG 4·8 g.p.l	4·7	5·5
Fast Red Salt B 5·5 g.p.l		
Caledon Brown RS	10·0	18·1

THE EFFECT OF COLOURED GLASS SCREENS DURING CHEMICKING

A set of experiments was made comparing the effect of amber and ruby glass screens during the chemicking in daylight of Indanthrene Rubine R and of Caledon Yellow GS, both of which show excessive tendering without the screens. The experiments were carried out at the neutral point, the glass screens being placed over the respective dishes. The results are given in Table XX.

Table XX—Effect of Coloured Glass Screens during Chemicking

Dyestuff	Solubility Number		
	Open	Amber Glass	Ruby Glass
Indanthrene Rubine R	47·9	38·2	35·8
Caledon Yellow GS	47·9	21·9	12·1

DISCUSSION OF RESULTS AND SUMMARY

From the results obtained by chemicking in daylight and in the dark, the excessive tendering effect shown in daylight by the majority of the red, orange, and yellow vat dyes examined appears to be a photo-catalytic phenomenon, the dyestuff behaving in a manner analogous to that of a photographic sensitiser. The use of the term " catalytic " appears justified, as the shade of the dyestuff does not normally become appreciably paler even when excessive tendering is produced. In the dark the tendering is of the same order as that shown by the undyed yarn. Most of the red, orange, and yellow vat dyes tested appear to be capable of absorbing active light rays of short wave-length and making them available for the activation of the hypochlorite. Of these dyestuffs the following produced the least tenderin effect: (1) Caledon Red BNS; (2) Indanthrene Golden Orange 3G; (3) Caledon Yellow 3GS.

Caledon Jade Green XS produced an effect of similar order to that given by the undyed yarn while Caledon Blue RCS and GCDS exert a definite protective effect.

The tendering shown by the Naphthol AS-G—Fast Red Salt AL combination is of the same order as that shown by Indanthrene Golden Orange 3G, while the other naphthol combinations tested show no appreciably greater tendering than does the undyed yarn, several in fact exert a protective effect. Chrysophenine, a direct dyestuff, was included for comparison. Its shade is similar to that of Caledon Yellow GS but it shows no appreciably greater tendering than does the undyed yarn.

The explanation of the different behaviour of the naphthol combinations tested compared with the vat dyestuffs is not apparent. As in photographic sensitisation all dyestuffs do not possess sensitising properties, it may be that the majority of the orange and yellow naphthol combinations are unable to re-emit or make available these rays for the activation of the hypochlorite, even though from their colour they must absorb rays of short-wave-length.

The region of maximum tendering both in the light and in the dark, is in the neighbourhood of the neutral point, viz., between *p*H 7·0 and *p*H 7·5. With most of the red, orange, and yellow vat dyes tested, the tendering in the light at *p*H values on the acid side of the neutral point is excessive, but in all cases less than at the neutral point, while comparatively little degradation occurs in chemics as alkaline as *p*H 11·5.

Indanthrene Rubine R produces increased tendering at *p*H 7·0 as the depth of dyeing is increased. The difference, however, between the tendering of the undyed yarn and that dyed with 0·5 per cent. is greater than that shown between 0·5 per cent. and 1·0 per cent. The tendering effect of this dyestuff in a 15 per cent. shade at *p*H 7·0 is reduced only to a small extent by coloured glass screens (yellow and red). These screens, however, greatly reduce the tendering of Caledon Yellow GS, the degradation under the red glass being of the same order as that shown in the dark by this dyestuff.

The green mixtures tested all show a certain yellowing at *p*H 7·0 both in the dark and in the daylight. The comparatively fast to light Anthraflavone GC-Caledon Blue GCDS is the only mixture tested which does not tender in daylight. It exerts quite a definite protective action in the dark of the same order as that shown by the blue alone.

It is recommended that for the safe bleaching of coloured border goods with hypochlorite a liquor of reaction not less alkaline than *p*H 10·0 throughout the whole period of chemicking should be employed, i.e., it should give a slight purple rim in the spot test. If it does become less alkaline during the course of bleaching, soda ash should be added until the purple rim is obtained. With some of the vat dyes tested, for example, Indanthrene Rubine R, and Cibanone Yellow R, unduly great tendering occurs, in presence of light, at *p*H values even higher than 10·0, and it is unwise to use such dyestuffs in goods which have to be bleached.

While the excessive tendering effect shown in this work may be produced in presence of light during the original bleaching, the effect is quite liable to occur with these dyestuffs during laundering of goods woven with yarns dyed with them, particularly when bleach liquor is used. No data have, however, yet been obtained relative to the standard "bleach in the boil" process recommended by the British Launderers' Research Association and work is proceeding along these lines. Light exposure tests have been made of linen materials dyed with some of the dyestuffs referred to in the present work, and it is hoped to compare the results in a forthcoming paper.

Most of the solubility number determinations were made by Miss C. P. Macoun.

June, 1932.

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24—SOME OBSERVATIONS ON THE *p*H VALUES OF HYPOCHLORITE SOLUTIONS

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The stock solutions employed for the preparation of sodium hypochlorite liquors in bleaching are usually strongly alkaline owing to the presence of caustic soda. In the case of stock solutions prepared from bleaching powder and soda ash the caustic soda is derived by the interaction of the soda ash with the caustic lime present in the bleaching powder. In the case of solutions prepared from chlorine gas and caustic soda, the latter is intentionally left in excess, while with solutions prepared electrolytically it may be intentionally added in order to increase the stability of the solution.

The quantity of excess alkali in such solutions may be determined by titration with standard acid after the hypochlorite, which would bleach the indicator, has been destroyed by the addition of neutral hydrogen peroxide, Metyhl red is commonly used as indicator in this titration.

It must be remembered, however, that pure sodium hypochlorite crystals would give a definitely alkaline solution when dissolved in water. For hypochlorous acid is a weak acid with a dissociation constant of the order of 10^{-8} and sodium hypochlorite is considerably hydrolysed.

$$NaOCl + H_2O \rightleftharpoons NaOH + HOCl.$$

For this reason a solution of sodium hypochlorite from which the *excess* alkali (i.e., the alkali present in excess of that which would naturally arise from the above hydrolysis) had been removed would not be neutral but would have a *p*H value considerably greater than 7·0 at dilutions commonly employed in bleaching. Thus, assuming a dissociation constant of $1{\cdot}0 \times 10^{-8}$ for hypochlorous acid, it may be calculated that the *p*H value of a pure sodium hypochlorite solution, at $N/25$ strength as regards available chlorine, would be about 10·15. Strictly speaking, therefore, in titrating a stock solution after decomposition with hydrogen peroxide, in order to determine the excess of alkali present, the acid should be added until the *p*H value corresponding with the alkalinity which would be produced by hydrolysis, at the particular strength of solution which is being titrated, is obtained. For practical purposes, however, as long as merely a measure of the excess alkali in stock solutions is required, this is not an important distinction as a very small further quantity of decinormal acid will shift the *p*H value of the solutions that is being titrated from, say, *p*H 10·15 to *p*H 7·0, provided of course that buffer substances are absent.*

The excess alkali present in hypochlorite solutions of strengths actually employed in bleaching is comparatively small even in fresh liquors, and here the *p*H value becomes of importance. The *p*H value of such solutions is not easy to determine, on account of the bleaching action of the hypochlorite on indicators. It cannot, in general, be determined by measurement after the hypochlorite has been destroyed by addition of hydrogen peroxide, a method which might immediately suggest itself. This is because the interaction of hypochlorous acid and hydrogen peroxide produces hydrochloric

* Buffer substances, e.g. sodium bicarbonate and the sodium salts of organic acids may be present in liquors which have been used for the treatment of goods.

acid.* If, for example, the *p*H value of a pure sodium hypochlorite solution is actually 8·0, about half the hypochlorous acid will be present as the free acid and half as hypochlorite, if $pK_A = 8{\cdot}0$. The amount of hydrochloric acid produced by the decomposition of this free hypochlorous acid is enough to render the solution very definitely acid, for example, of *p*H value 5·0, at strengths of solution commonly employed in bleaching.

Even when the liquor is initially sufficiently alkaline to give a distinct pink colouration with phenol phthalein-solution a *p*H value of 5·5 may be found after decomposition with hydrogen peroxide.

A similar difficulty does not arise in the *titration* of the *excess* alkali in typical stock liquors. Here the degree of hydrolysis of the sodium hypochlorite is negligible owing to the high alkalinity and there is practically no free hypochlorous acid.

In the case of very dilute and fairly strongly alkaline solutions the *p*H value may be determined with fair accuracy by the use of indicators after decomposition with hydrogen peroxide. At *p*H 11·0, for example, only about one-thousandth of the hypochlorous acid will be present as free acid and the amount of hydrochloric acid produced by decomposition is very small.

From the hydrolysis equation given above, and the fact that HOCl→HCl on decomposition with hydrogen peroxide, it will be seen that if a neutral reaction is obtained with indicators after the decomposition, the conclusion may be drawn that the alkalinity of the solution, before decomposition, must have corresponded with the natural alkalinity produced by hydrolysis. For a pure sodium hypochlorite solution which is $N/25$ as regards available chlorine, a neutral reaction after decomposition must indicate a *p*H value of about *p*H 10·15 before decomposition.†

There is another important consequence of the presence of considerable quantities of free hypochlorous acid in sodium hypochlorite solutions at *p*H values not too far removed from the neutral point (say *p*H 5·0 to *p*H 10·0). In oxidising the material which is being bleached this hypochlorous acid‡ gives up its oxygen and hydrochloric acid is thereby formed. In the past it appears that in attempts to account for the decrease in *p*H value observed as bleaching progresses less emphasis has been placed on this effect than on the formation of acid oxidation products.

TEST FOR THE REACTION OF CHEMICS

The following test for the reaction of chemics is believed to be the most reliable simple test at present available. With experience, and by comparison with the results obtained with buffered chemics of known reaction, it appears to give results reliable to within one *p*H unit over the range *p*H 5·0 to 10·0. It is much to be preferred to the hydrogen peroxide decomposition method over this range.

* When a buffered solution is prepared, the quantity of acid required to neutralise the excess alkali in the stock liquor being added, but not the further quantity of acid required to overcome the hydrolysis alkalinity, the *p*H value found by indicators after decomposition with peroxide is commonly very nearly the initial *p*H value of the buffer solution used. The buffered chemic so prepared has, however, actually a higher *p*H value than that of the buffer solution used. The hydrochloric acid produced on decomposition and the hydrolysis alkalinity in this case balance each other sufficiently closely for the buffer mixture to show approximately its initial *p*H after the hypochlorite has been decomposed.

† Again assuming that no buffer substances are present. If sodium bicarbonate, for example, is present a solution with *p*H lower than 9·0 before decomposition may have *p*H 7·0 after decomposition.

‡ According to Kauffmann (1), sodium hypochlorite itself has no bleaching action. It is certain that its bleaching action is, at least, comparatively slow, from the slow bleaching obtained with chemics of *p*H value 11·0 for example, as compared with that of chemics of, say, *p*H 8·0.

A filter paper, for example, Whatman's No. 5, 9 cm. diameter, is folded four times, so that eight thicknesses are obtained along the final fold. The folds should lie tightly together. The paper is held tightly folded and a drop of the chemic to be tested is placed on the eight-fold edge by means of a clean glass rod. Four or five further drops are then added, each drop being allowed to soak in before the next drop is applied. Immediately after the last drop has soaked in, a small drop (say 0·05 c.c.) of B.D.H. universal indicator is placed on the damp spot (which may with advantage be flattened out a little by pressure with the glass rod after adding the first two or three drops of chemic). The colour produced immediately after adding the indicator is noted and the colour compared with that obtained with buffered chemics of known *p*H values* and of the same available chlorine content. After experience has been gained reference to the buffered chemic is unnecessary.

The indicator solution used should show the greenish colour corresponding with a neutral reaction. The filter paper used should not be unduly acid; preferably it should show a greenish yellow colour when a drop of B.D.H. universal indicator is placed upon it. A slight acidity is not objectionable as the method adopted for adding the chemic will wash away traces of acids from the spot to which the indicator is to be applied.

The reasons for believing this spot-test to be much more reliable, in general, than the method depending on decomposition with peroxide are such as the following:—

If, for example, a sodium hypochlorite solution of *N*/25 strength as regards available chlorine is prepared, using a Sörensen phosphate buffer mixture of *p*H 8·0, the amount of acid necessary to neutralise the excess alkali in the stock liquor being added, a green colour is obtained in the spot test. If acid is added to an unbuffered solution of the same strength, until the same colour is obtained in the spot-test, it is found that the solution, after decomposition with peroxide, gives an orange colour with B.D.H. universal indicator, indicating a very definitely acid solution. The actual *p*H value of the buffered solution must, however, be somewhat greater than 8·0, owing to the effect of hydrolysis of the sodium hypochlorite. It may be assumed that the unbuffered solution, matching the buffered solution in the spot test, has very nearly the same *p*H value, as any bleaching effect on the indicator will presumably be closely similar.

An *N*/25 sodium hypochlorite solution made up with phosphate buffer mixture for *p*H 8·5 will give a pink colour with phenol phthalein solution used in the spot test. An unbuffered solution when still sufficiently alkaline to give an immediate bright pink colouration with phenol phthalein in the spot test may become distinctly acid when decomposed with peroxide. It follows, therefore, that a sodium hypochlorite solution of *p*H value even greater than 8·0 may give an acid reaction after decomposition with peroxide.

A solution which gives a bluish spot with a violet rim in the spot-test will remain alkaline after decomposition with hydrogen peroxide. In this case a *p*H value exceeding 10·0 is indicated and the hypochlorous acid produced by hydrolysis yields less hydrochloric acid on decomposition than is required to neutralise the caustic soda present. Theoretically, a 0·02 Molar solution will give an acid reaction after decomposition whenever the initial *p*H value is below about 10·15. The spot-test is suitable for chemics of strengths normally used in piece bleaching. It is not so reliable for very weak

* Obtained by comparison with sodium barbitone solution as described on p. 1312.

chemics (below 0·5 gm. available chlorine per litre). This is apparently due to the insufficient buffer action of such weak solutions. In the case of strong liquors (e.g., 5 gm. available chlorine per litre) dilution with one or two parts of neutral, preferably CO_2 free, distilled water may be desirable.

The alkali produced by the hydrolysis of sodium hypochlorite has, as already indicated, some significance in connection with the preparation of buffered hypochlorite solutions of any desired *p*H value. When such solutions are prepared from a stock sodium hypochlorite liquor containing excess alkali it is not sufficient, if the desired *p*H value of the buffer solution is to be strictly maintained, to add to the mixture the quantity of acid necessary to neutralise the excess alkali. It is necessary to add also a further quantity of acid to overcome the effect of the alkali produced by the *hydrolysis* of the sodium hypochlorite. That this is necessary may be shown by the addition of pure sodium barbitone* to a Sörensen phosphate buffer mixture of, say, *p*H 5·5. When this salt is added in a quantity (0·02 gm. mol. per litre) equivalent to the sodium hypochlorite in a solution which is $N/25$ with respect to available chlorine, the *p*H value is shifted to 6·5.

In order to prepare buffered hypochlorite solutions in which any considerable shift of *p*H value is avoided, the following procedure may be adopted.†

A solution is prepared containing pure dry sodium barbitone‡ at the same molecular concentration as the sodium hypochlorite in the stock solution and also containing the same concentration of caustic soda (and sodium carbonate, if present).

This solution is diluted with buffer solution of the desired *p*H value in order to produce the desired concentration of sodium barbitone (equivalent to the desired concentration of sodium hypochlorite) and acid (say, $N/5$ sulphuric acid) is added until the initial *p*H value of the buffer mixture is restored. With the result of this experiment as a guide further mixtures are made until the desired concentration of sodium barbitone and *p*H value are obtained.

The buffered chemic is then made, replacing the alkaline sodium barbitone solution by the same quantity of the sodium hypochlorite stock liquor, the quantities of acid and buffer solution being the same as finally found necessary for the barbitone mixture.

ADDITION OF SALTS OF WEAK ACIDS TO BUFFER SOLUTIONS

In order to gain an idea of the extent to which the *p*H values of buffer solutions may be shifted by the presence of sodium hypochlorite, when no acid is added to correct for the hydrolysis, a considerable number of experi-

* 5, 5-Diethyl-barbituric acid has a dissociation constant (first hydrogen) closely similar to that of hypochlorous acid; its value is given by Wood (1906) as $3·7 \times 10^{-5}$, i.e., this acid is somewhat stronger than hypochlorous acid if Soper's value ($1·0 \times 10^{-8}$) for the dissociation constant of the latter is accepted. See also footnote, p. T316.

† A simpler method which appears to give satisfactory results is described elsewhere (2).

‡ Barbitone being assumed to have very nearly the same dissociation constant as hypochlorous acid. Even if the dissociation constants of the two acids differ by as much as $3·7 \times 10^{-8}$ as compared with $1·0 \times 10^{-8}$ the quantity of acid found necessary by this method will be sufficiently near the theoretical to make very little demand upon the buffer. Thus, as shown in Tables I and II (below), the *p*H shift produced, over the useful part of the buffer range, by the addition, at fiftieth molar concentration, of the sodium salt of an acid with dissociation constant $3·7 \times 10^{-8}$ is, by calculation, not more than 0·35 *p*H unit less than the shift produced by the addition of the sodium salt of an acid with dissociation constant $1·0 \times 10^{-8}$ even when the *p*H shift produced by either salt is large (as in acetate buffer of *p*H 5·6 or phosphate buffer of *p*H 5·0 or *p*H 8·0). See also footnote, p. T316.

ments were made in which the sodium or potassium salts of weak acids (with dissociation constants approaching that of hypochlorous acid) were added to phosphate and acetate buffer solutions. An attempt has also been made to calculate what the shift would be. In general, the agreement between observed shift and calculated shift was as close as could be expected. The method of calculation adopted will be briefly described.

(a) Walpole Acetate Buffers (M/5)

Let $[CH_3{\cdot}COOH]$ = P.
$[CH_3{\cdot}COO']$ = Q.
$[H\bar{A}]$ = R. (free acid from added salt).
$[\bar{A}']$ = S.
$[H^{\cdot}]$ = h.
C = Concentration of added salt (gm. mols. per litre).
α_1 = degree of ionisation of sodium acetate at the dilution existing in the buffer solution.
α_2 = degree of ionisation of the added salt.
K_1 = dissociation constant of acetic acid.
K_2 = dissociation constant of the acid of the added salt.

The values of α_1 and α_2 will be assumed to be equal to the values for each salt if present alone with a concentration equal to the total salt concentration.

Since the buffer mixture is 1/5 molar the following relationship must hold :—

$$P + \frac{Q}{\alpha_1} = \frac{1}{5} \quad \text{.....(1)}$$

Further

$$R + \frac{S}{\alpha_2} = C \quad \text{.....(2)}$$

Electrical neutrality demands the following relationship :—

$$[OH'] + Q + S = [Na^{\cdot}] + h \quad \text{.....(3)}$$

The acid equilibria are expressed as follows :—

$$\frac{hQ}{P} = K_1 \quad \text{.....(4)}$$

$$\frac{hS}{R} = K_2 \quad \text{.....(5)}$$

From (1) and (4)

$$Q = \frac{k_1\alpha_1}{5(K_1+h\alpha_1)} \quad \text{.....(6)}$$

From (2) and (5)

$$S = \frac{K_2\alpha_2 C}{K_2+h\alpha_2} \quad \text{.....(7)}$$

The value of $[Na^{\cdot}]$ may be expressed thus :—

$[Na^{\cdot}]$ = total [Na] — unionised [Na]

$$= F+C-(1-\alpha_1)\frac{Q}{\alpha_1}-(1-\alpha_2)\frac{S}{\alpha_2}$$

$$= F+C+Q+S-\frac{Q}{\alpha_1}-\frac{S}{\alpha_2}$$

Substituting these values, equation (3) becomes

$$[OH']+Q+S = F+C+Q+S-\frac{Q}{\alpha_1}-\frac{S}{\alpha_2}+h,$$

$$\text{or } [OH'] + \frac{Q}{\alpha_1} + \frac{S}{\alpha_2} - h = F + C.$$

or, using equations (6) and (7),

$$\frac{K_W}{h} + \frac{K_1}{5(K_1 + h\alpha_1)} + \frac{K_2C}{K_2 + h\alpha_2} - h = F + C. \quad \ldots\ldots(8)$$

The value of h required to satisfy this equation in particular cases of the additions of a salt to the buffer solution may be found, approximately, by the method of trial and error. This is not very laborious, once the values of the second and third terms, for different values of h, of the L.H. side have been tabulated. The first and last terms of the L.H. side may be neglected, and the third term may be neglected when pK_2 is much greater than pH.

Using equation (8) and assuming that K_1 (dissociation constant of acetic acid) = $1{\cdot}8 \times 10^{-5}$ and that the degree of ionisation of the added salt is the same as that of sodium acetate, the results shown in Table I were calculated. The observed values are shown in the same table. The following values of α_1 were employed (Kohlrausch).

Total Salt Concentration. (Molar)	α_1
0·015M	0·900
0·036	0·856
0·053	0·831
0·098	0·795
0·118	0·784
0·141	0·773
0·158	0·764
0·181	0·753
0·191	0·748
0·198	0·745
0·221	0·733*

*extrapolated value.

In the same way the shift in pH value which would be produced by adding sodium hypochlorite to the buffer mixture has been calculated. This should indicate the shift which would occur when sodium hypochlorite stock liquor is added to the buffer solution together with only sufficient acid to neutralise the excess alkali present in the stock liquor, no acid being added to overcome the alkalinity due to hydrolysis.* It is calculated, for example, that, for an addition producing a solution $N/25$ as regards available chlorine, the reaction of a buffer solution of pH 5·2 would be shifted to pH 5·53. At a point nearer the end of the buffer range the shift is considerably greater.

(b) Sörensen Phosphate Buffer (1/15 Molar)

By a method similar to that employed for the acetate buffer the following equation was derived for a Sörensen phosphate buffer.

$$\frac{K_W}{h} + \frac{hK_2\alpha_3\alpha_1 + 2K_2K_3\alpha_1\alpha_2}{15(h_2\alpha_2\alpha_3 + hK_2\alpha_3\alpha_1)} + \frac{K_4C}{K_4 + h\alpha_4} - h = F + C \quad \ldots\ldots(9)$$

or, omitting negligible terms, and simplifying,

$$\frac{K_2\alpha_1}{15(h\alpha_2 + K_2\alpha_1)} + \frac{K_4C}{K_4 + h\alpha_4} = F + C \quad \ldots\ldots(10)$$

* The effect of the slight dilution of the buffer solution produced by these additions has been neglected.

Table I—Observed and Calculated *p*H values obtained on adding various salts to Walpole Acetate Buffer Solutions (M/5)

Ob. = observed. Cd. = calculated.

F.		0·015		0·036		0·053		0·098		0·141		0·158		0·181	
Initial *p*H of buffer } from compn.		3·6		4·0		4·2		4·6		5·0		5·2		5·6	
} by indicators		3·5		3·9		4·1		4·55		4·95		5·2		5·6	
Added Salt ...	C.	Ob.	Cd.	Ob.	Cd.	Ob.	Cd.	Ob	Cd.	Ob.	Cd.	Ob.	Cd.	Ob.	Cd.
Sodium Acetate ...	0·03	3·9	3·95	4·15	4·20	4·3	4·35	4·65	4·67	5·05	5·07	5·3	5·27	5·65	5·66
	0·04	4·0	4·14	4·3	4·32	4·35	4·45	4·70	4·77	5·1	5·12	5·3	5·29	5·7	5·68
Sodium Cacodylate ...	0·01	—	—	—	—	—	—	—	—	—	—	5·3	—	5·7	5·8
	·002	—	—	—	—	—	—	—	—	—	—	5·5	—	5·8	5·99
	0·03	—	—	—	—	—	—	—	—	—	—	5·7	—	6·0	6·15
	0·04	—	—	—	—	—	—	—	—	—	—	5·7	5·73	6·3	6·28
Sodium Barbitone ... (if *p*K = 7·43)	0·01	}									}	5·3	5·34	5·9	5·92
	0·02	}									}	5·5	5·53	7·1	6·6
	0·03	} ←	Acid thrown out in these buffers.								→ }	5·7	5·79	7·7	7·1
	0·04	}									}	6·7	6·2	8·2	7·4
Sodium Hypochlorite ...	0·02	—	4·0	—	4·25	—	4·41	—	4·80	—	5·25	—	5·53	—	6·9
	0·04	—	4·24	—	4·44	—	4·58	—	4·98	—	5·6	—	6·45	—	7·9
Potassium Cyanide... ...	0·01	—	—	—	—	—	—	—	—	—	—	5·3	5·34	6·0	5·93
	0·02	—	—	—	—	—	—	—	—	—	—	5·5	5·53	7·25	7·7
	0·03	—	—	—	—	—	—	—	—	—	—	5·9	5·8	9·1	8·64
	0·04	4·1	4·24	—	—	—	—	—	—	—	—	6·65	6·7	9·3	8·93
Sodium arsenite ...	0·01	—	—	—	—	—	—	4·7	4·71	—	—	—	—	6·3	5·93
	0·02	—	—	—	—	—	—	4·8	4·8	—	—	—	—	—	8·2
	0·03	—	—	—	—	—	—	4·9	4·88	—	—	—	—	9·6	9·11
	0·04	—	—	—	—	—	—	5·1	4·98	—	—	—	—	> 9·6	> 10·0
No addition ...	0·00	3·5	3·61	3·9	4·02	4·1	4·22	4·55	4·63	4·95	5·01	5·2	5·20	5·6	5·60

Here the symbols have the following significance :—

K_2 = second dissociation constant of phosphoric acid.

K_3 = third " " " "

K_4 = dissociation constant of acid in added salt.

a_1 = degree of ionisation of KH_2PO_4.
a_2 = ,, ,, ,, ,, Na_2HPO_4.
a_3 = ,, ,, ,, ,, Na_3PO_4.
a_4 = ,, ,, ,, ,, added salt.

The other symbols have the same significance as before.

Table II

F.		0·00083		0·0027		0·0080		0·0212		0·0407		0·0630	
Initial *p*H of buffer: from composition		5·0		5·5		6·0		6·5		7·0		8·0	
Initial *p*H of buffer: by indicators ...		4·95		5·5		6·0		6·5		7·0		8·0	
Added Salt ...	C.	Ob.	Cd.	Ob.	Cd.	Ob.	Cd.	Ob.	Cd.	Ob.	Cd.	Ob.	Cd.
Sodium cacodylate ...	0·02	6·0	6·1	6·0	6·15	6·2	6·3	6·6	6·61	7·1	7·06	8·2	8·1
	0·04	6·2	6·3	6·3	6·33	6·35	6·44	6·65	6·7	7·15	7·1	8·2	8·1
Na_2HPO_4 ...	0·02	6·3	6·31	6·3	6·36	6·6	6·5	6·8	6·77	7·2	7·22	8·35	8·16
	0·04	6·55	6·6	6·6	6·36	6·7	6·72	6·9	6·94	7·35	7·3	8·4	8·26
Sodium barbitone ... (if pK = 7·43)	0·02	6·5	6·4	6·5	6·45	6·62	6·59	6·95	6·88	7·45	7·32	8·5	8·35
	0·04	6·85	6·77	6·95	6·8	7·0	6·9	7·3	7·13	8·05	7·53	8·9	8·6
Potassium cyanide ...	0·02	6·5	6·5	6·5	6·5	6·7	6·7	6·9	7·0	7·7	7·7	9·7	9·6
	0·04	6·9	7·0	6·95	7·05	7·1	7·2	7·6	7·7	9·2	8·7	9·9	9·9
Sodium cyanide ...	0·02	6·3	6·5	6·3	6·5	6·6	6·7	6·9	7·0	7·7	7·7	9·6	9·6
	0·04	6·7	7·0	6·7	6·95	7·0	7·1	7·4	7·7	9·1	8·7	9·6	9·9
Sodium hypochlorite	0·02	—	6·44	—	6·5	—	6·64	—	6·93	—	7·49	—	8·7
	0·04	—	6·9	—	6·94	—	7·06	—	7·34	—	7·86	—	8·93
No addition ...	0·00	4·95	4·91	5·5	5·44	6·0	5·94	6·5	6·47	7·0	7·0	8·0	8·05

In our calculations we have assumed a value of $1{\cdot}206 \times 10^{-7}$ for K_2. This value gives better agreement between observed and calculated results than the value $2{\cdot}0 \times 10^{-7}$.* We have also assumed that sodium and potassium salts would be equally ionised.

From equation (10) it is calculated, for example, that the addition of sodium hypochlorite to a Sörensen phosphate buffer solution (M/15) of *p*H 7·0, in a quantity sufficient to produce a solution which was $N/25$ with respect to available chlorine (C = 0·02) would shift the reaction to *p*H 7·49, assuming a dissociation constant of $1{\cdot}0 \times 10^{-8}$ for hypochlorous acid. Table II shows the observed and calculated figures for the *p*H values produced by various salt additions to Sörensen phosphate buffer. The following dissociation constants were employed :—

Cacodylic acid, $6{\cdot}4 \times 10^{-7}$;
NaH_2PO_4, $1{\cdot}206 \times 10^{-7}$;
Barbitone, $3{\cdot}7 \times 10^{-8}$ (Wood, 1906) ([3]).†
Hypochlorous acid, $1{\cdot}0 \times 10^{-8}$ (Soper, 1924) ([4]) ;

* Cf. Prideaux and Ward, J.C.S., 1924, p. 423 (5). If K2 is taken as 6×10^{-8} the values of *h* which satisfy the equation do not agree well with the observed values obtained in the addition of sodium barbitone and other salts to the buffer mixture, the calculated values being too high.

† In investigations by Michælis (*J. Biol, Chem.*, 1930, **87**, 33) and by Britton and Robinson (*J. Chem, Soc.*, 1931, 1459), made since our experiments were completed, values of $1{\cdot}0 \times 10^{-8}$ and $1{\cdot}1 \times 10^{-8}$ respectively were found. These values give better

Hydrocyanic acid, $1{\cdot}0 \times 10^{-9}$; *
Arsenious acid, $0{\cdot}6 \times 10^{-9}$.

As in the case of the acetate buffers it was assumed that the degree of ionisation of each salt in the mixture was equal to the degree of ionisation it would have alone at a concentration equal to the total salt concentration. It was also assumed that the degree of ionisation of the added salt was equal to α_1. A slight uncertainty here does not in general greatly affect the calculation. The values employed are as follows :—

	α_1	α_2	α_3
Total salt concentration 0·067 gm. mols. per litre	0·802	0·636	0·517
,, ,, ,, 0·087 ,, ,, ,, ,,	0·782	0·608	0·492
,, ,, ,, 0·107 ,, ,, ,, ,,	0·766	0·588	0·476

The addition of 0·02 mol. of sodium barbitone is calculated to shift the *p*H from 7·0 to 7·32, assuming a dissociation constant of $3{\cdot}7 \times 10^{-8}$ for barbitone. The observed shift was from 7·0 to 7·45, which would, from the equation, agree almost perfectly with a dissociation constant of 1×10^{-8} for barbitone. This dissociation constant has been found to give better agreement between observed and calculated values also in the addition of sodium barbitone to acetate buffers. The sodium barbitone used when dissolved in neutral, CO_2 free, distilled water at 0·02 molar concentration gave a solution of *p*H 10·0 to 10·1, using thymol phthalein indicator. This value is intermediate between the values calculated for the two dissociation constants ($1{\cdot}0 \times 10^{-8}$ and $3{\cdot}7 \times 10^{-8}$). This method of checking is, however, not of very great reliability.

The good general agreement shown in Tables I and II between the observed and calculated figures for the *p*H values indicates that the equations used are reliable. Consequently the calculated values for the shift produced by the addition of sodium hypochlorite are probably fairly accurate. It appears, therefore, that unless acid is added to overcome the alkali produced by the hydrolysis of sodium hypochlorite, in addition to that required to neutralise the excess alkali, the reaction of buffered solutions may be shifted considerably from the initial *p*H value, particularly towards the ends of the buffer range.

It is probable that the reaction of a neutral Sörensen phosphate buffer (M/15) would be shifted at least to *p*H 7·4 when C = 0·02 (solution M/25 with respect to available chlorine). If, therefore, maximum activity is observed in bleaching with solutions made up with buffers of *p*H 7·0 (only an amount of acid necessary to neutralise the *excess* alkali being added) it is probable that the maximum activity actually occurs at about *p*H 7·4. In some recent experiments in which material was treated with buffered chemics in which the amount of acid estimated to reduce the hydrolysis-alkali to a point corresponding with the desired *p*H value was added[2] a definite indication was obtained that maximum activity occured at a *p*H appreciably greater than 7·0.

The change in *p*H observed on adding a salt of a weak acid to a buffer solution affords a sensitive method of estimating the dissociation constant of the acid, if, as appears, the equations used in this paper may be relied upon. For this purpose a buffer mixture should be chosen so that pK_A is of the

agreement between the observed and calculated *p*H shifts for the addition of sodium barbitone, the calculated values then being almost identical with those shown in the tables for sodium hypochlorite additions.

* Published values vary between $1{\cdot}32 \times 10^{-9}$ (Walker and Cormack, *J. Chem. Soc.*, 1900, **77**, 5) and $4{\cdot}52 \times 10^{-10}$ (Britton and Dodd, *J. Chem. Soc.*, 1931, 469). According to the results of Worley and Browne (*J. Chem. Soc.*, 1917, **111**, 1057) the degree of hydrolysis increases fairly rapidly with rising temperature.

same order as the *p*H of the buffer after the addition of the salt. The value of pK_A which gives best concordance between observed and calculated results gives the dissociation constant of the acid.

EXPERIMENTAL

The sodium hypochlorite stock liquor employed in the experiments was a commercial sample prepared by the interaction of bleaching powder and soda ash in solution. The solution was about 12° Twaddell and approximately normal with respect to available chlorine. It contained 10·8 gm. per litre of excess alkali, calculated as caustic soda. The excess alkali was, in fact, almost entirely caustic soda, formed by the interaction of caustic lime, present in the bleaching powder stock liquor, and the soda ash. A small quantity of sodium carbonate was also present, representing a slight excess of added soda ash.

The measurement of *p*H values was made by means of indicators, using mainly B.D.H. Capillators which had been checked against standard buffer solutions. The Hellig comparator was used in some cases. Measurements were generally made at room temperature (17-18° C.). A comparison of the results obtained at room temperature using the Capillators and at 25° C. using comparator tubes, showed differences not exceeding 0·1 of a *p*H unit in a number of experiments made to test the effect of temperature.

The sodium salts used for addition to the buffer mixtures were the purest available, as follows :—

Disodium hydrogen phosphate ...	B.D.H. analytical reagent.
Sodium barbitone	" Judex," dried at 100° C.
Sodium cyanide	" Judex," pure.
Potassium cyanide	" Judex " analytical reagent.
Sodium cacodylate	" Judex."
Sodium arsenite	" Judex."

No great accuracy can be claimed for the *p*H measurements recorded, but they are, in general, sufficiently accurate to confirm the approximate validity of the equations employed.

SUMMARY

(1) The excess alkali present in stock solutions of sodium hypochlorite may be estimated after the hypochlorite has been decomposed by means of neutral hydrogen peroxide, but the *p*H value of dilute bleaching liquors cannot, in general, be accurately determined after such decomposition.

(2) A simple method of determining the approximate *p*H values of dilute hypochlorite liquors is described.

(3) Equations are evolved from which the shift in *p*H value produced by adding the sodium (or potassium) salt of a weak acid to a buffer solution may be determined. The shifts experimentally observed on the addition of several such salts to acetate and phosphate buffers are recorded. Calculated values for the effect of the addition of sodium hypochlorite are given. The value of the fact that the dissociation constants of hypochlorous acid and barbitone are closely similar is pointed out.

(4) A method of determining the dissociation constant of a weak acid is indicated.

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TRANSACTIONS

25—THE TENSILE STRENGTH AND FLUIDITY IN CUPRAMMONIUM HYDROXIDE SOLUTION OF CHEMICALLY MODIFIED RAYON AND COTTON YARNS

PART I—OXIDATION BY HYPOCHLORITE SOLUTIONS

BERT PUSEY RIDGE, Ph.D., F.I.C., and HAROLD BOWDEN

I. INTRODUCTION AND SURVEY OF RESULTS.

In publishing the results of his original work in 1911, Ost[10] suggested that not only should the determination of viscosity in cuprammonium hydroxide solution serve to divide the cellulose materials to be used for the manufacture of gun-cotton, artificial silk, etc., into different "viscosity classes," and give fundamental information about their properties, but it should also afford a measure of the strength of artificial silks, since increase of strength was probably accompanied by increase in the viscosity of their solutions.

The importance of this measurement in investigations concerned with the modification of cotton materials by chemical agents is now so well recognised that it is hardly necessary to mention the extent to which his observations have since been justified, and in the present paper it is shown that what applies to cotton applies equally well to rayons of the regenerated cellulose types; in other words, the determination of viscosity (or its reciprocal, fluidity) has now become the most reliable means of assessing the extent to which chemical modification of all pure cellulose materials has occurred. Its value to the Textile Industries has increased rapidly during the past ten years, because the chemical methods for quantitatively describing the modification of cellulose (copper, silver, and permanganate numbers, methylene blue absorption, etc.) enable some estimate of the simultaneous tensile deterioration to be formed only in favourable circumstances, and their indications in this sense are completely unreliable if the material has received an alkaline treatment subsequent to attack. For example, a relatively low copper number may be accompanied by little, or by considerable, loss of strength according to the precise conditions of oxidation and the after-processing of the material. Chemical modification is always accompanied, on the other hand, by a rise of fluidity that bears

a much more general and less ambiguous relation to the percentage strength loss of fibres or yarns.

The relations between strength and the fluidity of cotton yarns that have been progressively modified by the action of oxidising agents and acids have been fully investigated by Clibbens and Ridge,[4] and their importance has been exceedingly well demonstrated in the solution of problems concerned with the nature and cause of damage in textile materials and in investigations of the effects of different chemical processes such as bleaching, dyeing, etc., on the strength and wearing properties of the finished goods. In the present paper, therefore, the obvious extension of this work has been made to the ordinary types of rayon yarns employed in textile manufacture with the object of showing to what extent measurements of fluidity are indicative of loss of strength in the chemically modified yarns, in what ways greater care is necessary in the wet processing of rayon than is required for cotton, and how the relations established for rayons may be compared with those already found for cotton.

It is now shown that for rayon yarns the determination is also very valuable ; that for the regenerated cellulose types—viscose, cuprammonium, and Lilienfeld varieties—increasing modification by oxidising (hypochlorite) liquids is always accompanied by an increase of fluidity, and that, again, there is a definite relation between this increase and the percentage strength of the modified materials, thus fulfilling Ost's second prediction.

At first sight it might appear difficult to compare results for rayons with those for cotton, first because 2 per cent. instead of 0·5 per cent. solutions of cellulose in the cuprammonium hydroxide have been used for rayons, and secondly because, although the fluidities of all unmodified cottons, independent of variety or origin, are low and of the same magnitude, those of rayons generally vary according to the type examined.[13] It is shown later, however, that when once the initial stages of oxidation have been exceeded, the same increase of fluidity corresponds with the same percentage loss of strength for all the materials examined, and whether the rayons are in the dry or wet condition. Thus, for yarns so modified that their fluidity values are higher than about 14, the curves representing the relation between fluidity and percentage strength for cotton and viscose are linear and are coincident, although these different concentrations of cuprammonium hydroxide solutions are used, whilst further, the corresponding curves for the Lilienfeld and cuprammonium yarns, and for all these rayons in the wet state, are also linear and run parallel to that found for cotton and viscose rayon (see Figs. 3 to 6).

It is not to be presumed that these linear relations hold for degrees of modification much exceeding those now represented in the accompanying tables and diagrams, but the range examined exceeds considerably that normally found for technically processed and tendered goods, and it is within this range that linearity holds. In the case of cotton, the additional results now given confirm the previous work by Clibbens and Ridge[4] in which it was shown that attack of cotton yarns by hypochlorite solutions yields a linear relation between fluidity and percentage strength over a considerable part of the curve obtained, namely, between fluidity values of about 13 to 32.

The effect of wetting is shown to be more serious for rayon yarns that have been chemically modified than might at first be supposed. If, for

example, a normal unmodified viscose yarn loses about 50 to 55 per cent. of its dry strength on wetting with water, when it is chemically tendered it still loses this amount on wetting *in addition* to that lost as a result of the chemical attack. Hence, chemical attack to an extent that would be quite negligible with cotton yarns that do not become weaker in water, is sometimes sufficient to reduce the wet strength of rayon to a point where handling or processing without injury to the fabric is a matter of considerable difficulty. The effect of wetting Lilienfeld and cuprammonium yarns is not so serious since here the respective losses of strength are about 36 per cent. and 40 per cent. as compared with the 50 to 55 per cent. for viscose rayon.

An investigation has also been made of the relative losses of strength of cotton and viscose yarns on oxidation under identical conditions, and of the further losses that occur when the modified yarns are submitted to a boiling treatment with dilute (1 per cent.) sodium hydroxide solution. The action of alkali of this concentration is likely to be greater than that resulting from normal scouring or laundry processes because rayon fabrics are not as a rule subjected to treatment with liquor of this concentration, so that the effects observed may be regarded as maximum for technical purposes. It is shown that when the oxidation is performed with a neutral, buffered, hypochlorite liquid the rate of loss of strength is approximately the same for single and two-fold cotton and for viscose yarns, but in a slightly alkaline liquor (pH9) viscose rayon is more quickly tendered than cotton. The rate of attack of both materials, however, is much more rapid in the neutral than in the alkaline solution (see Fig. 7).

On boiling the modified yarns a further loss of strength occurs which is small for cotton yarns oxidised with a bleaching liquor of fairly high alkalinity (pH 11·2) but is progressively greater as the alkalinity of the liquor decreases, and is greatest for a neutral (pH7) hypochlorite solution (see Fig. 8). Similar effects obtain with viscose rayon, but when the chemical attack has been considerable the viscose yarns lose a much greater percentage of strength than do the cotton materials. The loss of strength of the corresponding unmodified yarns is also different, since cotton loses only about 2 per cent. and viscose rayon 10 per cent. under the conditions of treatment employed.

Considerable weakening may be produced not only by the comparatively drastic treatment of overbleached viscose yarns with boiling caustic soda solutions, but by much milder boiling processes. Table XIV shows that water alone has a pronounced effect and that the tendering of the yarn is greater the more severe are the scouring conditions. Hence once the material has been overbleached or otherwise oxidised, even ordinary home or technical laundering processes are quite sufficient to cause further considerable deterioration. Similar effects are found for cotton, as shown by the same table, but here the loss of strength on boiling is not so great. Another noteworthy feature shown by these tables is the very pronounced increase of fluidity of the materials that occurs as a consequence of the boiling. This will be referred to later.

A striking example of the above effects is sometimes observed on washing curtains containing cotton and rayon yarns. The material is often tendered, particularly down folds, as a result of the exposure to light and the atmosphere at a window and, although before washing it appears quite strong and in good condition, after even the mildest treatment with hot soap solution it is so far weakened that it tears easily. Under these circumstances both

cotton and viscose rayon are tendered in much the same way but, since cotton is relatively stronger, particularly when wet, visible damage is more apparent in the rayon.

Such tendering is often found to coincide with fading of the dyes used on the yarns, and it has been stated[12] that the chemical attack of dyed cellulose materials on exposure to light and the atmosphere is accelerated by certain vat dyes. This possibility must not be overlooked, but little that is definite is known about the matter, which is now under investigation in these laboratories. It cannot, of course, be assumed that the chemical modification of cellulose due to the action of light and the atmosphere is identical in nature with that caused by oxidation with hypochlorite liquors, but measurements of the fluidity of cotton and rayon materials (made both before and after boiling with alkali) after tendering by both methods, and the considerable losses of strength resulting from such boiling treatments, indicate that there is at least a marked similarity between the effects of hypochlorite liquors and of light and air on cellulose.

If, then, the strength of rayon materials is to be preserved, it is highly important that not only should chemical attack of the cellulose in bleaching, etc., be avoided as far as possible on account of the total decrease in strength on wetting, but scouring or laundering treatments should never be so severe as those given to all-cotton goods, since under such conditions the loss of strength is considerable for unmodified yarns and becomes very much greater the more the materials have been chemically degraded.

No examination of the effects of the so-called " oxygenated washing agents " such as " Persil," or other powders containing ingredients that liberate hydrogen peroxide has yet been made, but the results of the present investigation suggest that great care should be exercised in the use of such preparations in home or technical laundry treatments in view of the pronounced weakening of viscose yarns that can occur as a result of washing after even comparatively mild oxidation of goods containing them.

It is instructive to consider what value of the fluidity might be considered as an upper limit beyond which rayon materials are to be regarded as over-bleached or excessively attacked by chemical agents. If the tensile properties are accepted as the criteria, and if losses of strength up to, say, 8 per cent. are tolerated, the corresponding fluidity limits would be approximately 12·5 for viscose, 7 for Lilienfeld, and 5 to 6 for the cuprammonium varieties when the fluidity is measured in 2 per cent. solution.

In considering such arbitrary standards, however, it is necessary to bear in mind the effects of alkali boiling subsequent to the chemical attack, since in many cases the materials to be examined may have been soaped or laundered with alkaline liquids after bleaching. These effects are shown by Figs. 9 and 10, and it is seen that a fluidity value of 12·5 for viscose rayon, due to a hypochlorite bleaching treatment alone, is increased to about 16 as a consequence of alkali boiling and the corresponding loss of strength of the yarn is then approximately 35 per cent. This loss is considerable, especially since the further loss on wetting is so important, and it is recommended therefore that the value suggested above as standard should be that for material which has been submitted to an alkali boiling treatment before the fluidity measurement is made. The value of 12·5 after thus scouring then corresponds with roughly 11 for the hypochlorite bleached but unboiled yarn or fabric.

For standard commercial viscose yarns that have never been submitted to further wet processing, the value 11 should certainly never be greatly exceeded, because the higher their fluidity, the greater is the loss of strength on scouring or laundering; hence it is essential that the chemical characteristics (copper number, fluidity, etc.) of the rayon should never be seriously increased by the processes involved in the actual manufacture of the yarns or in their subsequent bleaching. With the normal careful control of the operations prior to or subsequent to spinning there should be no great difficulty in producing material of fluidity values uniformly lower than 11, and evidence that this can be achieved is afforded by the fact that in no case has a value exceeding 11·1 been found in these laboratories for normal yarns of good quality made by one firm, whilst furthermore, the majority of samples of similar yarn from other firms examined both now and in a previous investigation have been found to have values very near to, or lower than 11.

When the initial stages of oxidation are exceeded, whatever the material—provided that the above concentrations of the cuprammonium solutions are maintained—a rise of fluidity of 5 units corresponds sufficiently well for technical purposes with a further loss of 10 per cent. in the strength of the yarns. This applies to plain (unmercerised) cotton and rayon materials that have not been submitted to boiling with alkaline liquids, and also to cotton yarns bleached in either neutral or alkaline hypochlorite solutions that *have* been thus treated (see Fig. 9). On the other hand, overbleached viscose yarns show a much greater loss amounting to 16 to 17 per cent. per 5 units rise of fluidity when they are given an alkaline boiling treatment, but here again the loss is the same whether the yarns are overbleached in neutral or alkaline hypochlorite liquors.

The behaviour of mercerised cotton differs in this respect from that of cotton and is discussed later.

The losses of strength of viscose yarns indicated above are of considerable importance in connection with low grade products. Thus it has already been stated[13] that cases *may* occur when rayon yarns that are classified as lower grade on account of poorer physical qualities, such as the number of broken filaments, etc., exhibit this physical inferiority because the yarns were spun from a viscose solution that was somewhat below the normal standard. If, for example, the ageing of the soda cellulose is carried a little too far, the cellulose becomes more degraded chemically than it should be if the normal high standard of yarn quality is to be maintained, and the resulting product is therefore also chemically inferior. Interesting results of an investigation of the factors that may affect the oxidation of soda-cellulose by atmospheric oxygen have recently been obtained by Davidson,[5] who has shown, for example, the importance of the presence of traces of metals in catalytically accelerating this oxidation. Alternatively, the chemical treatment during and subsequent to spinning may have been too severe. In either case the yarns will be inferior as regards their chemical properties, and will behave in exactly the same way as normal good quality material that has been submitted to oxidation such as that given to the yarns employed in this investigation. In other words, their losses of weight and strength on boiling with alkali, and their fluidity in cuprammonium hydroxide solution, will be abnormally high; furthermore, they will show a greater tendency to break down in the course of winding or handling, so

that sorting operations, in which the criterion of good quality is the absence of breaks, may well result in the classification of such yarns as lower grade.

Evidence of such chemical inferiority has been afforded in several instances of cotton-rayon cloths examined at this Institute that have shown breakdown of the weft—known to be of lower grade viscose rayon. The particular damage referred to takes the form of slits that run warp-way and generally persist over one pirn width only, and the holes cease abruptly at the weft changes on either side of the damaged pirn width. Measurements of fluidity have shown that the value obtained for the damaged weft in the neighbourhood of the holes is invariably higher than that of weft taken from the adjacent pirn lengths where there is no visible damage. Since in most cases the cloths were given only a mild scouring and bleaching or dyeing treatment, it cannot be maintained that this is responsible for the very pronounced and strictly localised chemical attack found over the damaged pirn widths of cloth, and, moreover, fluidity values for the cotton warp in the neighbourhood of the holes have been found as uniformly low as is consistent with such mild bleaching. The chemical modification of the defective pirns must therefore have occurred before the cloth was woven, and is to be regarded as due to some excessive action in the viscose preparation, or more probably in the later chemical treatment of the filaments in the spinning and bleaching processes.

It is also shown (in Table I, etc.) that the extensibility of viscose yarns decreases with increasing extent of chemical attack of the cellulose and that the effect is greater for wet than for dry yarns. This may also contribute to the greater susceptibility to damage, although it is realised that in this particular type of defect, in which the harder and stronger cotton warp cuts the soft rayon weft, the damage is probably due fundamentally to a lack of resistance to shearing stresses in the chemically degraded viscose rayon. Tensile strength tests, however, to a pronounced degree afford a measure of resistance to shear in colloidal substances, and the very considerable losses of strength that occur on wetting and boiling with alkali are sufficient to show that mechanical damage is much more to be expected with material that has suffered undue chemical modification than with normal, chemically sound yarn, and there can be little doubt that the inclusion of pirns of chemically inferior yarn in the weft of the cloths is primarily responsible for the damage that occurs in the subsequent wet processing.

Since the cloth manufacturer has generally no means of deciding whether viscose yarns are chemically inferior in quality, it is a matter for serious consideration whether chemical as well as physical standards of quality should not be adopted in buying and selling these lower grade yarns, and, in any case, the accidental mixing of chemically inferior with chemically sound material (although it may still be of lower grade as judged by present physical standards) must be avoided if this type of defect is to disappear.

Unpublished work previously carried out in these Laboratories has shown that where mercerised cotton yarns are concerned, the fluidity-percentage strength relation is quite different from that which obtains for plain cotton and the regenerated cellulose type of rayons. This has been confirmed during the present investigation and some results are included here for comparison (see Table XVI and Fig. 11).

It is observed that the rise of fluidity of such materials on oxidation with hypochlorite is very much greater than would be expected from

the comparatively small decrease of strength that occurs—judging by the effects shown by plain cotton. Thus although the fluidity of *unmodified* mercerised cotton is no higher than that of the corresponding unmercerised material,[13] when oxidised yarns are in question the fluidity corresponding with a given percentage loss of strength is much higher for the mercerised than for the plain cotton, and it is essential to bear this in mind in interpreting the results of fluidity measurements on fabrics that may contain mercerised cotton yarns.

When the mercerised yarns are boiled with alkali after the chemical modification, the relation between the strength and fluidity of the boiled material is nearer to that found for plain, unmercerised, cotton yarns, although the curve obtained is still by no means coincident with that for the plain cotton.

A fluidity-strength relationship similar to those found for rayons of the regenerated cellulose type cannot be obtained for cellulose acetate yarns, because loss of strength of these is caused mainly by hydrolysis of the cellulose acetate compound, which is accompanied by a decrease, and not an increase, of fluidity. In a previous publication,[13] however, it was mentioned that preliminary examination of the connection between the strength and fluidity of partially hydrolysed yarns indicated that a linear relation exists between these factors, and this relation has been further investigated, whilst the effect of hypochlorite liquors on the strength of the yarns has been studied in the same way as for the regenerated cellulose rayons. It is found that treatments corresponding with normal hypochlorite bleaching processes produce no significant increase of fluidity, little hydrolysis, and no important decrease of strength of the yarns during the times normally employed in the bleach-croft (see Table XVIII). In other words, acetate rayon yarns are scarcely affected by " chemicking."

When, however, hydrolysis occurs, as, for example, in treating these materials with sodium hydroxide solutions, the yarn strength and fluidity are both diminished in such a way that, after the initial stages of attack, the decrease of fluidity is directly proportional to the percentage decrease of strength over a range up to about 90 per cent. hydrolysis, provided always that dissolution of cellulosic material does not occur. Thus, a linear relation is found for the treatment of acetate yarns with 0·1*N* sodium hydroxide solution at 20° C. (see Fig. 12), but if 0·2*N* liquid is used cellulosic material is simultaneously dissolved and a greater loss of strength results for a given decrease of fluidity. Hence, use of the fluidity measurement as a means of assessing the degree of hydrolysis or loss of strength of acetate yarns is of minor importance since such use must be restricted to cases where it is quite certain that the treatment given has involved no dissolution of cellulose.

In view of the criticism that has been levelled at the cuprammonium viscosity or fluidity method on the grounds that the experimental procedure involved and the apparatus required are too complicated for a method capable of adaptation to routine technical requirements, results are also given which show that a simplified procedure, very similar to that used by Ost[10] can be employed quite satisfactorily with rayons, either for laboratory or works purposes.

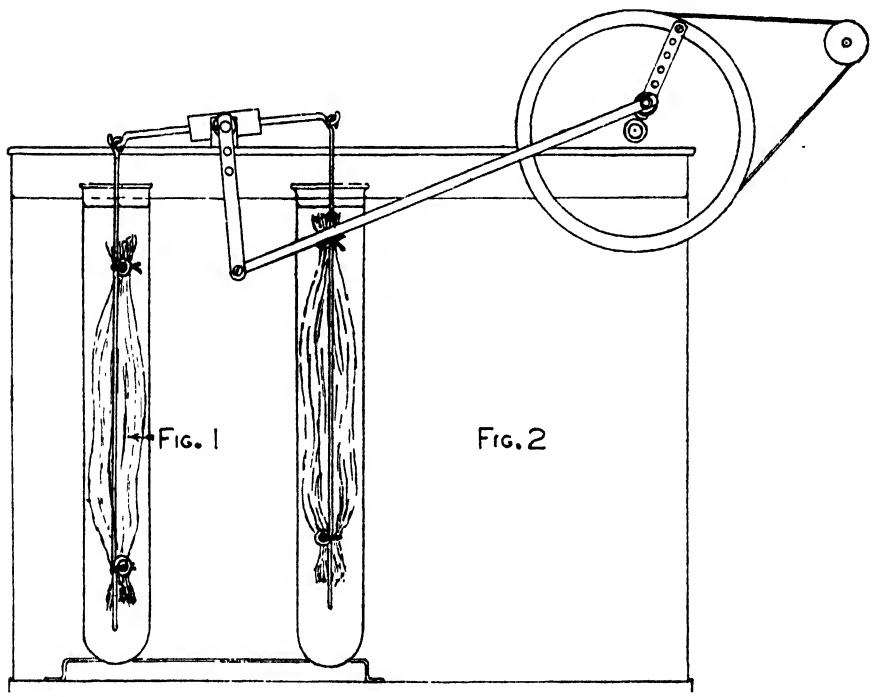
The time required for the complete dissolution of rayons in 2 per cent. solution is very short, and by the method described fluidity measurements

may be made on viscose yarns within half-an-hour, including the time for weighing out the sample. It is suggested, therefore, that no serious difficulties are presented in the adoption of this test as a means of control of chemical quality in the manufacture of rayons of the regenerated cellulose type, so that by suitable examination of the yarns from each batch of spinning solution, the accidental mixing of chemically inferior with chemically sound yarn should easily be avoided.

The effect of loss of ammonia from the cuprammonium liquid, due to use or storage, on the results of fluidity measurements, is also discussed.

II. EXPERIMENTAL SECTION

Continuous filament rayon yarns differ considerably from cotton yarns in that their strength depends so much on that of the individual filaments and not on twist. Thus in a normal rayon yarn containing, say, 20 filaments per thread, the low twist of 2 to 3 turns per inch contributes only slightly to the strength by bringing into play friction between the separate filaments, and if one of the latter is broken a loss of strength amounting to a few per-cent. may occur, whereas the breaking of a few cotton hairs in a more highly twisted cotton yarn is generally of no importance. Again, when rayon yarns are wetted, unlike cotton, they suffer a considerable diminution in strength, whilst further, those of the regenerated cellulose type are more susceptible to attack by chemical agents than are cotton yarns.



For these reasons, when comparative strength measurements are to be made after wet processing treatments, it is necessary to avoid not only mechanical damage to the filaments in washing and handling (otherwise there is danger of attributing to the particular chemical reaction concerned a greater tendering action than it really has) but also non-uniformity of

the chemical attack. Considerable errors were caused in preliminary experiments of this work by such mechanical damage, in spite of great care taken in washing and handling, and it was also found that, by treatment of bundles of yarn in bottles or by rotating them through the oxidising liquid, some parts were chemically attacked to a greater extent than others, with the result that the values for the breaking loads and fluidities of the test samples showed very considerable scatter.

Finally a method of treatment was adopted in which bundles of the yarn 14 inches long, tied at each end, and weighing in most cases approximately 15 g., were attached loosely to glass rods, as shown in Fig. 1, and subjected to a very slow up and down motion in long narrow glass tubes of about 750 c.c. capacity which contained the oxidising liquid and were immersed to within half-an-inch of the top in a thermostat electrically controlled at 25° C. This method of treatment is illustrated in Fig. 2, and had the great advantage that all oxidation and washing of the yarn with acid and water could be performed in the same tubes without removal of the bundles from the glass rods, and since the samples were also dried on the rods, all handling of the yarn was avoided right up to the time of testing, thus reducing the risk of mechanical damage to a minimum. A further advantage was that during the up and down motion in the tubes the liquid was efficiently stirred and the bundle of yarn " ballooned " out so that all the threads were separate, hence a uniform treatment by the liquid was secured.

By suitable arrangement of tubes and rocking arms in the thermostat eight preparations could be made at the same time under identical conditions.

Materials

The following first quality rayon yarns, delivered at the Shirley Institute on the dates shown, were used.

Variety		Denier	Date
Viscose	B_1	150	September, 1928, and July, 1930.
	B_2	,,	September, 1928.
	D_1	,,	March, 1930
	D_2 (unbleached)	,,	February, 1932
	D_3	,,	March, 1932
	E	,,	February, 1932.
	C	,,	February, 1932
	F	,,	February, 1932
Cuprammonium		150	May, 1931.
Lilienfeld		160	September, 1929
Acetate		140	September, 1930.
		150	April, 1930.

(Unless otherwise stated all these yarns were obtained in the bleached state, and those denoted by the same letter were from one firm)

The cotton yarns were a 2/50s combed Sakel and a 1/40s Tanguis, both of which had been kier-boiled with 1 per cent. sodium hydroxide solution at 20 lb. excess pressure and washed with dilute acid and water, whilst for the experiments on mercerised cotton, hanks of the scoured Tanguis yarn were treated with 7·5*N* (65° Tw.) caustic soda solution and washed and dried in the usual manner.

The staple-fibre yarn for comparison with the cotton and viscose yarns was of 20s count, 14 turns per in., spun at the Shirley Institute.

Sampling

The method of preparation of the 14-inch test samples was that previously described by Midgley and Peirce[8] and used subsequently by Clibbens and Ridge in similar work on cotton. The hanks of yarn were re-wound on a large wrap-reel and tied so as to give eight sections, two of which were reserved for control tests on the unoxidised material, while the remainder were tied to the glass rods and treated as described below. In some cases where more than one hank of the original yarn was necessary, two hanks were placed on separate stands and the ends were drawn off together, as one, in re-winding the material on to the large wrap-reel, thus reducing any effects of variations in the yarn from hank to hank.

The Oxidising Treatment

So far, in the present work, treatment has been restricted to the use at 25° C. of sodium hypochlorite solutions, generally 0·04*N* in oxidising power, and in view of the greatly accelerated attack of cellulose previously found to occur near the neutral point, the solutions were buffered by means of suitable salts to approximately *p*H 4·6, 7, 8, 9, and 11·2 as described in the earlier work.[4] It is realised that the use of buffer salts in this way to secure a range of definite *p*H values may be open to the objection that the salts themselves exert a specific action on the rate of oxidation, but it has already been shown[3] that while there may be some slight salt effect, there can be no doubt that the pronounced acceleration of the oxidation within the narrow region near the neutral point is principally due to the hydrogen ion concentration.

On immersion in a liquid, the bundles of rayon yarn—especially those having a large number of filaments per thread—carry with them a considerable volume of air, which is completely removed only with difficulty under the slow rocking conditions employed, and since this imprisoned air might interfere with the uniform attack of the material, the bundles were first placed in the buffer liquid contained in the glass tubes in the thermostat and agitated somewhat vigorously by means of the glass rods until no further escape occurred. The rod was then raised above the tube, the necessary volume of concentrated sodium hypochlorite to give a 0·04*N* solution was added, and the time of reaction was taken from the time of re-immersion of the yarn. Oxidation was continued for various periods up to 30 hours, according to the *p*H of the liquor, and the yarn was then washed, soured with 0·1*N* hydrochloric acid, further washed to neutrality with distilled water, dried in the air, and conditioned.

Blank Experiments

In order to determine the effects of the buffer liquids themselves in the absence of hypochlorite, and of the rocking treatments, one of the test bundles from each series of eight cut from the same hank of yarn was treated for at least six hours under the experimental conditions prevailing, but no oxidising agent was added. The effects on the resulting materials were found to be negligible, however, except with the acetate rayon, where, as shown below, with the most alkaline buffer liquid (*p*H 11·2) some hydrolysis and loss of strength resulted.

Hydrolysis of the Acetate Rayon Yarns

Hanks of the yarn were suspended over a rubber-covered roller placed horizontally across the top of a large inverted bell-jar so that as much as possible of their length was immersed in 20 litres of 0·1 or 0·2*N* sodium hydroxide solution contained in the jar. The temperature of the solution was adjusted to 20° C. and remained sensibly constant throughout the time of treatment. The hanks were rotated slowly through the liquid for various times, removed, washed in a large volume of water to stop the reaction, then with dilute acid, further washed with water, dried, re-wound on a wrap-reel, and sampled by cutting through the hank so as to give the necessary length of test specimens.

Testing

Breaking loads and extensibilities were measured on a Goodbrand single-thread machine adapted for rayon testing. The length of specimen was 28 cm. between grips, the rate of fall of the lower grip was 6 ins. in 30 seconds, and the relative humidity and temperature of the testing room were respectively 65 per cent. ± 2 per cent. and 65° F. (18° C.) ± 2°. All samples were carefully conditioned in the loose state at this humidity before testing, and at least 100 tests were made on each preparation, the threads being selected at random from the small bundles.

For measurements on the wet yarn, the test threads were placed in water in a shallow dish and allowed to sink under their own weight, whilst no account was taken of any increase in length due to wetting when placing the specimens in the grips. This procedure conforms to that recommended by the Bureau International pour la Standardisation des Fibres Artificielles (B.I.S.F.A.), except that the speed of fall of the lower grip is much less (300 mm. per min.) than that laid down by the Bureau (760 to 800 mm. per min.), whilst the test length in the latter case is 50 cms.

In all cases the breaking load results are expressed as percentages of the results for the corresponding untreated dry yarn. That is, after cutting the original re-wound hank into its eight sections, the breaking loads of the oxidised bundles are expressed as a percentage of that of the untreated part of this *same* hank, and not of a mean of several, or a grand mean of all the untreated portions of different hanks. This was found necessary because fairly large variations were obtained between the results of different hanks of the same yarn tested at different times.

The conditions for the cotton and staple fibre yarns were identical with those for the continuous filament rayons.

Fluidity Measurements

Whenever possible, these were made on the actual threads broken in testing, after cutting off short lengths at both ends where the bands had been tied round the bundles in attaching the yarn to the glass rods, but if the amount thus obtained was insufficient, some threads from the remainder of the bundle were included. The procedure employed has already been described[2,13] and the choice of the cellulose concentration of 2 per cent. for rayons is now shown to be further justified since, as shown below, the curves expressing the fluidity-strength relation for both cotton and viscose rayon are then coincident after the initial stages of oxidation.

There is, however, no reason why other concentrations should not be used if desired, and conversion of a series of values for one concentration to the corresponding ones for another may still be made by means of the

simple Arrhenius equation log $F_R = CK$ (where F_R is the fluidity of the solution relative to that of the solvent (66), C is the concentration, and K a constant) or by that given by Farrow and Neale[6] which, although it may perhaps give somewhat closer relations, is expressed in terms of viscosities and is not so easy to manipulate. These equations hold for rayons as well as cotton over a wide concentration range.

Expression of the results as "fluidities," instead of the more usual "viscosities," is retained in this paper for the sake of conformity with the more recent work published by the Association, and because again, as with cotton, the relations between fluidity and strength are linear over the greater part of the technically important ranges.

The Acetic Acid Content of Partially Hydrolysed Acetate Rayons

This was determined by the ether extraction method elaborated by H. L. Parsons of this Institute.[11]

Boiling with Alkali

The bundles of threads, tied at each end, were sewn into separate narrow bags made from a scoured cotton fabric of open weave, immersed in a boiling 1 per cent. solution of sodium hydroxide solution contained in a flask fitted with a reflux condenser, and treated at the boil for three hours, after which they were washed with dilute acid and water and dried in the air. Use of such bags ensured that mechanical damage to the threads due to vigorous boiling, or to breaks in disentangling the yarns after treatment, was reduced to a minimum.

III. DISCUSSION OF RESULTS

(1) The Tensile Strength-Fluidity Relations for Cotton and Rayons of the Regenerated Cellulose Type

Tables I to VII, VIII and IX, respectively, show the collected results of fluidity, percentage strength and extensibility measurements on the various viscose, Lilienfeld, and cuprammonium yarns after oxidation of these materials for various times with 0·04N hypochlorite solutions at the above-mentioned pH values. A few results obtained after treatment with solutions more concentrated than 0·04N are also included, whilst in some cases copper numbers are given for comparison with the fluidity and strength values. In Tables I and VIII results for the oxidation at all the various pH values are given, but since it was found from these that, as with cotton,[4] the same fluidity-strength relation was obtained independent of the particular pH of the oxidising liquid, the treatments for most of the other materials were restricted to that at pH7 where the required tendering effects could be produced in the shortest time.

From these same tables it is at once obvious that, again as with cotton, copper number does not always give a reliable indication of the extent of loss of strength, since under some conditions of oxidation with bleaching solutions of exactly the same concentration of hypochlorite, relatively high copper numbers correspond with only small loss of strength, whilst under others a comparatively small increase in this property is accompanied by considerable weakening. On the other hand, however, all the tables show that increasing chemical attack of the regenerated cellulose types of rayon is always accompanied by an increase of fluidity.

The relations found between the fluidity and percentage strength of both the dry and wet rayon yarns now examined are shown by the curves of Figs. 3 to 6. Curve 1, Fig. 3, is obtained from the collected results for

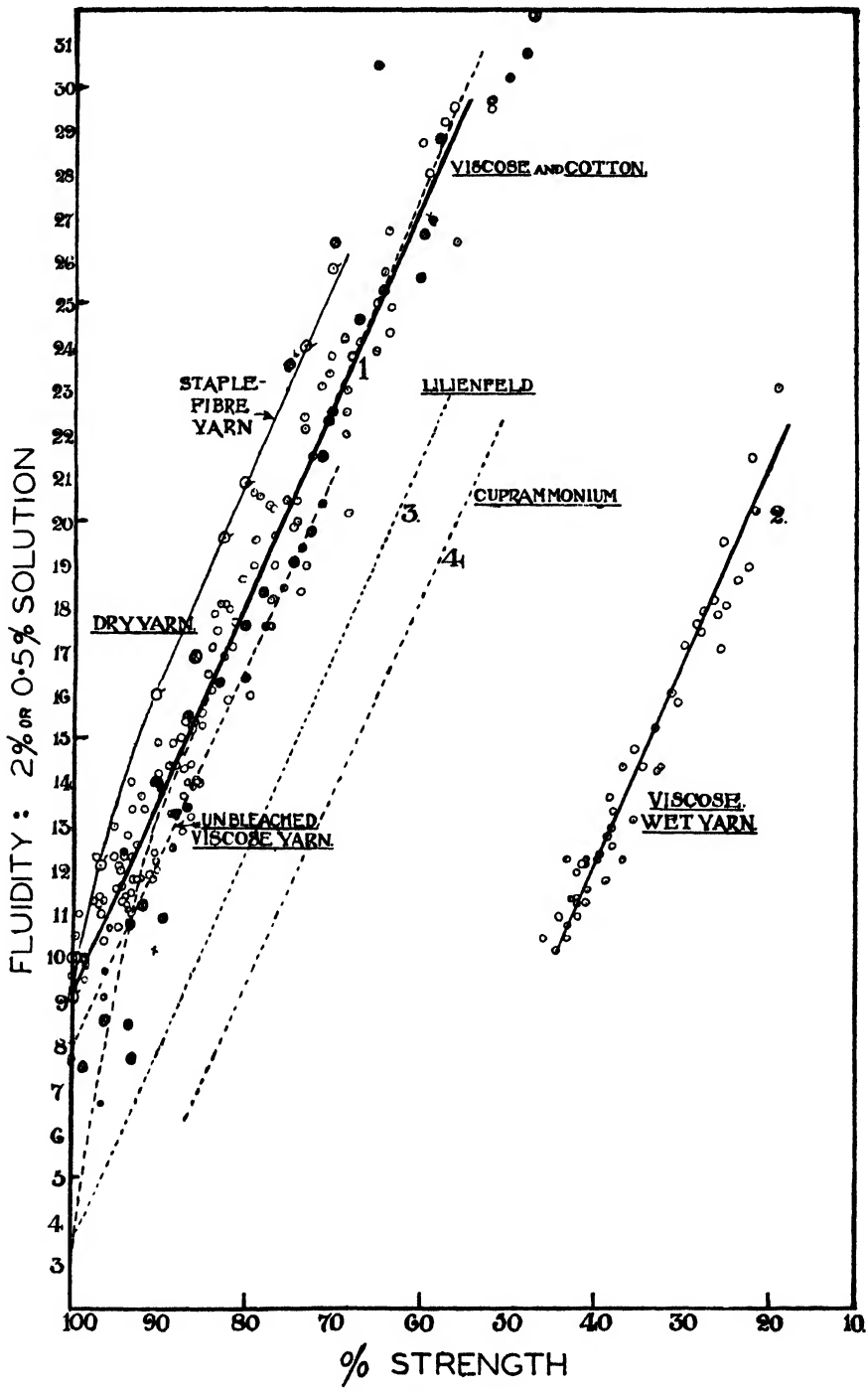

FLUIDITY : 2% OR 0·5% SOLUTION
% STRENGTH
VISCOSE AND COTTON
STAPLE-FIBRE YARN
LILIENFELD
CUPRAMMONIUM
DRY YARN
UNBLEACHED VISCOSE YARN
VISCOSE WET YARN
1
2
3
4
8

FIG. 3

all the varieties of bleached viscose yarns in the dry state and shows that this relation is best represented by a straight line, and since the points plotted include those obtained for all the different *p*H conditions investigated, the relation is independent of the precise acidity or alkalinity of the bleaching liquors used. Figs. 4 and 5 (corresponding to Tables VIII and IX, respectively) show that the same obtains for the Lilienfeld and cuprammonium rayons.

This behaviour is exactly analogous to that previously found by Clibbens and Ridge[4] for cotton yarns oxidised with hypochlorite solutions of similar *p*H values, and furthermore, the relations established for cotton and viscose rayon correspond with one another to an unexpected degree. Thus if the values previously given in Table I of the paper on cotton, together with others now obtained (Table X) are plotted in Fig. 3 of the present paper (see crosses), the points are found to lie on one and the same curve except for the initial stages of oxidation. Hence, after these preliminary stages, the same percentage loss of strength of both cotton and viscose yarns corresponds with the same rise of fluidity for both materials, although in the one case the concentration of the cellulose-cuprammonium solution is 0·5 per cent. and in the other 2 per cent.

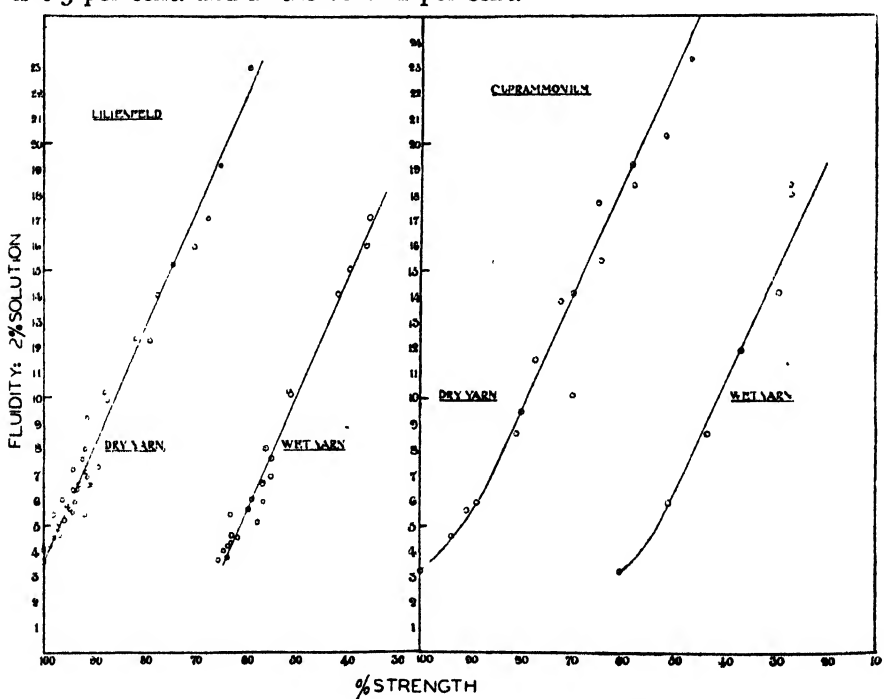


FIG. 4 FIG. 5

The coincidence of these curves is to be regarded as entirely accidental, although it might perhaps be just possible that the ratio of these concentrations bears some relation to the mean length of the micellar chains in the cotton and viscose rayon respectively.

For the dry yarns a rise of fluidity of 5 units corresponds with a loss of strength of both cotton and viscose rayons of approximately 10 per cent. Fig. 4 shows the relation obtained for the chemically modified Lilienfeld, and Fig. 5 that for the cuprammonium yarn, and, except for the initial

stages of oxidation, here also straight lines are obtained, whilst if these curves be included in Fig. 3 (see dotted curves 3 and 4 respectively), they are both found to run parallel to the curve for the viscose yarns, although, since the fluidities of the original unmodified materials are here much less than that of the normal viscose rayons, they lie below it.

Furthermore, the corresponding curves in all these diagrams showing the relations for the yarns tested for strength in the wet state run parallel to those for the dry yarns; in other words the curves establishing the fluidity-strength relations for plain cotton and for all the regenerated cellulose rayons in both the dry and wet states are all parallel to each other, so that for all these materials a given rise of fluidity always corresponds with the same percentage decrease of strength, and this affords an unexpected and very convenient relation between the various types of yarn.

For the sake of simplicity in Fig. 3 (curve 2), the wet strength relation is shown for Samples B_1 and B_2 only, but the similar relations for the other samples, including those for unbleached as well as the ordinary technically bleached yarns, are shown in Fig. 6, where the corresponding curve for the dry materials is also given for comparison. Here it is shown that although the various kinds of material may have the same dry strength relation, different curves may be obtained for the wet yarns from different firms and also for different yarns from the same firm. Thus samples E and F appear to have a slightly lower percentage wet breaking strength for the same fluidity than have samples B_1, B_2 and C; also sample D_1 obtained in 1930 has a significantly lower wet strength than have the bleached or unbleached materials D_2 and D_3 from the same firm that were produced by a modified process and delivered at the Institute in 1932. The unbleached yarn marked Lot II (Table VIIA) is, in fact, characterised by a higher percentage wet strength for a given fluidity than obtains with the other viscose yarns examined, although the corresponding bleached yarn (Lot II bleached), and also Lot I unbleached and bleached, give a fluidity-strength curve that is intermediate in position between those for samples B_1, B_2 and C, and samples E and F, respectively, and are therefore normal in their behaviour.

On account of the low fluidity of the original unmodified and unbleached yarns of Lots I and II (Tables VIA and VIIA), these materials also give a curve for the dry-strength fluidity relation which is somewhat displaced from that for all the different varieties of bleached yarns, although, again, the corresponding technically bleached yarns are normal in this respect.

Here it must be emphasised that the results obtained apply to the particular samples of yarn actually examined, and if yarns from other deliveries from the same or from different producers were tested similarly it would be expected that minor variations would be found in their fluidity and strength relations, although the slope of the curves should be the same.

From the curves of Figs. 3 and 6, it is seen that the wet strength of unmodified (technically bleached) viscose yarns is roughly only 45 per cent. of that of the corresponding dry material, and since the curves representing the fluidity-strength relations for the wet are parallel to that for the dry yarns, the oxidised yarns also lose about 55 per cent. of their strength on wetting with water. This fact is of considerable technical importance since it shows that the loss of strength of yarns that have been overbleached may become very serious indeed when the material is wetted. For example,

a yarn overbleached in such a way that its fluidity is about 17—a figure sometimes encountered with technically processed fabrics—has lost about 17 per cent. of its original strength; this loss is not very important so long as the yarn is kept dry, but on wetting, its strength is further reduced to only 30 per cent. of the original value, and it is therefore readily understood

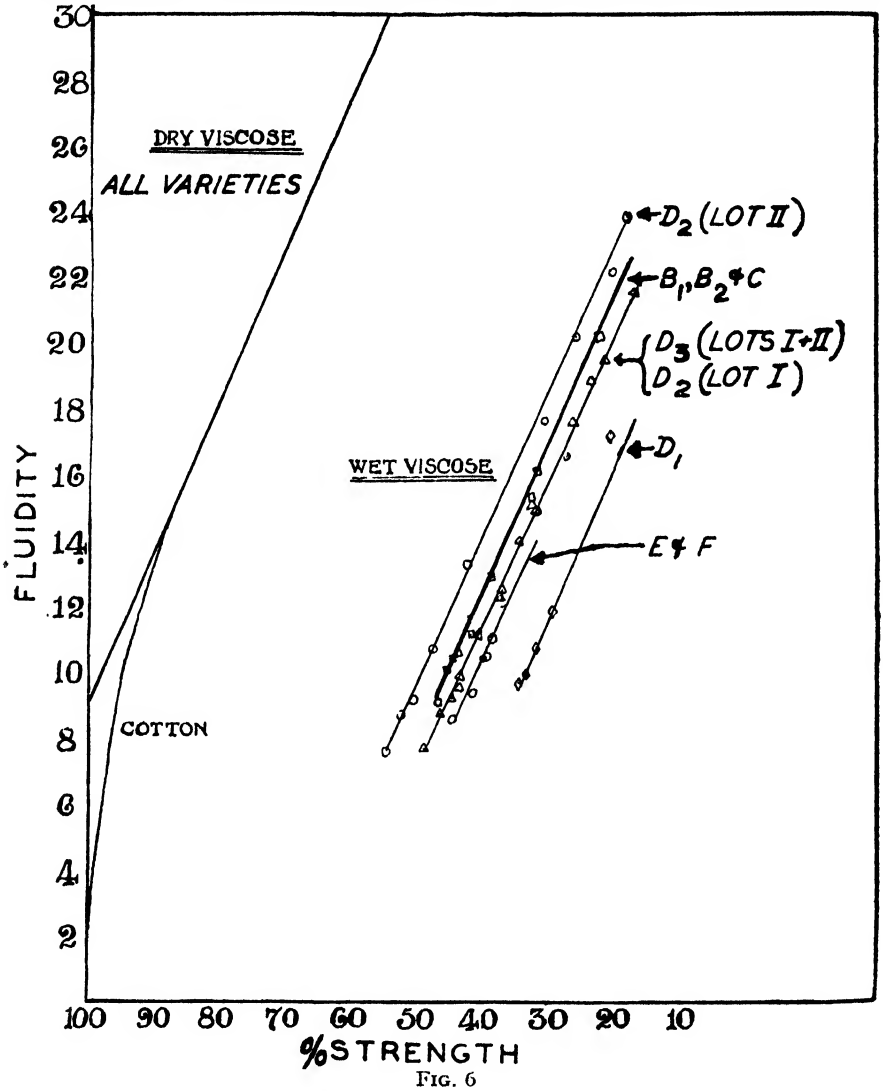


FIG. 6

why breakdown of the viscose threads occurs sometimes in the wet processing of rayon or cotton-rayon cloths that have been somewhat severely treated with hypochlorite solutions. The more severe is this overbleaching treatment, the more serious becomes the loss of strength on wetting, because whatever is the loss due to the oxidising treatment alone, there is always a additional loss of over 50 per cent. when the rayon is wetted. Referen is made to this again in discussing the effects of boiling the modified yar with alkaline liquids.

The loss of strength on wetting the Lilienfeld rayon is not so serio

as that for viscose yarn since it amounts to only about 35 per cent. instead of 50 to 55 per cent. of the strength of the dry yarn, and further, the actual breaking load of the former (160 den.) is roughly 2½ times that of a viscose yarn of the same denier, so that even after a high percentage loss of strength the Lilienfeld yarn would still be relatively strong. The cuprammonium rayon, with roughly the same breaking load as the viscose (150 denier yarns), loses about ⅘ per cent. of its strength on wetting and is therefore intermediate in this respect between the Lilienfeld and the viscose yarns.

Examination of the curves of Figs. 3 to 6 leaves little doubt that the relations found are best represented by straight lines, but the scatter of the points plotted is somewhat greater than could be desired, and therefore, the best straight line representing the relation was found by arranging the fluidity values in order of increasing magnitude, deriving the equation to this line by the method of "Zero Sum"[1] and then drawing the lines as shown. Some equations thus obtained are:

	Dry Yarns	Wet Yarns
1. Cotton	$F = 57{\cdot}6 - 0{\cdot}495B$	
2. Viscose	$F = 54{\cdot}5 - 0{\cdot}45B$	$F = 30{\cdot}6 - 0{\cdot}46B$
3. Lilienfeld	$F = 48{\cdot}5 - 0{\cdot}45B$	$F = 32{\cdot}4 - 0{\cdot}45B$
4. Cuprammonium	$F = 44{\cdot}8 - 0{\cdot}44B$	

(where F = fluidity and B = % strength)

and from these, or by examination of the curves, it is evident that within the limits of experimental error, the curves are all parallel, and those for cotton and viscose rayon are coincident after the initial steep portion of the cotton curve is passed.

It has long been known that individual tensile strength results for yarns spun from natural textile fibres show considerable variations for one and the same material and that a comparatively large number of tests is necessary in order to give reliable mean values. Rayon yarns, however, are much more uniform, and a minimum of 100 tests on each preparation could be regarded as adequate. In spite of this and of the fact that every care was taken to avoid mechanical damage to the filaments before testing, the scatter shown was obtained, and the following factors may have contributed to this: first, mechanical damage that is not reflected by the fluidity value may actually have occurred in some cases; secondly, absolute uniformity of chemical attack may not have been secured in all cases; thirdly, slight variations in the atmospheric humidity conditions during testing may have had more serious effects on the breaking load than has hitherto been realised, and fourthly, variations in the strength of the yarn obtained from one and the same hank may have occurred which would cause some of the eight test sections obtained from it to have different mean breaking load values. Thus the following results have been obtained by taking 100 threads at random from each of the eight sections from re-wound hanks and breaking them under identical conditions.

Viscose Yarn.

Section No.	1	2	3	4	5	6	7	8
				Hank 1				
Breaking load, g. ...	255·1	252·5	258	254·3	256·5	257·8	256·7	258·5
Per cent. on the lowest	101·0	100	102·2	100·7	101·6	102	101·6	102·3
				Hank 2.				
Breaking load, g. ...	252·3	258·1	254·3	252·1	245·1	259·4	258·6	255·6
Per cent. on the lowest	102·9	105·3	103·7	102·8	100	105·8	105·4	104·2

There is no significant difference between the values for hank 1, and only a very small difference in percentage strength would be obtained by using as a control any one of the eight sections instead of any other. In hank 2, however, greater variations are found which, in some cases, represent the same order of magnitude as is shown by the scatter of the points plotted in Fig. 3, and it is thus possible for variations of a few per cent. to occur in this way.

(2) Extensibility Changes in Modified Rayon Yarns

As is well known, the percentage extensibility of rayon yarns varies within fairly wide limits according to the method of their manufacture; thus, whereas the present dry viscose yarns have values of 16 to 25 per cent., most acetate yarn is more extensible (23 to 30 per cent.), the cuprammonium rayon is only slightly less extensible than viscose (16 to 18 per cent.), and the Lilienfeld variety is comparable with cotton yarn since its extensibility is only about 7 to 8 per cent. (Tables I to IX and XVIII). On wetting with water, the Lilienfeld yarn shows a slight decrease in this property, whilst the other varieties show an increase which is considerable for the cuprammonium material.

With the exception of the acetate yarns, however, for which rather variable results are found, and which are shown to be more resistant to attack by hypochlorite liquors, all these materials show a progressive decrease of extensibility with increasing chemical modification of the cellulose. The decrease is small for Lilienfeld and cotton yarns in both the dry and wet states, but is marked for dry viscose and cuprammonium rayons, and even greater for the corresponding wet yarns, so that oxidation with, for example, a neutral hypochlorite liquor for a few hours results in a reduction to half the value recorded for the unoxidised yarn (see Tables I to IX and XVIII). Examination of Table I shows further that the ratio of percentage breaking load to extensibility for dry viscose yarns is approximately constant over the range of oxidation investigated. Hence the overbleaching of these rayons adversely affects two of their most important textile properties—strength and extensibility.

(3) The Effects of Boiling Modified Cotton and Viscose Yarns with Dilute Alkali

The loss of strength on subjecting chemically modified cotton yarns to alkali boiling treatments has already been investigated by Clibbens and Ridge,[4] and for purposes of comparison with the values obtained with rayon, the results obtained by them are included with others obtained on cotton during the present work.

In the experiments now described, hanks of the purified Sakel and Tanguis yarns were divided into bundles 14 inches long by the cut-skein method mentioned above, and, together with similar bundles of viscose yarn B_1, were treated with 0·04*N* hypochlorite solutions at various *p*H values for different times at 25° C. Each bundle was oxidised in a separate tube, but otherwise the conditions of treatment were identical. After the usual washing, each bundle was split into halves, one of which was reserved for tests on the yarn not boiled with alkali, whilst the remainder were boiled as described in the experimental section, and finally breaking load and fluidity measurements were made on all the samples. Results of these tests are given in Tables XI to XIII and plotted in Figs. 7, 8, and 9.

Figure 7 shows the rate of loss of strength of the cotton and viscose

yarns with increasing time of oxidation at both *p*H 7 and 9. With the neutral (*p*H 7) liquor the percentage loss for a given time of treatment is substantially the same whether the yarn in question is viscose rayon or single or two-fold cotton, but for the slightly alkaline bleaching liquor at *p*H 9 the rayon loses a greater percentage of its strength than does the cotton yarn. At this *p*H, however, the chemical attack is much less rapid for both kinds of yarn than at *p*H 7; for example, a loss of strength of the viscose rayon amounting to 13 per cent. is produced in six hours with the former, whereas only two hours are required with the latter liquid.

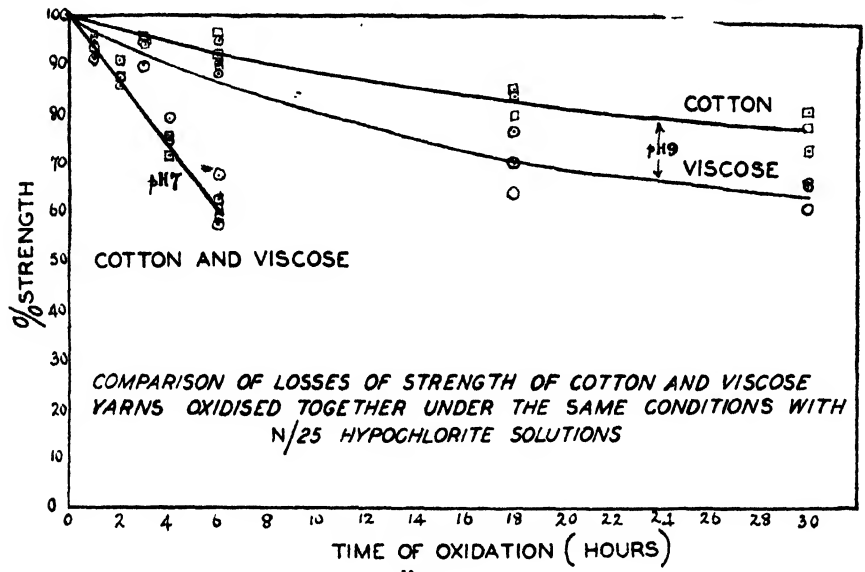


FIG. 7

The effects of boiling with alkali are shown by Figs. 8 and 9. In the former, strength before boiling is plotted against the corresponding strength after this treatment, and curves 1, 2 and 3 show the behaviour of cotton oxidised at respectively *p*H 11·2 (most alkaline), 9 (less alkaline) and 7 (neutral)—curve 1 being taken from the paper on cotton already referred to[4]—whilst curves 4 and 5 illustrate the effects for viscose yarns treated with the bleaching liquid at respectively *p*H 9 and 7.

The losses of strength produced on boiling in this manner are shown to depend on the conditions of the previous oxidation treatment. For cotton, as already shown,[4] when the modification is due to a bleaching liquor as alkaline as indicated by *p*H 11·2, little further change of strength occurs on boiling, but the loss so occasioned becomes greater for the less alkaline oxidation at *p*H 9, and is considerable when a neutral liquid is used. The same obtains for viscose rayon; yarns oxidised with a neutral liquor show a greater loss of strength than do those modified in an alkaline one, and further, when the unboiled material has been considerably weakened by the oxidation, the weakening on boiling appears greater for viscose than for cotton yarns.

It should be noted, also, that whereas scoured but chemically unmodified cotton yarns are not significantly affected by re-boiling, normal viscose yarns lose about 10 per cent. of their strength after the same treatment.

This is no doubt due mainly to loss of weight of the material, since, as shown previously,[13] unmodified first quality viscose yarn loses about 8 per cent. in weight as a result of boiling with dilute sodium hydroxide solutions.

The boiling treatments given to both cotton and viscose yarns in the present case were the same, but in the previous work the cotton materials were kier-boiled under pressure, and from the fact that the points obtained for yarns oxidised in neutral hypochlorite and then kier-boiled lie on the curve now found for the milder conditions of boiling (Fig. 8, curve 3), the conclusion is drawn that [illegible] ame effect as a pressure boil in reducing f [illegible] ed yarns.

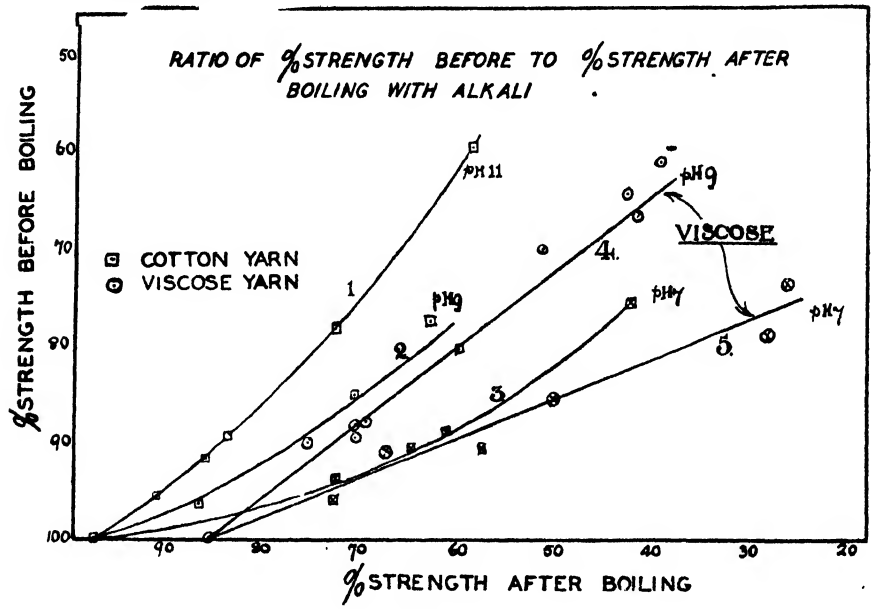


FIG. 8

The fluidity-strength relations for the boiled and unboiled cotton and viscose materials are shown by Tables XII and XIII, and Fig. 9. Curve 1 of this diagram is identical with curve 1 of Fig. 3 and is included for comparison —it shows the relation for oxidised but unboiled cotton and viscose yarns— whilst curves 2 and 3, respectively, show the corresponding relations for these materials after the open boiling treatment described. Curve 2 lies very near to, but slightly to the right of, 1, whilst 3 deviates considerably from them. It is evident, therefore, that a given fluidity value corresponds with a slightly greater loss of strength for the boiled than the unboiled cotton yarns, although, again, a rise of fluidity of 5 units corresponds with a further loss of strength of about 10 per cent.; moreover, this relation holds whether the cotton was originally oxidised by neutral or alkaline hypochlorite, thus again confirming the previous conclusions drawn by Clibbens and Ridge.

For the viscose yarns, however, a given fluidity corresponds with a much greater loss of strength for the boiled yarns than obtains with cotton, and a rise of 5 units now indicates a further loss of strength of about 17 per cent.; nevertheless, this relation again holds whether the overbleaching originally occurred in a neutral or alkaline liquor. Thus from Fig. 9 it is seen that cotton and viscose yarns having a fluidity of, say, 18, have both lost about

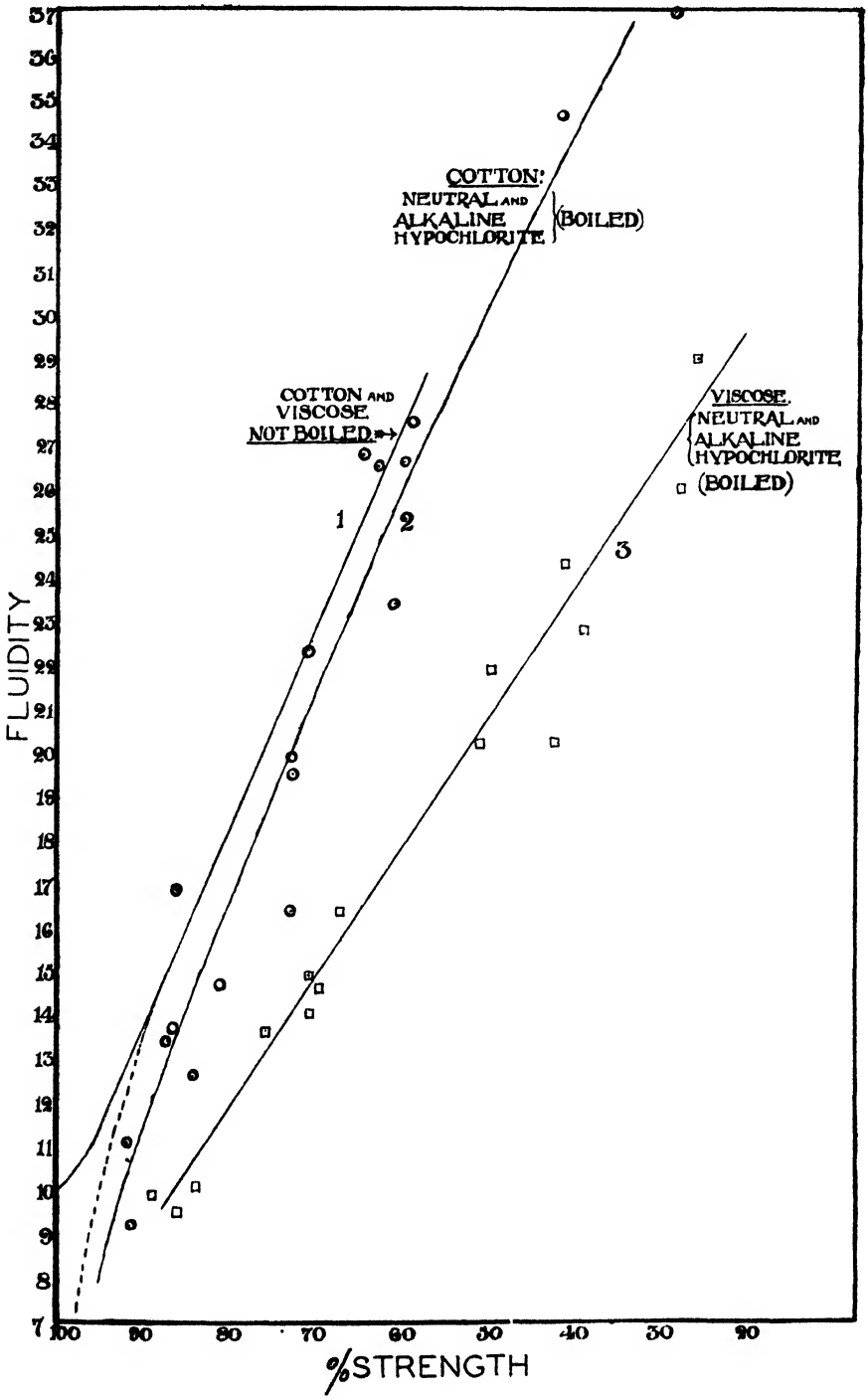

FLUIDITY
%STRENGTH
COTTON:
NEUTRAL AND ALKALINE HYPOCHLORITE (BOILED)
COTTON AND VISCOSE NOT BOILED
VISCOSE.
NEUTRAL AND ALKALINE HYPOCHLORITE (BOILED)
1
2
3

FIG. 9.

20 per cent. of their original strength provided that they have not been boiled, but if this has occurred, the same fluidity corresponds with a loss of about 23 per cent. for cotton and 40 per cent. for viscose rayon.

The changes of fluidity resulting from such boiling treatment are also shown by Tables XII and XIII and are illustrated by Fig. 10. The horizontal pairs of values in the tables are strictly comparable, and in the diagram those for the unboiled are plotted against those for the corresponding boiled material. Here it is apparent that whereas little effect is produced by boiling unoxidised viscose or cotton, the oxidised yarns invariably show an increase of fluidity as a consequence of this treatment, and, in general, the increase is greater the more severe has been the oxidising process. Under

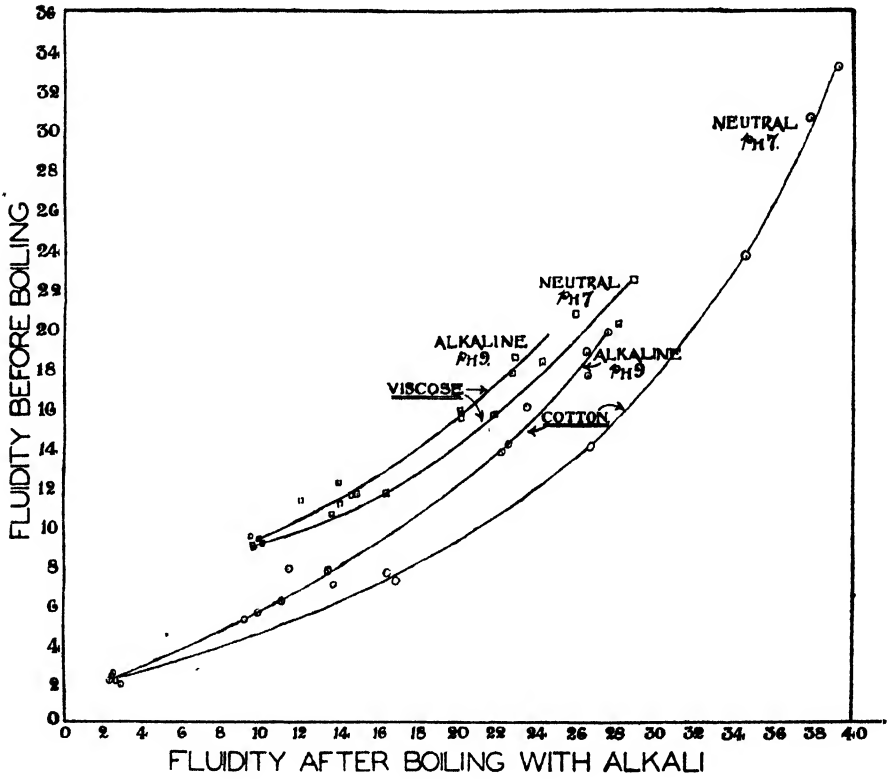


FIG. 10.

some conditions of comparatively mild oxidation the fluidity of cotton after boiling may be even more than twice the corresponding value for the unboiled material—a truly remarkable increase. It has previously been shown for cotton that the fact that the fluidity of oxidised materials increases as a consequence of boiling with alkali, whereas that of acid-attacked cellulose does not, affords (in some circumstances) a means of distinguishing between these two types of chemical modification, and work still in progress in these laboratories shows that the same is true for rayons of the regenerated cellulose varieties.

Figure 10 shows further that when cotton or viscose yarns are overbleached in a neutral hypochlorite liquor, boiling with alkali produces a greater increase of fluidity than when the oxidation occurs in an alkaline solution; furthermore, a greater rise for materials of the same original value is generally found for cotton than for viscose yarns under the particular conditions of measurement—0·5 per cent. concentration for cotton and 2 per cent. for viscose rayon in the cuprammonium solution—here employed.

(4) The Effect of Milder Boiling Treatments

The boiling treatments given above are perhaps severe for rayon materials, since attempts are generally made to keep the scouring or washing processes as mild as possible, but considerable losses of strength and increases of fluidity are occasioned by processes much less drastic than that with 1 per cent. caustic soda. Thus Tables XIV and XIVA show the effects on these properties of submitting, respectively, overbleached and unmodified cotton and viscose yarns to boiling treatments for two hours with various liquids. The fluidities of the oxidised but unboiled yarns were respectively 12·5 and 18·9, which represent losses of strength of the original materials of 11 per cent. for the cotton and 21 per cent. for the viscose rayon With the viscose yarn it is seen from Table XIV that water alone produces a significant rise of fluidity accompanied by a further loss of strength of 10 per cent.; the soap, soda ash, mixed soap and soda ash, and the 0·5 per cent. caustic soda liquors, however, all produce an increase of fluidity to approximately the same value (25), but the strength of the yarn decreases progressively with increasing severity of the boil. Even the 0·2 per cent. soda ash solution—a fairly common scouring liquor for rayon materials—has reduced the strength to about 50 per cent. of its original value before oxidation. The results with the cotton yarn are similar, but the decrease in strength here is not so great. Table XIVA, which illustrates the effect of the same liquors on the unmodified materials, shows that whilst cotton loses a negligible proportion of its strength, the viscose rayon may lose up to 10 per cent. under the most severe conditions of boiling employed. The change in fluidity is, however, unimportant in both cases.

As already mentioned in the first part of this paper, a remarkable example of this effect of the treatment of chemically modified fabrics with alkaline washing liquids is given on washing curtains containing cotton and rayon yarns which have been exposed for some time at a window, when, although the fabrics are still quite strong before washing, they may afterwards develop holes or actually fall into rags in spite of the fact that the washing process was very mild. In this case the chemical attack of the curtain material must be considered due to the action of light and the atmosphere at the window (and of course it may not necessarily be wholly an oxidation effect), but since some dyes are known to accelerate the chemical modification of cellulose, it may be that the particular dyes used in finishing the cloth are of importance in determining the extent to which the tendering before washing occurs.

Dry cleaning with, for example, petrol does not produce the same marked loss of strength of the curtain fabrics as is occasioned by the boiling or washing treatment with alkaline liquids, and if the curtains have been in use at a window for some time it would appear desirable to use some such dry cleaning method in order to avoid the development of the tendering probably already latent in the material.

(5) The Significance of the Fluidity Test as Applied to Defective Samples of Rayon and Cotton Materials

From the results established above, it follows that scouring, washing, or even some dyeing processes may cause approximately the same increase of fluidity of the overbleached material, but the more severe the treatment, that is, the more alkaline the liquor, the greater is the loss of strength produced, and in the examination by means of the fluidity measurement of cloths or yarns suspected of having been chemically damaged, it is highly important to take these effects into consideration in judging the extent to which they have been weakened. Thus, suppose a piece of cloth or a garment has been returned as defective, and that fluidity tests are made in order to determine whether the damage is due to excessive attack by chemical agents; then the actual values obtained depend not only on the original oxidation (chemicking) treatment, but also on whether the material has been subsequently laundered or washed, and if it has been washed, the treatment may have been too mild to increase the fluidity to its maximum. Furthermore it is often very difficult, if not impossible, to ascertain whether washing has occurred or not. An intermediate fluidity value may therefore be obtained that cannot be related definitely to any corresponding loss of strength, and when the values for the material as received are near to 10 for cotton and to 12 to 13 for viscose rayon it is often desirable to know whether these result from the chemical attack alone, or whether they are due to overbleaching followed by a washing treatment, since in the former case the technical processing of the original cloth in the works would probably have been too severe, whereas in the latter it would be above suspicion.

The necessity for a treatment of the material with hot alkali before fluidity measurements are made, so that a value may be obtained from which the damage due to the chemical attack itself can be reliably assessed, is therefore apparent, and for this purpose it is the practice in these laboratories to subject the cloth or yarn to a boiling treatment with 1 per cent. caustic soda solution for half-an-hour, followed by washing with acid and water, before the tests are made. The value for the corresponding modified but unboiled material (which correctly indicates the loss of strength due to the oxidising attack alone) is then found, if desired, from the curves of Fig. 10. Only in this way can the true significance of the fluidity values be ascertained. If the original modification of the cellulose is caused by acid attack, washing or boiling fails to produce any important increase in the fluidity value, but since it is often difficult to ascertain beforehand whether damage has been caused by acid or oxidising liquors it is better to give the preliminary boiling treatment in all cases. The above conditions of boiling are suitable for both rayon and cotton materials, and although milder treatments would probably give the required maximum fluidity (see Table XIV), the use of 1 per cent. caustic soda solution conforms more nearly with the conditions under which the curves of Fig. 10 were obtained. A further possible advantage of measuring the fluidity of a boiled sample is that the value so obtained gives a very good indication of the maximum loss of strength which the material may suffer as a consequence of further laundering or washing treatments.

It is convenient at this stage to review the facts established above from the point of view of their practical importance. First, rayon yarns lose 35 to 55 per cent. of their original dry strength on wetting with water alone,

although this loss is recovered when they are dried; secondly, if they are overbleached a further loss occurs which, for wet yarns, is additional to that experienced merely as a result of wetting, and increases with increasing extent of the chemical modification, whilst finally, if the overbleached material is scoured or laundered a further considerable loss occurs which, again, is greater the more pronounced is the chemical attack of the rayon and the more severe are the conditions of boiling or washing. It is obvious, therefore, that the overbleaching of all-viscose or cotton-viscose goods with oxidising liquors may easily have much more serious consequences than might at first be supposed, and in bleaching such materials it is imperative that the oxidation should be as mild as possible. For this reason the use of processing liquors that are neutral or nearly so should be avoided because they attack cellulose much more rapidly than do alkaline solutions[3] (cf. Tables I and VIII); in fact, since for cotton the control of the alkalinity of such liquors within a *p*H range of approximately 10 to 11 affords a means of securing a good and permanent white with negligible attack of the cellulose, it is recommended that such a degree of alkalinity should be maintained in all bleaching operations where rayons of the regenerated cellulose types are involved, especially as they need but little bleaching to make them white. (Liquors of this alkalinity should not be used for acetate rayons, however, as shown below.)

In some cases of cotton-viscose cloths, for example handkerchief fabrics, where a good white is desirable without loss of strength or lustre in the finished material, it might be better to use a bleached cotton warp in weaving in order to avoid undue chemical tendering of the viscose yarns during the scouring or oxidation treatments necessary for producing a satisfactory white in the finished articles, and to ensure that no great weakening would result from subsequent laundering treatments. This, however, must be determined by considerations of the extra cost involved.

The case of viscose yarns of lower grade that are also chemically inferior has already been dealt with at length in the first part of this paper, and three typical illustrations are given in Table XV for cloths A, B, and C. Values are recorded for the fluidity of the viscose weft removed from consecutive pirn widths, of which the middle one contained the damaged places while the other two appeared quite sound. Similar values for the cotton warp pulled out from the defective parts of the cloth are also included, but they are quite low and show that in no case was the piece bleaching of the cloth excessive. On the other hand, the values for the viscose yarns from the damaged pirn widths are in every case higher than those from the corresponding adjacent portions, so that there is no doubt that it is the weft itself that is defective. Actually, in a few cases, values for the undamaged weft are higher than the lowest figures recorded for the damaged yarn, whereas it might be expected that all yarns having fluidities above a certain value would show damage and those with values below it would remain intact. This is readily explained, however, by the fact that the fluidity is an accurate measure of the *tendency* of the viscose yarn to break down, but whether it does so or not depends to a great extent on the actual conditions of processing or handling the particular piece of cloth concerned.

The values at the end of Table XV are taken from a previous paper[13] and show that variations similar to those recorded for these cloths were also found for lower grade yarns that had never been submitted to any wet

processing, thus confirming the statement that the weft itself is sometimes chemically defective before the cloth is woven. Reference to Fig. 9 shows that even if the high fluidities of the damaged weft from the cloths are partly due to the effect of the scouring treatment with an alkaline liquor, and not wholly to oxidising attack, the range indicated (15 to 22) still corresponds with a loss of strength of 30 to 35 per cent., and if the further loss on wetting be taken into account, it is obvious that such modified weft must be very susceptible to damage by a stronger cotton warp during mangling and other processes.

One of the most important indications of these results is, therefore, that the maintenance of a suitable high standard of chemical as well as physical quality should be among the chief aims of the viscose yarn producer. This, of course, is fully realised by firms of repute, but if cloth manufacturers or merchants are content to buy low grade yarns in the cheapest possible market without guarantee that they are chemically sound, it is to be expected that defects in processed cloths such as those now described will be met with occasionally.

Two points of more theoretical interest arising from the work already described may now be briefly discussed.

In considering to what the loss of strength on boiling modified viscose yarns with alkali may be due, it might at first sight appear that this is explained by the dissolution in the alkaline liquid of some of the cellulose material. Thus it has been shown previously for cotton that the more highly modified is the cellulose, the greater is its loss of weight on boiling with alkali, and therefore the more strength must it lose on account of this loss of weight. There is no doubt that this dissolution effect must be a contributory factor, but it does not fully account for the observed facts. It is the more highly degraded parts of an oxycellulose preparation, i.e. portions of very high fluidity, that are soluble in the liquid (for example, it is the highly reducing and therefore greatly modified parts that are removed, as evinced by the much lower copper number of the boiled residue as compared with that of the modified but unboiled material), and if these highly degraded portions are dissolved away, the residual material should have a lower fluidity than the original degraded cellulose if the above explanation is sufficient. On the contrary, however, the fluidity value for the residual material is much higher after the boiling—in some cases more than twice as high—and if the usual interpretation of the significance of the fluidity measurement is retained, this can only mean that the boiled residue is more chemically degraded, i.e. it has a shorter mean micellar chain length than has the modified but unboiled material. Hence the actual boiling process itself must have a further degrading as well as a dissolution effect, on the modified cellulose. It therefore appears probable that not only does the oxidation cause a shortening of the micellar chains of the original cellulose, which results in some reduction of strength, but that it also produces weak places in these chains without actual rupture, and that the final rupture or hydrolysis at these weakened places is produced by the action of the hot alkaline liquors, thus giving rise to a further loss of strength on boiling. In other words, alkali boiling develops latent damage in modified cellulose and results in the further rise of fluidity and loss of strength.

Thus in the case of the curtains mentioned above, the washing process

itself cannot be held responsible for the marked loss of strength; the tendering is actually due to the chemical modification of the cellulose that occurs as a result of the exposure at the window, and the washing merely reveals more damage already latent in the component yarns.

With regard to the second, it has already been shown (see Table XIV) that when overbleached (oxidised) cotton or viscose yarns are given increasingly severe boiling treatments with the liquids indicated, the fluidity value for the boiled residue is increased by the water treatment, and further raised by the soap boil, but then remains approximately constant for the more severe processes. The attainment of this constant value is probably explained by what has been said above, namely, that while the fluidity tends to be increased as a result of the hot alkaline treatments it also tends to be decreased on account of the dissolution of the more highly degraded material in the liquor, and thus a state of approximate equilibrium is reached when these two factors balance one another with the result that little further change in the value occurs.

(6) The Behaviour of Mercerised Cotton

It has now been sufficiently well established that no significant increase of fluidity is produced as a consequence of the mercerisation of cotton materials that have not suffered chemical modification,[13] but when oxidised cotton is in question very significant changes occur, and, as already mentioned, the fluidity-strength relation for yarns that have been mercerised before oxidation is quite different from that obtaining for plain yarns.

When the mercerisation process *follows* oxidation, a reduction in the strength of the yarns occurs that is similar to, but perhaps even greater than, that produced by boiling with alkali. For example, it has been shown previously[4] that when cotton yarns that had been modified by neutral hypochlorite in such a way that their loss of strength was approximately 10 per cent. were mercerised and re-tested, their strength was only 76·2 per cent. of its original value, but reference to Fig. 8 shows that this loss is greater than would normally result from an alkali boiling treatment of such material.

The oxidation of yarns that have already been mercerised, however, is characterised by a very marked rise of fluidity for a relatively small decrease of strength, as illustrated by the values recorded in Table XVI and plotted in Fig. 11. Curve 1 in this diagram again shows the fluidity-strength relation for plain (unmercerised) cotton and viscose yarns, whilst curve 2 shows the relation for mercerised cotton. From these it is apparent that a given rise of fluidity corresponds with a very much smaller decrease of strength for the mercerised than for the unmercerised yarn: fluidities of 14 to 16 scarcely indicate overbleaching, whilst a value as high as 29 means a loss of strength of only about 20 per cent., whereas the same figure for plain cotton or viscose rayon would correspond with a loss of over 40 per cent.

When the mercerised and oxidised yarns are given an alkali boiling treatment their strength is considerably reduced, and then their fluidity-strength relation is nearer to that found for plain cotton yarns, as shown by the second part of Table XVI, and curve 3 of Fig. 11.

(7) The Fluidity-Strength Relation for Modified Staple-Fibre Viscose Yarns

It will be noticed in Fig. 3 that the difference between the curves showing the fluidity-strength relations for cotton and viscose consists in the fact that whereas the curve for the latter is linear throughout the length examined, that for cotton shows an initial curved part which slopes steeply upward

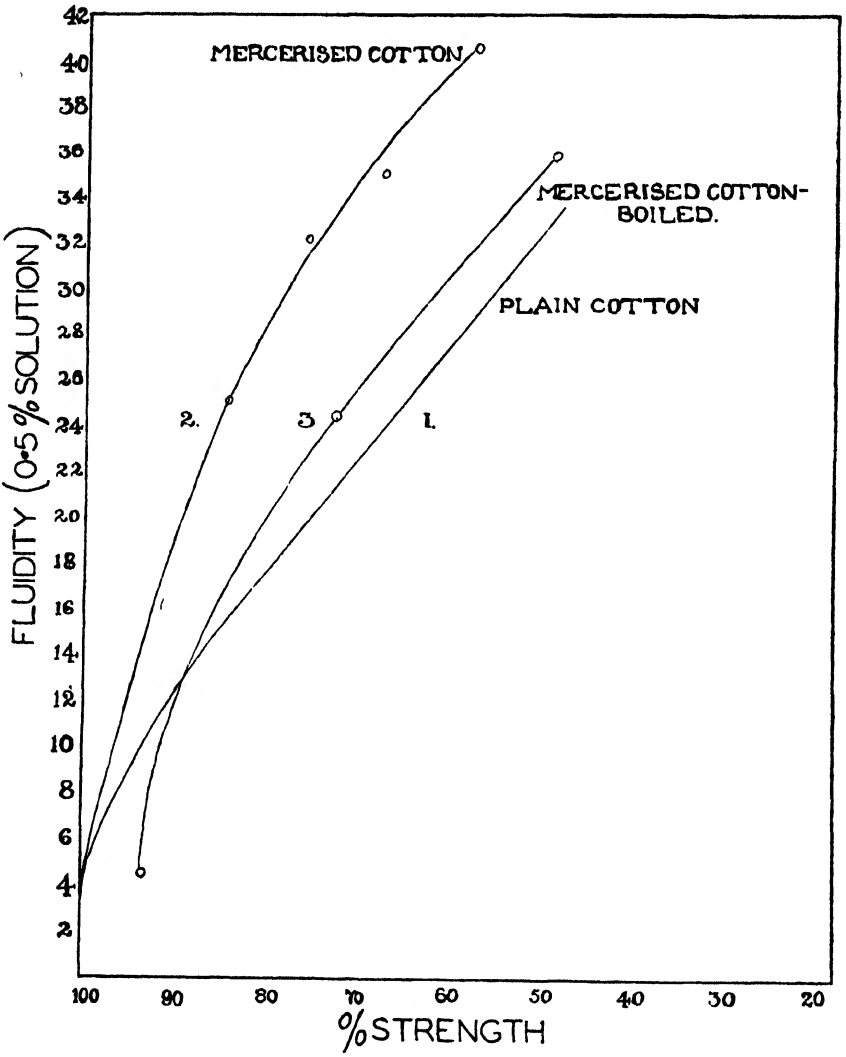


FIG. 11.

until eventually it becomes coincident with the viscose line. Since the rayon yarns used in this work, and which all give the strictly linear relations, were of the continuous filament type, whereas, of course, cotton yarns are composed of short individual fibres twisted together to form the threads, it was of interest to find how a staple-fibre yarn spun like cotton from short lengths of viscose rayon filaments would behave.

Samples of a viscose staple-fibre yarn spun at the Institute were accordingly oxidised in the same way as the normal viscose and cotton yarns and their fluidity-percentage strength relation was determined in the usual way. The results are given in Table XVII, whilst the curve so obtained for the dry material is included in Fig. 3, and it is at once obvious that it shows the same initial curved part as the cotton curve, in fact it runs parallel to the latter. Hence it appears that the same factor controls the shape of both the staple-fibre and cotton curves, and this is probably the

slippage over one another of some of the component hairs or filaments in these threads during the actual breaking of the samples on the testing machine. Such slippage is, of course, impossible in continuous filament yarns, but the possible explanations of this and of other points arising from the present work will be discussed in a later publication.

(8) The Fluidity-Strength Relation for Acetate-Rayon Yarns

It has already been mentioned[13] that the fluidity of acetate rayon materials has a different significance from that associated with yarns or fabrics that are composed wholly of cellulose. This is due to the fact that here the fluidity itself may be affected in two different ways, namely by hydrolysis of the material with alkaline liquids, whereby the acetic acid residues are split off from the cellulose acetate compound, and by modification of the cellulose itself by oxidising agents or acids. When the former alone occurs, increasing hydrolysis results in a *decrease* of fluidity because the residual material is richer in cellulose and poorer in acetic acid residues ; for instance, in preparing 2 per cent. solutions in cuprammonium for fluidity tests, the liquid containing unhydrolysed acetate rayon is only about 1·24 per cent. in actual cellulose, but with progressive hydrolysis this concentration approaches nearer and nearer to 2 per cent., and finally reaches this value when all the combined acetic acid has been removed.

On this account one might expect to find a simple relation between the degree of hydrolysis and the fluidity of the hydrolysed products. Further, since the removal of acetic acid residues from the acetate rayon represents a direct loss of weight, there should also be a relation between degree of hydrolysis and percentage strength, and therefore between fluidity and strength. On the other hand, when oxidising attack is considered, the fluidity of the material may be increased as a result of oxidation of the cellulose, but decreased as a consequence of hydrolysis if the bleaching liquor is sufficiently alkaline to produce this effect, and no prediction as to the exact behaviour can be made before carrying out an investigation under controlled conditions.

Table XVIII shows the results of an examination of acetate rayon yarn (140 den.) after treatment with buffered solutions of sodium hypochlorite in the same way as the viscose and cotton yarns described above, and the outstanding feature is seen that for times of treatment up to four hours, except perhaps with the neutral liquor of *p*H 7, modification of the material by any of the bleaching solutions used is negligible, whether it is measured by breaking load, fluidity, yield of acetic acid, or copper number. This indicates that the introduction of acetic acid residues into the cellulose gives a product that is much more resistant to attack by the oxidising agent. No doubt this increased resistance is due to the fact that the substituent groups occupy positions in the molecular complex which would otherwise be open to attack, but since acetylation is never complete in acetate rayons (generally only about 2·4 acetyl groups per $C_6H_{10}O_5$ unit are introduced) it may be that the groups already present afford some measure of protection to the cellulose compound against further chemical modification, as in the well-known cases of steric hindrance. Even neutral hypochlorite, which has been shown on many occasions to attack cellulose most rapidly, is here without any very serious effect on the strength of the yarn for some hours, and a significant loss of strength and of acetic

acid occurs, in fact, only with the most alkaline of the bleaching liquors, at *p*H 11. This liquid, which is buffered with sodium carbonate, has a definite hydrolysing action in the absence of hypochlorite, as shown by the fact that yarn treated with the buffer liquid alone, without added hypochlorite, for a period of eight hours, gives a yield of acetic acid of only 43 per cent. instead of the original 52 per cent. (see Blank experiment, Table XVIII, *p*H 11·2 series), whilst further, the strength of the yarn is thereby reduced to 85 per cent. of its original value, a figure that is approximately the same as that obtained for yarn treated for this time in the oxidising liquor of the same *p*H (86·8 per cent.). From this the conclusion is drawn that weakening of the material caused by bleaching acetate rayons with solutions of this alkalinity is due to hydrolysis of the cellulose acetate and not to oxidising attack. It will be noted that treatments with buffer solutions of the other *p*H values in the absence of hypochlorite produce no such loss of strength. A significant increase of both fluidity and copper number is shown, however, when the yarn is oxidised for four hours or more with the neutral hypochlorite liquor, and here, since no loss of acetic acid residues occurs, the cellulose itself must be attacked.

It is very seldom that technical hypochlorite bleaching processes are continued for times as long as four, or even two, hours, unless piling is resorted to, but here it is usual to employ a dilute chemic liquor and to have a relatively small amount of it in actual contact with the fabric, and as the oxidising agent is then used up in a comparatively short time the danger of chemical attack of the material is small.

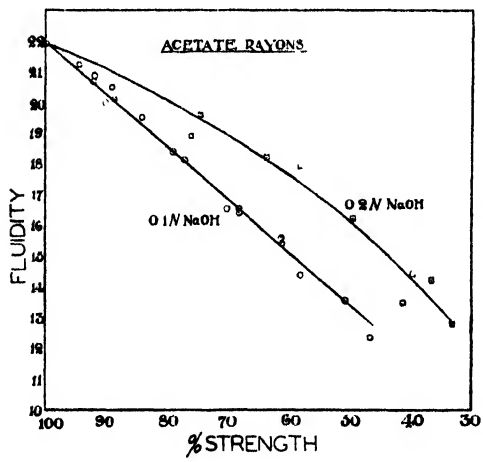


FIG. 12

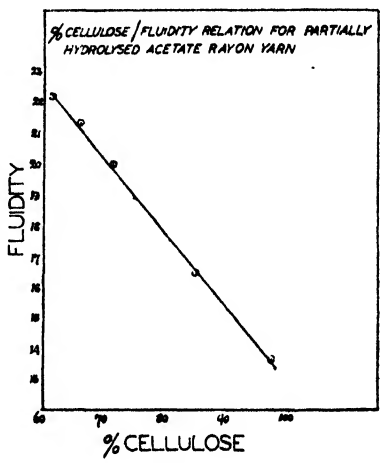


FIG. 13

In order to examine the changes of fluidity associated with progressive hydrolysis, hanks of acetate rayon yarns were treated at 20° C. with 0·1 and 0·2*N* sodium hydroxide solutions for various times as described in the experimental section and their breaking loads and fluidities were measured in the usual way. The results are given in Tables XIX and XX and plotted in Fig. 12, and it is seen that the points fall on two distinct curves, one representing hydrolysis with the less, and the other with the more, concentrated alkali. For the former a linear relation between fluidity and percentage strength is indicated over the greater part of the hydrolysis

range, whilst for the latter the relation is not linear and shows a greater loss of strength for a given fluidity value. When the 0·2*N* sodium hydroxide solution is used a considerable amount of cellulosic material is simultaneously dissolved, as shown by the formation of a gelatinous precipitate on acidifying the liquor, but such is not the case with the 0·1*N* solution and the greater loss of strength under the former conditions is therefore probably due mainly to this dissolution of cellulose. When no such dissolution occurs, the fluidity is found to be very nearly proportional to the percentage of residual cellulose in the hydrolysed material, as shown by Table XXI and Fig. 13, but it is obvious that relations such as those suggested at the beginning of this section obtain only in certain very limited circumstances.

(9) The Fluidity-Concentration Relation

From the results recorded in Table XXII it will be found that in accordance with the Arrhenius equation a linear relation is obtained if the logarithms of the fluidity values are plotted against concentration, whilst if the values $1/m$ and $1/\log \eta/\eta_B$ corresponding to the Farrow and Neale equation (where m is percentage concentration and η and η_B are the viscosities of the solution and solvent respectively) are similarly plotted, straight lines are also obtained. These relations hold at least over the concentration range 0·25 to 2·5 per cent., and although they may not obtain for concentrations higher than about 2·75 per cent. such viscous solutions are outside the scope of the present test so far as its application to textile problems is concerned.

IV. MODIFICATION OF THE FLUIDITY MEASUREMENT FOR RAYONS

(1) A Simplified Procedure for the Determination of Fluidity in Cuprammonium Hydroxide Solution

The fact that a decrease of viscosity (increase of fluidity) of solutions of cellulose in cuprammonium hydroxide is produced when the liquid is allowed to stand in contact with air was well known to Ost,[10] who recorded decreased values for solutions after standing for two and seven days ; and since his results were published many workers who have investigated further the relations between viscosity and chemical modification of cellulose have taken elaborate precautions to exclude all air from their apparatus and to protect the solutions from light. For this reason the apparatus required has tended to become much more complicated, and the procedure somewhat involved, and this has led to criticism of the analytical method on the grounds that it is not sufficiently easy to use. For example, Okada[9] has stated that the operations concerned are " very difficult and complicated " and has proposed to replace the method by one involving nitration of the cellulose and measurement of the viscosity of an acetone solution of the product in an Ostwald viscometer.

The importance of excluding air in the measurement of fluidity depends very greatly on the type of cellulose material under investigation. In order, for example, to obtain accurate measurements on a very lightly scoured cotton, the strictest exclusion of air is necessary. With normal bleached cotton materials special precautions must also be taken to restrict the contact of the solution with air, and the standard B.C.I.R.A. viscometer was designed to enable this to be done without unnecessary elaboration of the apparatus. It seemed likely, however, that for rayon solutions greater latitude could be permitted in this respect, with a further simplification of technique, and the following experiments were made in order to test this possibility.

Sufficient viscose yarn to give respectively 1, 2 and 5 g. of dry material was weighed out and the samples were placed in 250 c.c. stoppered bottles. A few glass beads were added, and then 50, 100, and 250 c.c., respectively, of cuprammonium hydroxide were poured in quickly from a measuring cylinder. The stoppers were replaced and the bottles shaken for a few minutes until dissolution of the rayon was complete. In this way the resulting liquids were all 2 per cent. with respect to cellulose but were in contact with different amounts of air during the dissolution, the completion of which required about five minutes for the smallest, and 15 to 20 minutes for the largest, volume of liquid. The clear solutions were poured into standard B.C.I.R.A. viscometers, placed in a thermostat at 20° C. for a few minutes and run out in the usual way. Control tests were also made on the same original material by the ordinary method, and the results of these and of other experiments, including some for a highly tendered viscose rayon, are given in Table XXIII.

It is evident that no important error is introduced as a result of this modified procedure for rayon materials, and that for ordinary textile purposes there is no significant difference between the values for the controls and those given by the modified method. The different volumes of air enclosed in the bottles also have no effect during the short times required for dissolution. If the liquids are allowed to stand overnight, an increased fluidity is obtained as shown by the value 10·2 for the normal viscose rayon, but there is no object in keeping the solutions for this time.

Hence, for ordinary routine purposes this simplified procedure is satisfactory and much quicker than the usual one, and furthermore, since much larger amounts of material than 0·4 g. can be used, no very great accuracy in weighing the samples is required, whilst if no thermostat is available, the temperature of water contained in any suitably large vessel can be controlled sufficiently well by the addition of warm or cold water when necessary. In this way the adaptation of the method to the requirements of works control processes is simple, and it is suggested that the adoption of the test by rayon manufacturers would permit of the grading of yarns according to chemical as well as physical properties, and the present work shows that as regards bleaching, laundering and other wet processing, the former are at least as important as the latter.

(2) The Effect of Ammonia Concentration on the Fluidity of Rayons

In suggesting the measurement of fluidity as a works control test it is necessary to refer to one factor which may affect the results, namely, loss of ammonia from the cuprammonium liquid during storage. It was shown by Joyner[7] some years ago that, when conditions are otherwise the same, a decrease in the concentration of ammonia produces a more viscous cellulose solution, but the solutions of scoured cotton used by him were very viscous indeed (corresponding with fluidities of less than 1), and it cannot be assumed, therefore, that the magnitude of the effect of a certain decrease in this concentration is the same for much more fluid solutions of tendered cotton or rayons. The following experiments were accordingly made to find the importance of this effect with rayons and also to show how the concentration of ammonia varies under certain conditions of storage and use.

Ammonia was progressively removed from a solution of cuprammonium hydroxide containing originally 240 g. NH_3 per litre by blowing a stream

of nitrogen through it, and at certain intervals some of the liquid was removed and used to determine the fluidity of a sample of viscose yarn that had been cut up finely and thoroughly mixed. Immediately before filling the viscometer, the ammonia content of the cuprammonium solution was determined by the usual method of analysis. The results obtained are shown by Table XXIV, from which it is evident that a progressive decrease of fluidity is obtained with decreasing concentration of ammonia amounting to approximately 0·13 unit for a loss of ammonia of 10 g. per litre. Hence, if a stock solution of cuprammonium hydroxide were kept in, say, a Winchester bottle, from which viscometers were filled in the course of making routine experiments, the loss of ammonia that would occur on removing the stopper from the bottle would cause the fluidity of a standard sample of viscose rayon to be lower if the liquid used were taken from a nearly empty than from a full bottle. The loss under these conditions is not likely to be great, provided that care is taken to replace the stopper each time after pouring out some of the liquid, as shown by the results of the following experiment.

A bottle corresponding approximately in its dimensions to a Winchester was nearly filled with the standard cuprammonium liquid, the ammonia content of which was then determined. At intervals extending over several days the stopper was removed for periods of ten minutes, during which time the liquid was occasionally shaken gently, and the ammonia content was redetermined after each period. The loss of ammonia resulting from this treatment is shown by Table XXV, whilst if the results are plotted it is found to be directly proportional to the time of exposure. It is also evident, however, that if the stopper were left out of the bottle for an hour—a time considerably longer than need be taken in making the possible number of roughly 100 fluidity tests from one Winchester bottle of liquid—the ammonia concentration would fall by only about 10 g. per litre, which corresponds with a decrease of about 0·2 unit in the fluidity of a normal viscose yarn as determined with cuprammonium from a full and a nearly empty bottle. Such a decrease is negligible for purposes of routine analysis.

When the liquid is stored in a vessel under such conditions that nitrogen or other inert gas is admitted as cuprammonium is withdrawn and a solution of pyrogallol is used to exclude oxygen, provided that a tap is placed between the cuprammonium bottle and the pyrogallol container to prevent possible diffusion of ammonia into the atmosphere, the ammonia concentration remains constant for a considerable time as shown by the values recorded in Table XXVI.

Hence, provided that care is taken in the storage and use of the cuprammonium liquid, variations in fluidity values due to loss of ammonia may be considered negligibly small.

The large amount of routine testing involved in this work has been ably carried out by H. S. Cliff, B.Sc., Miss M. Burtles, Miss E. H. Birtwell, B.Sc., and Miss M. Compson, to all of whom the authors' thanks are due.

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Table I

Oxidation of Viscose Rayon B_1 and B_2 with Hypochlorite Solutions at various *p*H values

Time (Hours)	Fluidity	% Breaking Load		% Extension		Copper Number
		Dry	Wet	Dry	Wet	
Oxidation at *p*H 4·6						
0	9·16	100	—	19·9	—	1·1
½*	12·25	97·8	43·6	17·2	18·7	1·52
	9·77	99·2	—	17·6	—	1·32
1*	12·8	93·9	36·7	15·9	15·1	1·77
	10·1	98·3	—	17·3	—	1·51
1½	10·5	94·1	—	19·6	—	—
2*	14·4	88·4	32·6	15·7	13·9	2·59
	11·0	93·1	—	18·7	—	1·76
4*	17·1	81·8	25·9	13·8	9·0	3·70
	11·8	92·6	—	18·0	—	2·26
6*	18·7	80·7	24·0	13·6	8·5	5·0
	11·9	91·3	—	17·4	—	2·91
18	11·64	94·3	—	17·0	—	3·82
Oxidation at *p*H 7.						
0	10·5	100	46·3	20·3	20·8	1·2
½	11·0	100	42·4	19·2	18·8	1·92
	12·3	94·1	37·0	15·4	14·7	—
1	13·7	92·2	33·7	14·2	13·6	—
	15·2	86·4	—	19·1	—	2·76
2	14·3	87·3	33·1	15·9	14·9	4·0
	16·1	84·2	31·5	13·3	12·1	—
4	15·9	82·4	30·8	15·5	12·3	6·0
	19·6	79·4	25·6	13·0	9·2	—
*	25·0	65·3	—	12·8	—	7·81
6	23·1	71·6	19·5	12·1	7·3	—
	17·7	81·6	28·7	14·1	11·8	—
*	29·2	57·6	—	11·0	—	10·43

Table I—*continued.*

Time (Hours)	Fluidity	% Breaking Load		% Extension		Copper Number
		Dry	Wet	Dry	Wet	
Oxidation at *p*H 8.						
0	10·5	100	43·5	19·1	20·7	1·23
½	11·0	96·6	42·2	—	—	—
1	11·3	96·5	41·3	—	—	—
2	12·3 —	93·3 95·3	40·0 41·4	18·0 —	19·3 —	1·89 —
4	13·4	91·8	38·2	17·1	17·5	2·42
18	18·1 20·3	83·3 77·2	25·2 22·0	14·5 —	9·3 —	4·45 —
20	21·5	72·7	22·5	—	—	—
Oxidation at *p*H 9.						
0	10·6	100	—	19·3	—	1·10
½	11·4	94	42·2	—	—	—
1	11·3	97·5	42·4	—	—	—
2	11·6	95·0	41·0	—	—	—
4	12·4	—	38·0	—	—	—
6	13·0	95·2	38·4	—	—	—
18	17·5	83·7	28·4	—	—	—
20	18·0	82·4	28·1	—	—	—
Oxidation at *p*H 11·2.						
0	11·0	100	43·9	17·9	21·7	1·27
½	11·80 10·8	93 94·6	39·0 —	17·7 17·5	19·0 —	1·26 1·16
1	12·4 11·2	90·6 93·8	39·8 —	17·6 17·1	18·6 —	1·26 1·19
2	12·6 12·0	92·7 94·6	38·2 —	16·7 16·3	17·3 —	1·22 1·21
4	14·4 13·4	86·5 93·4	34·8 —	16·3 15·5	14·8 —	1·28 1·28
6	15·3 14·2	85·2 90·2	33·3 —	16·2 14·9	14·6 —	1·31 1·24
8	13·9	86·3	—	15·8	—	1·27
18	19·0 18·2	77·0 77·3	22·6 —	14·1 12·8	9·3 —	1·37 1·46

* Hypochlorite more concentrated than 0·04 *N*.

Table II

Viscose yarn C, oxidised with 0·04 *N*-Sodium hypochlorite Solution at *p*H7.

Time of Treatment	Fluidity	Dry		Wet	
		% Breaking Load	% Extension	% Breaking Load	% Extension
Untreated	9·1	100	25·2	46·4	30·3
¼ hour	10·0	98·5	23·5	44·5	29·6
½ ,,	10·4	96·3	24·9	—	—
1 ,,	12·9	87·5	23·0	38·6	26·9
2 hours	14·4	89·0	20·8	*31·9	21·5
4 ,,	22·1	73·4	17·1	20·5	9·5
6 ,,	23·9	65·5	14·6	—	—
8 ,,	25·3	64·9	12·9	—	—

* Fluidity 16·0.

Table III

Viscose yarn F, oxidised with 0·04 *N*-Sodium hypochlorite Solution at *p*H 7.

Time of Treatment	Fluidity	Dry		Wet	
		% Breaking Load	% Extension	% Breaking Load	% Extension
Untreated	8·1	100	24·5	44·5	21·9
¼ hour	8·7	96·5	21·9	42·7	21·1
1 ,,	12·0	90·3	18·1	36·1	18·3
2 hours	16·5	84·8	17·7	27·7	13·0
4 ,,	22·0	68·9	15·3	15·4	8·2
6 ,,	26·4	56·3	12·8	—	—
8 ,,	29·7	52·4	11·9	—	—

Table IV

Viscose yarn F, oxidised with 0·04 *N*-Sodium hypochlorite Solution at *p*H 7.

Time of Treatment	Fluidity	Dry		Wet	
		% Breaking Load	% Extension	% Breaking Load	%Extension
Untreated	9·3	100	16·1	41·3	16·2
¼ hour	10·4	97·1	15·3	39·4	16·6
½ ,,	11·0	99·2	15·1	38·5	16·6
1 ,,	12·3	94·4	14·7	37·4	15·1
2 hours	14·9	90·3	13·5	32·0	11·8
4 ,,	20·7	79·6	12·5	—	—
6 ,,	33·8	70·6	12·6	—	—
8 ,,	24·3	64·0	10·7	—	—

Table V

Viscose Yarn D_1, oxidised with 0·04 *N*-Sodium hypochlorite Solution at *p*H 7.

Time of Treatment	Fluidity	Dry		Wet	
		% Breaking Load	% Extension	% Breaking Load	% Extension
Untreated	9·6	100	22·8	34·3	23·3
½ hour	9·9	98·4	22·0	33·0	22·0
¾ ,,	10·7	94·6	20·9	31·8	21·9
1 ,,	11·8	92·7	21·1	29·4	19·9
2 hours	17·3	84·3	16·2	21·1	11·1
4 ,,	23·8	67·9	11·4	—	—
6 ,,	28·7	60·1	9·8	—	—
8 ,,	29·5	56·7	7·3	—	—

Table VI

Viscose Yarn D_2, Lot 1, Bleached (1932 Sample) Oxidised with 0·04 *N*-Sodium hypochlorite Solution at *p*H 7.

Time of Treatment	Fluidity	Dry		Wet	
		% Breaking Load	% Extension	% Breaking Load	% Extension
Untreated	8·5	100	23·3	44·4	26·7
½ hour	9·8	99·9	22·2	43·2	27·2
¾ ,,	10·3	102·6	20·5	44·9	28·4
1 ,,	11·1	93·6	20·6	41·6	27·3
2 hours	14·0	86·7	18·0	34·5	21·2
4 ,,	18·8	75·9	14·2	23·4	10·6
6 ,,	22·4	69·0	11·8	—	7·6
8 ,,	24·2	64·1	10·9	—	—

Table VIa.

Viscose Yarn D_2, Lot 1, Unbleached (1932 Sample) Oxidised with 0·04 *N*-Sodium hypochlorite Solution at *p*H 7.

Time of Treatment	Fluidity	Day		Wet	
		% Breaking Load	% Extension	% Breaking Load	%Extension
Untreated	7·7	100	19·5	49·2	32·0
½ hour	9·2	100	20·9	44·7	29·5
1 ,,	10·7	95·7	20·5	—	—
2 hours	12·5	88·5	17·8	36·3	23·5
4 ,,	17·6	78·1	14·6	26·1	14·3
6 ,,	19·4	73·8	12·0	21·4	9·3
8 ,,	20·4	71·8	13·0	18·5	8·5

Table VII

Viscose Yarn D_3, Lot II, Bleached (1932 sample) Oxidised with 0·04 *N*-Sodium hypochlorite Solution at *p*H 7.

Time of Treatment	Fluidity	Dry		Wet	
		% Breaking Load	% Extension	% Breaking Load	% Extension
Untreated	9·5	100	24·2	43·1	20·6
¼ hour	9·5	98·5	21·2	43·1	22·5
½ ,,	11·2	97·1	20·9	40·4	20·9
1 ,,	12·1	94·9	20·6	36·7	19·6
2 hours	15·3	86·6	18·3	32·8	15·9
4 ,,	23·0	68·9	13·8	—	—
6 ,,	25·8	58·6	10·3	—	—

Table VIIa

Viscose Yarn D_3, Lot II, Unbleached (1932 Sample) Oxidised with 0·04 *N*-Sodium hypochlorite Solution at *p*H 7.

Time of Treatment	Fluidity	Dry		Wet	
		% Breaking Load	% Extension	% Breaking Load	% Extension
Untreated	7·6	100	17·4	54·9	27·1
¼ hour	8·7	101·9	19·5	52·6	24·8
½ ,,	9·7	96·2	18·7	50·1	25·5
1 ,,	10·7	99·0	18·7	47·3	24·2
2 hours	13·3	88·7	17·6	42·3	20·0
4 ,,	17·6	82·2	14·9	30·1	12·5
6 ,,	20·2	77·3	13·6	25·7	9·1

Table VIII

Oxidation of Lilienfeld Rayon with Hypochlorite Solutions at various *p*H Values

Time (Hours)	Fluidity	% Breaking Load		% Extension		Copper Number
		Dry	Wet	Dry	Wet	
Oxidation at *p*H 4·6.						
0	3·6 4·35	100 100	65·4 —	7·7 7·8	7·0 —	— 0·78
½	3·90 4·73	95·5 99·4	62·9 —	7·6 7·9	6·7 —	— 1·15
1	4·2 4·94	98·9 97·1	63·5 —	7·8 7·6	6·9 —	— 1·32
1½	5·13	97·0	—	7·9	—	1·44
2	4·5 5·38	92·9 98·1	61·4 —	7·3 7·6	6·7 —	— 1·57
4	5·7 6·4	88·8 93·1	58·4 —	7·0 7·5	6·4 —	— 2·23
6	7·15	94·1	—	7·4	—	2·78
18	6·55	90·9	—	6·3	—	4·10

Table VIII.—*continued.*

Time (Hours)	Fluidity	% Breaking Load		% Extension		Copper Number
		Dry	Wet	Dry	Wet	
Oxidation at *p*H 7.						
0	4·3 4·0	100 100	61·9 —	7·8 7·7	7·3 —	0·98 0·77
½	5·6 —	94·7 91·9	59·1 —	7·7 7·6	7·1 —	1·88 1·84
1	6·6 7·3	90·4 88·8	56·3 —	7·3 7·1	7·0 —	2·77 2·98
1½	9·9	87·1	—	7·5	—	4·40
2 *	10·2 12·2	87·7 78·7	51·3 —	7·2 6·6	6·4 —	4·86 —
4 *	15·0 19·1	74·4 64·6	39·0 —	6·5 5·8	5·4 —	7·52† 8·81†
6 *	17·0 22·9	67·2 58·9	35·1 —	5·9 5·4	5·0 —	9·09† 12·10†
Oxidation at *p*H 8.						
0	3·70	100	63·7	7·5	7·0	0·77
½	4·17	93·3	65·3	7·4	7·0	0·95
1	4·6	96·6	62·9	7·3	6·8	1·15
2	5·1	87·3	57·4	6·7	6·7	1·29
4	—	87·4	59·4	6·8	6·7	1·69
6	6·94	91·1	54·6	7·2	6·4	2·10
23	—	72·5	54·2	6·2	5·5	4·56
Oxidation at *p*H 9.						
0	4·29 4·31	100 100	65·5 —	7·3 7·5	6·9 —	0·82 0·78
½	4·13 4·67	100·2 98·6	64·4 —	7·6 7·6	6·8 —	1·13 1·03
1	4·68 4·84	98·7 100·5	63·1 —	7·4 7·8	6·7 —	1·35 1·11
1½	4·93	97·0	—	7·6	—	1·16
2	5·36 6·70	91·6 101·6	63·0 —	6·8 7·9	6·7 —	1·90 1·22
4	5·96	96·3	58·5	7·2	6·4	2·97
6	8·02 —	91·7 91·7	55·8 —	7·0 7·4	6·2 —	3·62 2·50
8	6·40	94·0	—	6·95	—	2·40
18	9·27	89·1	—	6·6	—	2·61
23	15·90	69·9	35·7	5·9	4·9	—

* Hypochlorite solution more concentrated than 0·04 *N*.
† Copper numbers determined on 1 g. samples.

Table VIII—*continued*

Time (Hours)	Fluidity	% Breaking Load		% Extension		Copper Number
		Dry	Wet	Dry	Wet	
Oxidation at *p*H 11·2.						
0	4·29 4·60	100 100	62·9 —	7·9 7·5	7·0 —	0·78 0·80
½	4·44 5·16	96·9 95·9	56·1 —	7·7 7·6	6·5 —	0·98 0·94
1	5·52	94·1	—	7·6	—	0·93
2	5·82 5·90	95·4 93·6	56·1 —	7·6 7·4	6·7 —	1·10 0·89
4	6·61 7·06	92·8 91·3	56·4 —	7·4 7·3	6·7 —	1·09 0·99
6	7·58	92·4	54·6	7·5	6·5	1·03
24	14·0 12·3	77·2 81·6	41·4 —	6·7 6·3	5·4 —	1·40 1·34

Table IX

Oxidation of Cuprammonium Rayon with Hypochlorite Solutions at various *p*H Values

Time (Hours)	Fluidity	% Breaking Load		% Extension		Copper Number
		Dry	Wet	Dry	Wet	
Oxidation at *p*H 7.						
0	3·8	100	61·0	17·7	24·5	0·47
1	5·9	88·8	51·2	15·3	18·8	2·19
1½*	9·5	80·0	—	12·4	—	3·1
2	8·6	81·0	43·5	13·1	14·5	—
2½*	13·8	72·3	—	10·5	—	5·2
3	11·5	77·4	36·7	11·3	11·5	4·7
3½*	17·7	65·0	—	8·9	—	6·6
4	14·1	69·8	29·4	9·9	8·8	6·1
4½*	19·2	58·3	—	7·2	—	8·0
5	15·4	64·3	27·9	9·2	8·5	7·0
5½*	20·3	51·6	—	6·7	—	9·5
6	18·4	57·7	27·1	7·6	8·0	7·7
6½*	23·3	46·6	—	5·5	—	9·8
Oxidation at *p*H 9.						
0	2·3	100	—	15·8	—	0·5
3	4·6	93·9	—	14·2	—	0·95
6	5·6	90·9	—	13·4	—	1·3
18	10·1	69·6	—	11·2	—	2·1

* Hypochlorite more concentrated than 0·04 *N*.

Table X
Modified Cotton (Unmercerised): Fluidity-Strength Relation.

Fluidity	13·8	14·0	14·0	15·5	16·3	16·4	16·9	17·6	18·4
% Breaking Load	90·0	90·4	90·4	86·9	83·4	80·2	86·0	80·2	78·2
Fluidity	19·1	19·8	21·5	22·3	22·5	23·6	24·6	25·6	26·4
% Breaking Load	74·9	72·7	71·5	70·8	70·5	75·4	67·4	60·3	70·1
Fluidity	26·6	26·9	27·0	28·8	30·5	30·2	31·7	30·8	
% Breaking Load	60·0	58·7	59·5	58·4	65·2	50·4	47·3	48·3	

Table XI
Comparison of Strength of Cotton and Viscose Yarns.
Oxidation at *p*H 7.

Time (hours)	0	3	6	18	30
Viscose (a)	100	90·8	85·2	78·9	57·6
(b)	—	93·2	87·1	74·6	67·3
Cotton 2/50s (a)	100	95·9	90·4	75·1	62·5
2/50s (b)	—	94·4	86·9	71·5	58·4
1/40s	—	91·4	90·4	75·4	60·4
Oxidation at *p*H 9.					
Time (hours)	0	3	6	18	30
Viscose (a)	100	89·5	88·1	69·9	66·6
(b)	—	94·3	94·8	76·8	65·5
(c)	—	89·9	87·7	64·2	61·1
Cotton 1/40s (a)	100	95·4	91·7	84·9	77·3
1/40s (b)	—	—	96·3	83·4	72·7
2/50s	—	93·8	89·8	79·7	80·2

(a), (b), (c) represent different series of experiments made on the same batches of yarn.

Table XII
Effect of Boiling Modified Cotton and Rayon Yarn with Alkali.
Oxidation at *p*H 7.

	Before			After Alkali Boiling		
Time (Hours)	Fluidity	% Breaking Load	% Extension	Fluidity	% Breaking Load	% Extension
Cotton.						
0	2·1	100	7·4	2·3	96·8	8·3
0	2·25	100	6·2	2·4	98·8	7·3
1	7·6	95·9	7·3	16·4	72·9	7·1
1	7·2	91·4	6·9	16·9	86·0	6·9
2	14·0	90·4	6·9	26·8	64·9	6·5
4	23·6	75·4	6·4	34·6	42·2	6·0
6	30·5	65·2	5·9	37·9	29·0	5·6
6	33·1	60·4	5·4	39·3	31·4	6·3
Viscose Rayon.						
0	9·2	100	19·4	9·9	88·8	19·6
1	11·5	90·8	18·5	16·4	67·3	16·3
2	14·7	86·3	16·8	21·9	50·0	13·6
4	19·3	80·8	14·3	26·0	27·9	9·0
6	20·1	73·6	13·1	29·0	26·0	8·5

Table XIII

Effect of Boiling Modified Cotton and Rayon Yarn with Alkali.

Oxidation at *p*H 9.

Before.				After Alkali Boiling.		
Time (Hours)	Fluidity	% Breaking Load	% Extension	Fluidity	% Breaking Load	% Extension
			Cotton.			
0	2·1	100	6·9	2·7	98·1	7·8
0	2·5	100	8·9	2·5	100	11·4
3	5·2	95·4	7·3	9·2	91·3	7·2
3	6·1	100	9·7	11·1	91·8	11·9
6	7·0	91·7	7·2	13·7	86·3	6·8
6	7·7	96·3	9·8	13·4	87·0	12·4
18	13·7	84·9	6·9	22·3	70·8	6·3
18	14·1	—	9·0	22·6	—	13·3
30	17·6	80·2	6·7	26·6	60·0	5·9
30	—	77·3	8·5	26·5	62·9	7·9
			Viscose Rayon.			
0	9·0	100	19·4	9·5	85·8	17·6
0	9·1	100	23·4	10·1	83·8	21·5
3	10·5	89·9	18·6	13·6	75·6	16·1
3	11·1	89·5	20·7	14·0	70·6	18·1
6	11·5	87·7	16·7	14·6	69·6	14·5
6	11·6	88·1	19·2	14·9	70·7	17·8
18	15·8	64·2	11·6	20·2	42·6	9·8
18	15·4	69·9	15·7	20·2	51·3	14·9
30	17·7	61·1	11·8	22·8	39·3	10·1
30	18·2	66·6	14·5	24·3	41·5	15·5

Table XIV

Effect of Increasing Severity of Boil on the Strength and Fluidity of Chemically Modified Cotton and Viscose Yarns.

	Untreated Yarn	Oxidised	Water	Oxidised and Boiled with			
				0·2% Soap	0·2% Soda Ash	0·2% Soap 0·2% Soda Ash	0·5% Caustic Soda
			Cotton (2/50's Sakel, Scoured).				
% Strength	100	89·2	83·4	67·5	67·2	66·2	61·6
Fluidity ...	1·8	12·5	16·0	23·5	25·3	25·8	25·6
			Viscose Rayon.				
% Strength	100	79	69	58·2	51·2	46·6	41·1
Fluidity ...	10	18·9	21·1	25·0	24·0	25·8	25·3

Table XIVa.

Effect of Increasing Severity of Boil on the Strength and Fluidity of Unmodified Cotton and Viscose Yarns.

	Untreated Yarn	Water	Boiled with			
			0·2% Soap	0·2% Soda Ash	0·2% Soap 0·2% Soda Ash	0·5% Caustic Soda
			Cotton (2/50's Sakel, Scoured).			
% Strength	100	97·0	99·3	98·6	100·1	99·4
Fluidity ...	2·4	2·8	3·1	2·3	2·9	2·6
			Viscose Rayon.			
% Strength	100	94·8	95·4	93·9	94·1	90·8
Fluidity ...	10·4	9·9	10·0	10·5	10·3	10·8

Table XV

Fluidities of Cloths containing Defective Weft.

Cloth	Viscose Weft			Cotton Warp
	Undamaged	Damaged	Undamaged	
A.	11·7	19·7	16·4	2·8
	13·1	15·5	11·5	3·2
	11·4	20·0	15·0	3·0
	12·7	18·7	12·3	3·1
B	12·5	14·8	14·6	3·4
	10·4	15·1	12·7	2·7
	15·5	15·6	13·7	3·0
	16·5	16·9	15·0	3·0
	10·4	18·3	12·3	3·2
C	14·5	17·6	15·9	3·6
	13·1	19·4	14·5	3·4
	12·6	24·5	15·7	4·1
	13·1	22·7	13·5	3·8

Lower Grade Weft[13] :—15·4, 10·3, 14·5, 14·7, 10·2, 9·8.

Table XVI

Mercerised Cotton Oxidised with 0·04 *N* Hypochlorite.

Fluidity-Strength Relation Before and After Boiling with Alkali.

	Before Boiling.							After Boiling.		
Fluidity ...	3·5	13·8	25·1	32·1	35·3	40·5	40·1	4·6	24·4	35·8
% Strength...	100	90·0	84·3	75·6	67·3	57·0	48·0	93·4	72·3	48·7

Table XVII

Oxidation of Viscose Staple-Fibre Yarn with 0·04 *N* Hypochlorite at *p*H 7·0.

Time (Hours)	0	¼	1	1½	4	5	6	8	8½
Fluidity	9·05	10·0	11·2	12·1	16·0	19·6	20·9	24·0	25·8
% Strength ...	100	99·5	96·7	96·9	90·6	82·9	80·5	73·8	70·6

Table XVIII

Oxidation of Acetate Rayon with 0·04 *N* Hypochlorite Solutions at various *p*H Values.

Time (Hours)	Fluidity	% Breaking Load		% Extension		% Acetic Acid	Copper Number
		Dry	Wet	Dry	Wet		
			Oxidation at *p*H 4·6.				
0	— 21·83	100 100	66·5 —	25·5 29·2	27·2 —	51·8 —	— 2·52
½	— 22·0	101·8 97·7	66·8 —	26·6 29·5	27·9 —	— 51·8	— 2·96
1	— 22·5	100·8 98·3	67·3 —	26·6 29·4	26·9 —	— 51·8	— 3·16
1½	— 22·33	100·8 97·6	62·7 —	25·8 28·8	25·9 —	— 51·8	— 3·06
2	— 21·98	100·6 99·4	64·8 —	26·3 29·2	28·6 —	— 52·0	— 3·11
4	— 22·87	99·5 98·7	61·2 —	25·4 28·6	30·9 —	— 52·1	— 3·42
6	— 23·44	96·8 99·4	62·0 —	25·1 28·6	31·0 —	— 52·1	— 3·58
8	—	98·95	—	29·6	—	—	3·76
18	—	98·7	—	29·9	—	—	4·14
Blank	—	100·2	—	—	—	—	—
			Oxidation at *p*H 7.				
0	— 21·3	100 100	— —	25·1 29·0	— —	52·2 —	3·01 2·61
½	— 21·64	99·4 101·4	— —	27·1 28·7	— —	— 52·2	3·13 2·66
1	— 21·4	95·2 97·4	— —	26·5 29·9	— —	— 51·9	3·38 2·93
1½	— 22·1	96·1 99·2	— —	25·4 29·3	— —	— 52·3	3·37 3·49
2	— 22·73	96·6 98·6	— —	26·3 28·8	— —	— 52·2	3·93 3·73
4	— 25·58	91·3 94·2	— —	24·9 27·4	— —	— 52·2	4·2 4·56
6	— 30·47	81·2 89·7	— —	23·1 26·6	— —	— 52·4	5·7 5·26
Blank	—	102·0	—	28·7	—	—	2·84

Table XVIII—*continued.*

Time (Hours)	Fluidity	% Breaking Load		% Extension		% Acetic Acid	Copper Number
		Dry	Wet	Dry	Wet		
			Oxidation at *p*H 8.				
0	—	100	68·1	22·4	30·2	—	2·96
½	—	103·2	69·8	27·5	28·1	—	3·11
1	—	100·8	70·0	25·9	28·0	—	3·00
2	—	104·1	67·8	24·1	28·6	—	3·08
4	—	104·4	66·6	24·5	27·7	—	3·24
6	—	94·4	69·9	21·9	26·0	—	3·44
24	—	89·5	53·1	22·0	22·9	—	4·37
Blank	—	100·5	—	25·9	—	—	3·09
			Oxidation at *p*H 9.				
0	— —	100 100	65·3 —	23·2 30·0	27·2 —	— 52·2	2·98 2·66
½	— 21·66	99 100·2	64·3 —	26·8 30·4	27·2 —	— 51·6	2·91 2·91
1	— 21·76	97·7 100	65·8 —	26·3 29·9	27·1 —	— 51·8	3·03 2·94
1½	21·6	97·6	—	29·8	—	51·6	2·96
2	— 21·36	98·8 98·8	64·6 —	26·7 29·8	28·1 —	— 51·6	2·97 2·82
4	— 21·96	97·6 98·3	58·1 —	24·2 29·5	34·6 —	— 51·6	3·13 3·18
6	— 22·65	91·6 99·3	58·5 —	24·3 29·1	31·7 —	— 51·6	3·17 3·11
8	—	98·6	—	29·1	—	—	3·17
18	—	96·8	—	28·4	—	—	3·37
23½	—	88·8	54·1	24·4	29·2	—	3·60
Blank	—	100·7	—	26·9	—	51·6	2·92

Table XVIII—*continued.*

Time (Hours)	Fluidity	% Breaking Load		% Extension		% Acetic Acid	Copper Number
		Dry	Wet	Dry	Wet		
Oxidation at *p*H 11·2.							
0	20·36 —	100 100	— 64	29·2 26·1	— 29·1	— 51·6	2·6 2·71
½	21·04 —	97·7 98·1	— 67·2	30·0 28·0	— 26·8	50·7 —	2·74 3·05
1	21·43	96·9	—	29·8	—	51·1	2·96
2	21·26 —	95·0 98·4	— 67·7	30·3 28·1	— 28·2	49·4 —	2·77 2·93
4	21·13 —	92·6 95·4	— 61·6	29·8 28·2	— 27·6	51·0 —	2·77 2·96
6	20·71 —	91·6 99·0	— 60·4	30·0 27·9	— 29·7	48·4 —	2·77 2·96
8	—	86·8	—	29·3	—	49·3	2·82
18	22·13	74·8	—	23·7	—	45·1	2·15
22¼	—	90·5	45·9	26·9	33·3	—	3·02
24	—	73·1	—	25·0	—	—	2·33
30	—	83·6	—	25·3	—	—	—
Blank 8 hours	21·0	85·4	—	29·3	—	43·0	2·6

Table XIX

Acetate Rayon, 140 den. and 150 den. treated with 0·1 *N* Sodium hydroxide Solution at 19-20° C.

Time (Minutes)	Fluidity	% Hydrolysis	% Strength	Time (Minutes)	Fluidity	% Hydrolysis	% Strength
0	22·2, 21·7, 21·9, 22·2 21·5, 21·3, 21·5, 21·7	Nil	100 100	45	16·5 18·1 16·4 18·4		68·3 77·0 70·3 78·8
10	20·9	5·4	91·8				
15	21·3 21·2 21·3		92·4 94·4 92·5	50	15·6	65·8	60·1
				60	13·65 16·4 —		54·7 68·0 55·8
20	20·7	12·8	92·1		14·4		58·1
30	20·0 20·5 20·1 20·0 19·5	18·5	84·0 88·9 88·4 90·1 84·0		13·6	85·6	50·6
				70	12·4	94·5	46·5
				75	12·4 15·4 12·5		53·1 61·0 52·5
40	17·8	42·0	72·1				

Table XX

Acetate Rayon, 140 den., and 150 den. treated with 0·2 *N* Sodium hydroxide Solution at 19-20° C.

Time (minutes)	Fluidity	% Strength
0	22·0 21·5	100 100
15	17·9 18·9 18·2 19·6	57·9 75·7 63·5 74·6
20	14·2 14·4 16·2	36·5 39·7 49·3
25	12·8	33·2
30	12·7 13·5	— 41·2
35	12·6	—

Table XXI

Progressively Hydrolysed Acetate Rayon.

Fluidity ...	22·2	21·3	20·0	16·5	13·7
% Residual Cellulose ...	62·0	66·5	72·0	85·2	97·5

Table XXII

Relation between Fluidity (in absolute units) and Concentration.

VISCOSE RAYON				CUPRAMMONIUM RAYON			
Not chemically modified		Bleached for 6 hours with 0·04 *N* Hypochlorite at *p*H 7.		Variety 1		Variety 2	
Conc. %	Fluidity	Conc. %	Fluidity	Conc. %	Fluidity	Conc. %	Fluidity
0·25	51·8	0·25	59·1	0·25	44·8	0·25	48·9
0·50	38·9	0·50	52·3	0·50	28·1	0·50	35·1
0·75	28·9	0·75	43·1	0·75	18·5	0·75	24·6
1·00	22·3	1·00	36·3	1·00	12·3	1·50	9·95
1·25	16·9	1·25	30·4	1·25	8·40	2·00	5·85
1·50	13·6	1·50	27·5	1·50	5·93	2·50	3·13
1·75	11·2	2·00	20·8	1·75	—	—	—
2·00	8·47	2·50	15·1	2·00	3·02	—	—
2·25	6·77	—	—	2·25	2·02	—	—
2·50	5·26	—	—	2·50	1·47	—	—
2·75	4·01	—	—	—	—	—	—

Table XXIII

Simplified method for the Determination of the Fluidity of Viscose Rayon

Bottle Method		Normal Procedure	
Sample No. B_1	Fluidity	Fluidity	
(1) 1 gm. to 50 c.c. in 250 c.c. bottle ...	9·4	(1)	9·3
(2) 2 gms. to 100 c.c. in 250 c.c. bottle ...	9·6	(2)	9·5
(3) 5 gms. to 250 c.c. in 250 c.c. bottle ...	9·3	—	—
(2) After standing overnight	10·2	—	—
Sample of Unknown Origin.			
(1) 1 gm. to 50 c.c. in 250 c.c. bottle	11·2	(1)	11·1
(2) 1 gm. to 50 c.c. in 250 c.c. bottle	11·1	(2)	11·0
Sample No. B_1 (overbleached).			
1 gm. to 50 c.c. of solvent	25·6	—	26·3

Table XXIV

Effect of Ammonia Concentration on the Fluidity of an Unmodified Viscose Yarn.

NH_3 gm. per l.	233	230	227	222	216	212	180	162	124	66
Fluidity ...	9·2	9·3	8·9	9·3	9·0	8·9	8·7	8·2	7·8	7·0

Table XXV

Effect of Exposure of Cuprammonium to Air.

Time of Exposure (minutes) ...	0	10	20	30	40	50	60
NH_3 Content, gm. per l. ...	231·5	229·8	228	226	224·5	222·3	220·6

Table XXVI

Effect of Storage of Cuprammonium in a Closed Atmosphere of Nitrogen.

The Liquid was used from Time to Time for Routine Experiments.

Time (Days)	Immediately after Preparation	After Filling Bottle	10	16	25	30
NH_3 gm. per l. ...	240	227	228	229	228	230

26—THE DETECTION AND ESTIMATION OF MEDULLATED FIBRE IN NEW ZEALAND ROMNEY FLEECES

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(Forwarded by the Wool Industries Research Association.)

INTRODUCTION

The following work on fleece examination for medullated fibres, by means of a new method, which, in contrast to the results of relying on visual inspection, detects the slightest trace of medulla, was promoted as a result of the complaints levelled by certain large buying concerns, that New Zealand Romney wool contains too large a proportion of hairy or strongly medullated fibres. Although it has since been acknowledged that a proportion of the New Zealand Romney wool clip may be regarded as "ideal wool"[1] and that a great deal of it is above serious complaint, the trouble complained of is nevertheless serious, and is receiving, therefore, a great deal of attention by research workers in New Zealand. The various genetic, nutritional and climatic conditions which may govern the production of medullated fibre are one by one being brought under investigation, and much valuable information is accumulating.

From the breeder's point of view one of the main difficulties standing in the way of the eradication of this defect is the fact that medullation can only be detected by eye when it exceeds a certain coarseness. The writer has satisfied himself that neither breeders, wool-classers nor buyers are able to detect the presence of fine medullation by ordinary visual examination. The genetics of medullation has not yet been scientifically elucidated so that any efforts aimed at the eradication of this feature must be founded, for the time being, on the broad base of general breeding experience. The following is accordingly the working hypothesis that is being developed in New Zealand.

There is sufficient breeding experience to support the statement that strong medullation is mainly an inherited feature, so that it can be gradually eliminated by selection; and there is no reason to doubt that this applies equally to slight medullation. If this be so we are led to the conclusion that the presence of slightly medullated fibres in a Romney fleece, though apparently not objectionable to the manufacturer, is an undesirable feature from the breeder's point of view, in that the inherited inability to keratinise the fibre output, thereby manifested, even though slight, is likely to be passed on to the progeny in whom circumstances may conspire to produce the defect on a more serious scale; more especially if both parents have displayed the same characteristic. In other words, in the absence of exact knowledge, it is assumed that an animal which possesses only a slight degree of medullation in its fleece, is liable to give rise to off-spring whose fleeces are more intensely medullated. Instances of this occurring are frequently reported. Support for this assumption is found in the fact that there is evidence of a similar repression and subsequent development of an inherited characteristic in the case of pigmented fibres in the fleece of the Suffolk sheep.[2] If on the other hand selection against animals producing medullated

fibre, though even to a very slight degree, be carried out as far as is economically possible, we may confidently expect the chances of coarse medullation being produced by the progeny to be very much reduced.

Working along these lines a large number of New Zealand Romney breeders are giving serious attention to the improvement of their flocks; and for this purpose the newly developed benzol test for the detection of medullated fibres in staples of wool is proving indispensable. It is the persistent hairy fibre, as distinguished from kemp, that is being considered in this paper. True kemps do not occur in New Zealand Romney fleeces to the same undesirable extent as do persistent hairy fibres. According to Dry[3] the latter commence their growth in the lamb's fleece as hairy fibres, but not so coarsely medullated as true kemps; then instead of falling out they persist, becoming finer, and eventually turning into non-medullated "pure wool" fibres. Then, in the following spring and summer, they are inclined to regain their vigour and again become medullated and hairy, giving rise to the so-called "hairy tip," which is so objectionable to the manufacturer.

According to Waters[4] the measurements of growth rates made so far on New Zealand Romney fleeces show that, in the case of most of the animals studied, growth is decidedly more rapid in the spring and summer months, tailing off very considerably with the harder conditions of autumn and winter. Correspondingly the wool grown after shearing in the spring has invariably been found to be more strongly medullated than that grown later on (if medulla is being produced by the animal at all). Evidence is being obtained by other workers at this college that the process of shearing itself causes an increase in the degree of medullation of the fibre which is produced during the few weeks immediately following shearing; but there appears to be no doubt that the above mentioned seasonal fluctuation exists quite independently of this.

Thus in a New Zealand Romney staple that is not free from medullation the medullated fibre is commonly confined to the distal or outer half of the staple, the inner or proximal half of the staple being finer and almost or entirely free from medullation. If the shearing or sampling has been late, however, the production of medullated fibre may have recommenced before the staple is removed from the skin; in which case a zone of medullation occurs also across the proximal end of the staple.

THE BENZOL TEST

The Benzol Test[5, 6, 7] makes use of the fact that the refractive index of benzol and wool keratin are very similar. The test is a development from the method of medulla detection described by Wilson,[8] who made use of the similar refractive index of glycerine in examining individual fibres. This latter method suffers from several disadvantages; the glycerine rapidly absorbs moisture from the breath of the observer and so becomes less effective; it is messy in use and what is most important, cannot be adapted to the examination of large numbers of fibres at once.

That the examination of fibres one by one is an impracticable means of making an examination of a fleece is made clear by the following analysis of a typical medullated Romney staple, which was carried out in order to ascertain more exactly the nature of the materials which were to be examined.

The staple, from the rib wool of a Romney ram, was tied tightly at the tip so as to preserve the arrangement of the fibres within the staple while it was thoroughly scoured and cleaned in petrol. The tip was untied and the staple teased out into a thin uniform layer about five inches wide, and then placed between two glass plates leaving ½ inch of the skin end protruding. The staple was sampled three times in the following manner.

(*a*) A needle was poked at random through the protruding end of the staple at ten different places, and the nearest ten fibres in each case carefully withdrawn for examination, by means of forceps.

(*b*) A pair of dividers with their points fixed one eighth of an inch apart were pierced through the protruding end of the staple and all the fibres between the points withdrawn for examination. This was done at eight even intervals across the width of the staple. Thus about one-fifth of the staple was selected by this method of sampling.

(*c*) The sampling was repeated in the same manner as for (*b*).

Care was taken not to break any of the fibres in the above processes. All these fibres were then tested individually for medullation, and finally the whole of the remainder of the staple was tested in similar manner, so that the representative nature of each sample could be determined.

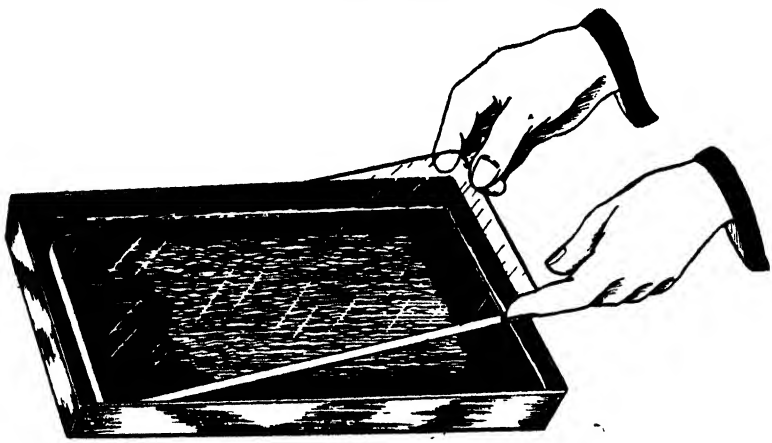

FIG. I.—THE TEST.
Lowering the glass plate on to the wool immersed in benzol.

Each fibre, held by a pair of forceps, was simply dipped into benzene contained in a glass basin, which was standing on a piece of rough black paper. When immersed, only the medullated portion of the fibre remained visible. It was found an advantage if the liquid was coloured a pale golden brown by the addition of some discoloured aniline. Under the lighting conditions by which the work was done (immediately in front of a window facing away from the sun) matt surfaced black paper gave a more convenient background than black velvet or the use of a black vessel.

The fibres were classified as hairy, moderate, slight or non-medullated. Hairy, if medullated more than half of their length ; moderate, if medullated more than ½ inch ; and slight if possessing less than ½ inch of medulla. The results are presented in Table I.

Table I

	No. of Fibres.	No medulla.	Slight.	Moderate.	Hairy.	Total % of medullated Fibres.
		%	%	%	%	%
Whole staple (including samples).	2372	45·0	10·7	26·4	18·0	55·1
Sample *a*	100	30·8	16·8	29·9	22·4	69·2
Sample *b*	514	36·2	12·2	26·5	25·1	63·8
Sample *c*	326	45·7	10·1	23·3	20·8	54·3

They serve to illustrate the complex nature of a Romney staple, and show that even one-fifth of the whole staple (Sample *b*) selected as impartially as possible, may not provide a truly representative sample.*

A means was therefore sought, whereby, making use of the same principle, a large number of fibres, preferably a whole staple, could be examined at once. Finally, after various trials, the present technique of what has come to be known as the benzol test, already in use by a large number of sheep breeders in New Zealand, was developed.

This test makes no attempt at evaluating numerically the degree of medullation, but merely makes clearly visible to the naked eye every trace of air-filled medulla in a staple subjected to the test. The test is carried out as follows :—

The staple is given a preliminary scouring in some solvent (petrol is commonly used) to remove grease and dirt. After shaking in the air to dry off the solvent, the staple is teased with the fingers into a thin uniform layer, bundling of the fibres being eliminated as much as possible, and then laid in a shallow black tray containing benzene (commercial benzol suffices). A glass plate is carefully lowered over the wool so as to exclude all air bubbles from between the fibres (see Fig. 1). The easy wetting of the wool by the benzene is an advantage here. In the early stages a glass tray, resting on black velvet was used for the test. As this was unsuitable for use on the farm owing to its liability to breakage, the testing trays now in use are made of sheet iron, coated with stoved cycle enamel. If three coats of this enamel are applied, each coat baked on hard, before the application of the next, a black covering that is resistant to the solvent action of benzene is obtained. Black porcelain enamel would probably be the most durable and resistant covering. It has not been used so far owing to it being unprocurable in New Zealand.

* It is interesting to record that the length of each fibre was measured when it was withdrawn. The fibres ranged in length from one up to twelve inches, and were sorted as they were measured, into twelve glass basins according to their length. Although no diameter measurements were made a most decided correlation between fibre diameter and length was apparent, the mean diameter appearing to increase steadily with increasing length.

Furthermore, when kemps, short broken pieces and short new fibres with new uncut tips were kept out of consideration, hardly any of the fibres less than six inches long were medullated, while from this point the percentage of medullated fibres and their degree of medullation increased rapidly with increasing fibre length. In other words medullation did not occur until a certain minimum rate of growth was attained, and from this point a very pronounced correlation between the rate of growth and degree of medullation existed.

Viewed in this manner by ordinary diffused daylight, non-medullated wool fibre is practically invisible while medullated fibre remains clearly visible owing to the light reflected by the air-filled cavities of the medulla. It is inadvisable to work in direct sunlight, as the pure wool is then too clearly visible. It is the medulla only that is seen, so that regardless of actual fibre diameter, medullas of different diameters are just as easily distinguished as are wools of different counts.

Thus not only is the degree of medullation of several thousand fibres seen at a glance, but its distribution over the length of the staple, i.e., its seasonal occurrence, is clearly shown, a feature that is highly important from the breeding point of view. Careful scrutiny, aided perhaps by a hand lens, will not fail to detect the minutest trace of air-filled medulla. The test has been successfully applied to lightly dyed samples of wool and to the examination of combed tops and noils. By no means its least advantage lies in the simplicity of equipment and technique for thus it can be used anywhere, on the farm or in the woolshed or in the store, and by anyone without previous experience. Already 150 owners of stud-flocks in New Zealand are using this test in the selection of their breeding stock.

Other liquids of similar refractive index have been used, e.g., toluene, xylene, and aniline. The liquids benzene, toluene and xylene are best because of the ease with which the wool is wetted by these liquids. Of these three, benzene was chosen for farm use, because it is cheaper and because of the rapidity with which it dries off the hands and off wool samples. For long continued routine testing a mixture of equal parts of xylene and kerosene has been found to possess decided advantages over benzene, in that its vapour is less objectionable, and that the non-medullated fibres can just be seen and this enables the proportion of the staple which is medullated to be more easily judged.

There are two abnormal conditions met with in the Romney wools with which the writer has been dealing which affect the application of the test. The first is a condition of the non-medullated " pure " wool fibre which gives it a pale smoky appearance under the test, though this is quite easily distinguishable from the appearance of medulla. It is found to be due to the scattering throughout the fibre of large numbers of extremely small cavities, presumably lying between the cortical cells. The feature appears to be confined almost entirely to the outer half of the staples in which it occurs, and to be most prevalent in " open " back wools from which the yolk has been well removed by rain. It resembles the condition described by Mark,[9] observed by him in fibres from which the last 1 per cent. of yolk had been extracted by the prolonged action of hot solvents. It is also rather similar in appearance to the condition of wool fibres that have been partially " retted " by the action of the pink-rot organism, as described by Waters[10].

On account of its appearance the term " smoky wool " is suggested as a name for wool naturally possessing this feature. No comparisons have yet been made, but it is suspected that, like the degreased fibres of Mark, this " smoky wool " has had its physical properties impaired to some extent.

The other condition is an apparent infilling of the medulla by some material which has been observed to occur to certain wool samples which have been stored in the laboratory for about a year, and also to occur to

certain hairy tipped fleeces which were left unshorn on the animal's back for one year more than usual. Although instances have been noted where such "infilling" of medulla appears to have occurred to wool during its twelve months' growth, these are slight and seldom encountered, and do not materially affect the efficacy of the benzol test. Needless to say such "infilled" medulla is not detected by the test. The nature and cause of this phenomenon are being investigated, and results so far obtained suggest that it is associated with changes in moisture content of the wool.

THE ASSESSMENT OF THE DEGREE OF MEDULLATION OF STAPLES BASED ON THEIR APPEARANCE UNDER THE BENZOL TEST

The benzol test in this simple form is probably as useful now to the individual breeder's requirements as it is ever likely to be. Accurate evaluation of degrees of medullation is not needed by a breeder, testing his own rams; visual impressions, in comparing one animal with another, will in most cases be quite accurate and lasting enough for his purpose.

However, for the organised use of the test, both in wool production research and for the purposes of organised fleece-testing, which it is hoped to develop in New Zealand, some method is required for translating the visual impression of the test into an empirical value which shall be sufficiently representative, for practical purposes, of the actual proportion of medulla in the staple. Probably the best measure of the degree of medullation of a staple is the actual proportion by volume of medulla to the total volume of fibre. The writer is developing an absolute method of determining this quantity, details of which it is hoped will be published shortly, but some simple and rapid empirical method of arriving at an approximation to this quantity, based on the appearance of a staple under the benzol test, is most desirable. The work of developing such an empirical method, standarised with the aid of the absolute method, is at present occupying the writer's chief attention.

In order to obtain such an empirical value, the following dimensional features must be separately evaluated and integrated into a single value:—

(*a*) Mean diameter of medulla.
(*b*) Mean diameter of fibre.
(*c*) Proportion of the total length of fibre that is affected by medullation.

The following discussion of the problem indicates the extent to which it may be possible to estimate visually and integrate these factors, and discloses what has already been done in that direction.

(a) Mean diameter of Medulla

It has already been shown that considerable variations both of medulla and fibre diameter are to be found in any one staple, but judging from experience it would seem possible in most cases to form an estimate of the average coarseness of the medulla just as is done for fibre diameters in the estimation of counts.

In the Romney wool examined the medulla diameters range from about 4μ up to as much, in an extreme case, as 64μ, and the volume of medulla per unit length of fibre therefore varies as the square of these dimensions. Hence mean medulla diameter is an extremely important feature to be judged, and it is necessary to be able to classify it according to some system

of standards. Applying the Weber-Fechner psycho-physical law to this classification and dividing the whole range into a series of increments, equal in their visual aspect, and therefore in geometric progression as regards their actual dimensions, the following system is suggested (see Table II) :—

Table II—Classification of Medullas according to Mean Diameter

Class	Medulla diameters	Mean of Class	Volume Factor
	μ (microns)	μ (microns)	
Slight	4– 8	6	×1
Moderate	8–16	12	×4
Hairy	16–32	24	×16
Coarse hair	32–64	48	×64

In the fourth column the " volume factor " gives the relative volume per unit length of the medullas of the respective mean diameters. The total range of medulla volume per unit length varies by as much as 256 times, and we observe that a maximum error of ×2 in the estimation of the percentage volume of medulla can be made in the treatment of a border line case. This, of course, could be reduced by making the number of classes larger, but in view of the very heterogeneous nature of the staples this is not likely to be practicable.

As a guide to the classification of staples according to this system large numbers of carefully selected fibres possessing these particular sizes of medulla are being mounted in Canada Balsam, on black glass slides, under which conditions they present the same appearance as they would if subjected to the test.

(b) Mean Diameter of Fibres

New Zealand Romney wools range in count almost entirely between 56's and 36's ; in other words the mean fibre diameters range roughly from 27μ to 54μ. Hence the maximum possible variation in volume of fibre per unit length is only ×4, a much smaller variation than is possible in the volume of medulla, per unit length. Obviously with a fixed amount or size of medulla, this change in count would be responsible for a change of × 4 in the proportion of medulla, so that count must be included among the factors to be estimated. The error involved in its estimation would be relatively small.

(c) Proportion of Total Length of Fibre that is Medullated

In Romney wool, medullation is usually confined to one or more fairly well defined zones of the staple, corresponding to certain seasonal periods of growth, while all or only a few of the fibres may be medullated within these zones. Hence the evaluation of this feature resolves itself into the estimation of :—

(1) The proportion of the total length of the staple affected by medullation.

(2) The percentage of medullated fibre in those zones.

The first factor is easily estimated with the aid of a scale etched across the glass plate used in the test. The second factor is the most difficult of all to estimate with any certainty. It is proposed to prepare a series of

mounted standards, as described above, possessing various known percentages of medullated fibres at intervals of say 20 per cent. The error in estimating these two factors could hardly ever exceed 33 per cent. each in extreme cases, which combined give a maximum possible error of 45 per cent. Combining this with the maximum possible error of 100 per cent. in estimating the mean volume of medulla per unit length, we find that the greatest possible combination of errors could amount to $\times 2{\cdot}9$, but that this could only be possible in the case of the lesser degree of medullation.

At first sight this would appear to condemn any such method of evaluation. But it must be remembered that the range of degrees of medullation encountered is extremely large, for the proportion by volume of medulla in a staple composed entirely of coarse hair is about 5,000 times that in a staple only slightly medullated at the tips. A scale of values so extended as this, is obviously undesirable.

Both these difficulties can, however, be overcome by expressing degrees of medullation on a logarithnic scale to the base 2, in the following manner:

If M = proportion by volume of medulla in a staple, estimated either absolutely or empirically,
and $M = 2^{-n}$
Then n = the "medullation number" of the staple and ranges in value from 0 up to about 12.

In this way a staple would be placed in one of twelve classes, while the maximum possible combination of errors could not place it more than 1½ units out of its correct position on this scale.

In practice "n" could be computed directly from the observations by means of a special slide-rule.

Being thus forced to this conclusion, namely, that carefully standardised estimation of all the factors involved might only be relied upon to place a staple in one of twelve classes (with a possible error of one class either way) the question arises as to whether the same result could not be achieved, just as accurately and far more simply, by experienced personal judgment without attention to the details discussed above. It is with these alternative considerations in mind that the writer is at present endeavouring to evolve and standardise a satisfactory empirical method of assessing degrees of medullation of wool staples.

For the purpose of the work described below, on the distribution of medullated fibre over the Romney fleece, a tentative and less precise method based on the above considerations was adopted. The factors (*a*) and (*c*) were estimated by eye without any recourse to standards of comparison. The influence of count when making comparisons within a single fleece is only slight and in this work it was neglected. Medulla diameters were classified into three classes, hairy, moderate and slight, to which the arbitrary values $\times 3$, $\times 2$ and $\times 1$, respectively were given. It is interesting to note that the medulla diameters which by personal judgment and practice came to be regarded as slight, moderate and hairy, when checked up later by microscopic measurement, were found to correspond remarkably with the classes defined above which are based on the psycho-physical law.

For each staple these observations were recorded on a chart as illustrated in Fig. 2. In the example given, in the outer $2\frac{1}{2}$" of the staple, 50 per cent. of the fibres were estimated to be moderately medullated, and the value $50 \times 2\frac{1}{2} \times 2 = 250$, was assigned to this portion. The next $3\frac{1}{2}$" of the staple was estimated to contain 20 per cent. of the fibres slightly medullated and the value assigned to this was $20 \times 3\frac{1}{2} \times 1 = 70$. The last inch of the staple was free from medulla. Summing these values and dividing by the length of the staple we obtain the single value 46, which represents the

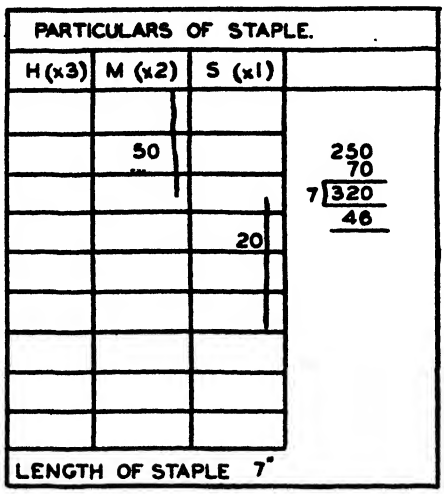

FIG. II.

total percentage of fibre affected by medullation multiplied by the appropriate factors for coarseness. The possible maximum out of which these values are expressed is 300, corresponding to 100 per cent. of hairy fibre for the whole length of the staple. The values obtained in this manner, using the factors $\times$ 1, $\times$ 2, and $\times$ 3, while they do not possess a direct relationship with the true proportion of medulla, do sort the staples roughly into their correct order, as regards degrees of medullation, and so they served as the best means available at the time of classifying the large numbers of staples under examination.

THE DISTRIBUTION OF MEDULLATED FIBRE OVER THE NEW ZEALAND ROMNEY FLEECE

When the Benzol Test came to be applied to the examination of fleeces it soon become apparent that the Romney fleece is a far more heterogeneous unit than had been supposed. It was discovered that adjacent staples frequently differ to an extraordinary extent in their degrees of medullation: so much so that a few isolated medullated staples may sometimes be found in an otherwise non-medullated part of the fleece, and *vice-versa*. It is interesting to consider this in relation to the observation of Roberts[11] that very considerable differences often occur between the mean fineness of adjacent staples. Table III gives the tests of a series of bundles of adjacent staples selected to illustrate this irregularity.

This fact coupled with the lack of any exact information on the mode of distribution of medullation over the fleece very much complicated the problem of fleece sampling for the purpose of applying the test, and the

Table III—Degrees of medullation of seven bundles of adjacent staples.

Bundles of adjacent Staples	1st Staple	2nd Staple	3rd Staple	4th Staple	5th Staple
A	Tr	9	1	7	30
B	51	40	3	45	45
C	30	Tr	30	Tr	10
D	Tr	Tr	26	Tr	0
E	71	60	62	Tr	39
F	54	59	8		
G	10	160	45		

Trace of medulla only = Tr. " Pure " wool = 0 100% coarse hair = 300

following pages record the results to date of the efforts to solve that problem. The fleeces of seven Romney cross-bred ewes, selected more or less at random from the College flock, were sampled in considerable detail. The term " more or less at random " is used because it was necessary, before a very detailed examination was embarked upon, to ensure, by means of a preliminary rough survey, that each animal selected had a measurable amount of medullated fibre in its fleece. Apart from this no conscious selection of the animals to be examined was made.

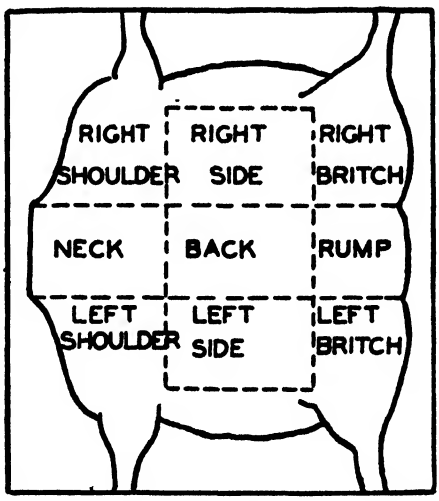

FIG. III.

For convenience each fleece was divided into nine roughly similar areas. The hip bones were used as points of reference, and vertical and horizontal lines were drawn from these points. The mode of division is illustrated in Fig. 3. Each area was then sampled separately, as many in some cases as 36 staples, but never less than 12 staples being cut from evenly distributed and carefully noted positions within each area. The technique of sampling is dealt with later.

Each staple was then examined by means of the benzol test and its degree of medullation assessed out of a possible maximum value of 300 in the manner described above. It was thus possible to draw fleece maps showing the distribution of medullated fibres over the animal.

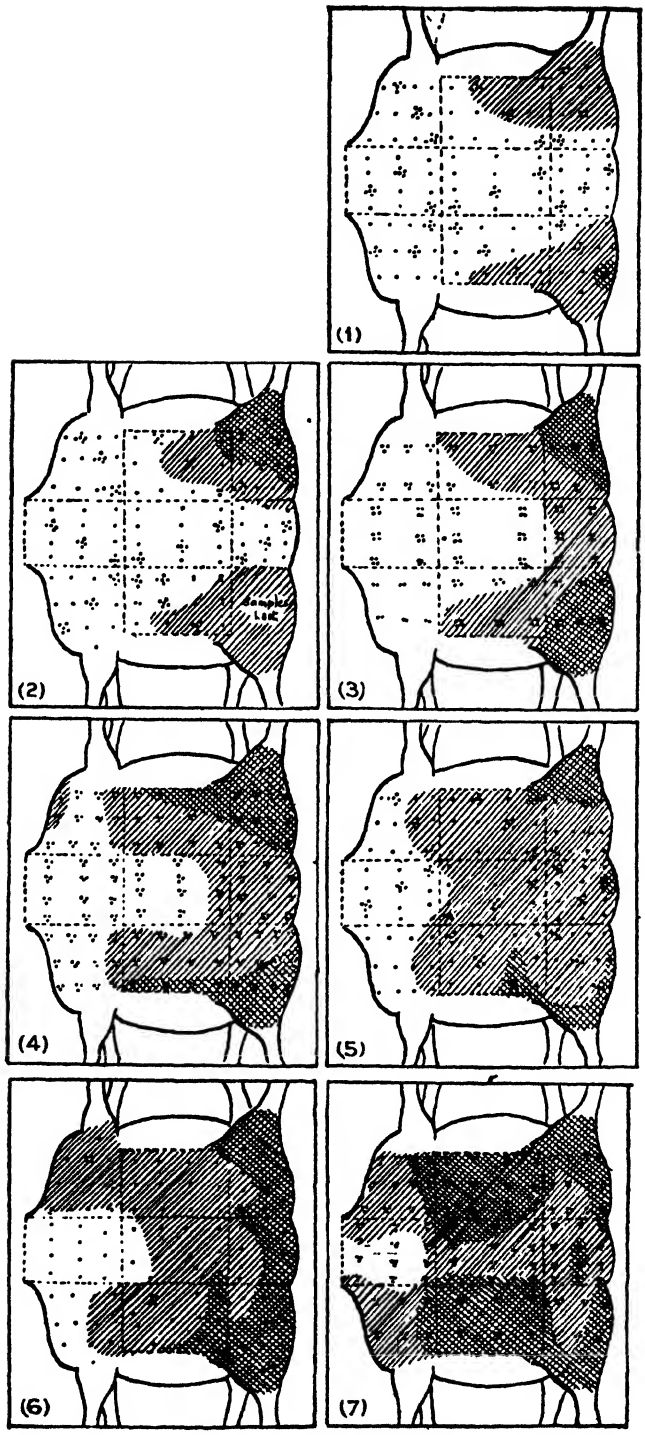

FIG. IV.

These are reproduced in Fig. 4. Each black dot marks as nearly as possible the position of a tested staple, small groups of dots representing bundles of adjacent staples. The areas covered with single shading are those in which the staples tested possessed more than a slight amount of medullation (assessed at 15 or more out of 300); the areas covered with double shading are those in which the staples tested received values of 100 or more out of 300, and they cover roughly those parts of the fleeces in which the wool was "hairy" to the naked eye.

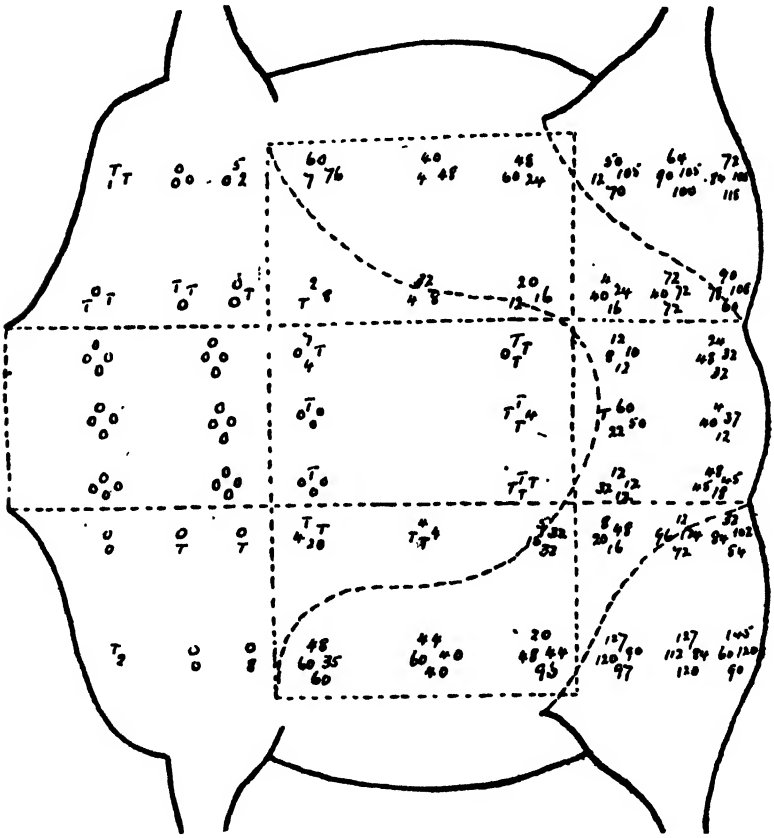

FIG. V.

Parts of the unshaded areas were free of even the slightest trace of medulla, especially the neck area (as defined in Fig. 3) which appears to be the last stronghold of pure wool. Other parts possessed various slight and relatively insignificant amounts of medullation unevenly distributed. Figs. 5, 6 and 7 illustrate this by showing the actual values assigned to each staple of three of the fleeces. These figures also illustrate the slight extent to which the boundaries of the shaded areas have been smoothed.

Fleeces 1, 2, 5 and 6 were sampled in the spring of 1930 as hogget fleeces, while fleeces 3, 4 and 7 were sampled the following season from the same flock, but from different animals, as two-tooth fleeces.

A study of those seven fleece maps, arranged in order of increasing degrees of medullation, shows that medullation distributed itself over them according to a simple rule which may be stated as follows:

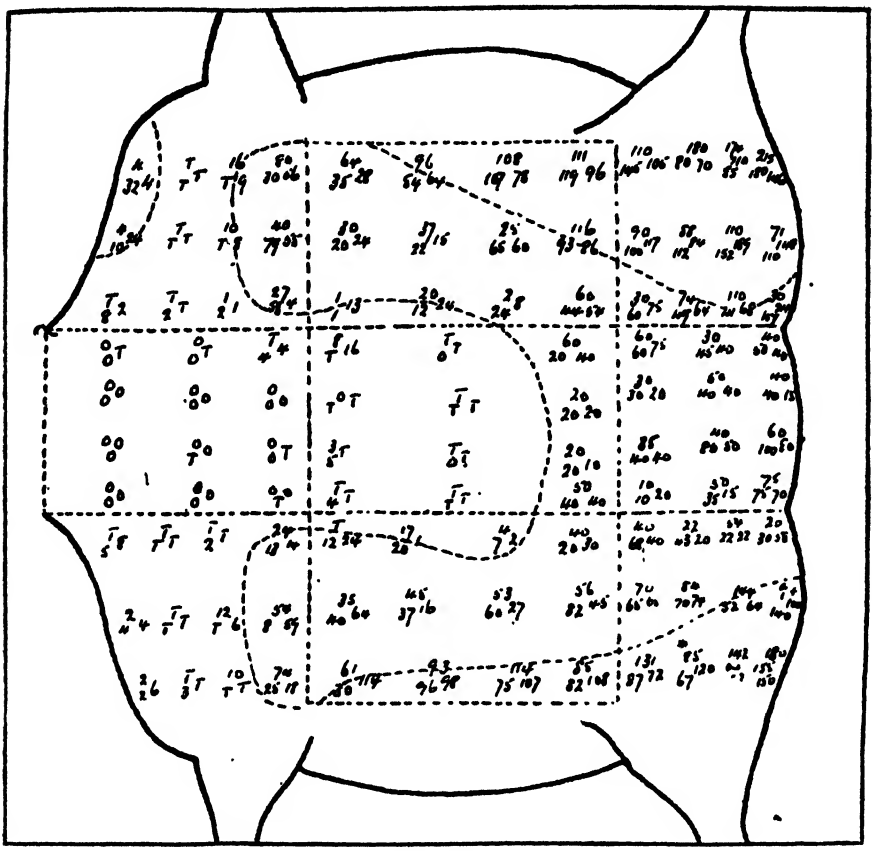

FIG. VI.

With increasing degrees of medullation the area affected spreads from the britch only, the flank being invaded before the rump, the rib before the back, and the shoulder before the wither, the last named area being least likely of all to be medullated. Furthermore, no striking differences between the two sides of an animal are so far indicated.

It is, of course, impossible to draw final conclusions from the examination of so few fleeces, and an extension of this investigation to a larger number of fleeces from several different flocks is in progress; however, the fact that these fleeces were selected at random, and that they fall into so simple and orderly a progression strongly suggests that although medullation extends over a larger or smaller area of the fleeces of different sheep, it does so in a dependably constant fashion.

No definite information is yet available as to the relation between the successive fleeces of the same sheep.

FLEECE SAMPLING

Based upon the above results provisional recommendations for fleece sampling have been published[12] for the guidance of breeders who are examining their own sheep. It is pointed out that the britch, side and

shoulder wools on one side of the animal should give a sufficient indication of the nature of the whole fleece, and that over these areas the wool may

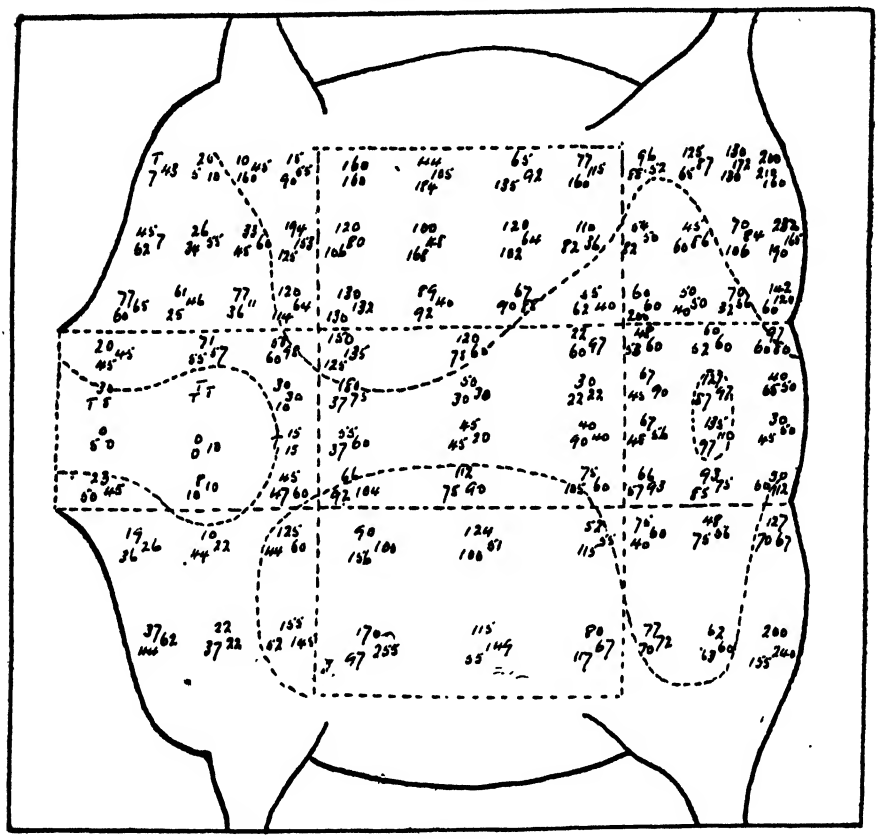

FIG. VII.

confidently be expected to improve regularly in its freedom from medullation as one advances toward the shoulder.

The actual procedure of sampling must depend on whether or not the staples are being tested on the spot as they are selected. In the event of the

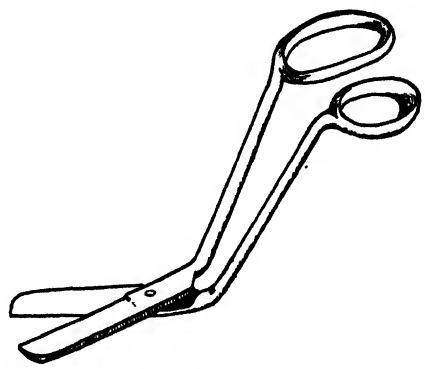

FIG. VIII.

testing being done at the same time as sampling, the extensiveness of the sampling will be determined to a large extent by individual circumstances.

Thus the first few staples examined may either condemn the animal straight away or raise it above suspicion. In other cases further examination would be necessary. Further, the extent to which discrimination against medullation may be economically pursued must depend on the average standard of the flock; in other words each breeder who is endeavouring to eradicate medullation by selection against it will have to work to the highest standard that he can afford; for the introduction of the test has shown that medullation is far more common a feature than was supposed, and that complete elimination even if desirable, is likely only to be the culminating stage of a gradual process of improvement. Paying attention for the time being to the main body of the fleece, apart from the britch which, medullated or not, is always removed in the process of skirting on account of its strength, the flank becomes the critical point for examination, as, if that area is free, the rest of the fleece, with the exception of the britch, is presumably also free. A large number of Romney breeders in New Zealand are strongly of the opinion that a certain degree of medullation in the britch wool goes hand in hand with a strong constitution, and that therefore, especially in the case of rams, no attempt should be made to eliminate medullation from that area. Others contend that this is not the case, and that although the wool covering the britch should be decidedly stronger than that on the shoulder, there is no essential need for this stronger britch fibre to be medullated. It seems likely that much of this conflict of opinion is based on an insufficient discrimination between strong pure wool and strong hairy fibre; and it is hoped that the extensive use of the benzol test by the breeders themselves, by removing the possibility for this confusion, will go a long way towards the solution of this problem.

Breeders have been recommended never to rely on less than four staples as a sample of any one of the fleece areas being studied. This number has been chosen for their purposes, where the accuracy of the sampling is not so important, as a compromise between the conflicting requirements of accuracy and economy of time, as it is realised that tedious and minute attention to detail does not readily find a place in the routine of farming operations. The representative nature of various numbers of staples from any one fleece area is discussed below.

For the purposes of the official testing and grading of fleeces and in other cases where testing is not being done on the spot, the process of sampling must be cast into a standard procedure capable of dealing satisfactorily with any fleece likely to be encountered. In this case all three areas, britch, side and shoulder, must be sampled regardless of their nature. The number of staples required to give a sufficiently representative sample of any one of these fleece-areas has been subject to a preliminary investigation, as is described below.

Each fleece-area of the three fleeces, Nos. 3, 4, and 7 (see Fig. 4), was repeatedly sampled, sometimes three times, sometimes four times, taking either six or twelve staples per sample. These were tested and their degrees of medullation evaluated as described above. The results are presented graphically in Figs. 5, 6 and 7 and are summarised in Table IV. In sampling an area several times, the same positions within that area were repeatedly approached, so that almost the same result would have been achieved by selecting a number of bundles of adjacent staples.

Assuming that the mean of all the staples taken from any particular fleece-area was the true mean value for that area, the various deviations from this mean on the part of individual samples (of 6 or 12 staples) are expressed by means of the standard deviation formula.

$$\Delta = \sqrt{\frac{\Sigma d^2}{n-1}}$$

Admittedly Δ does not possess its full significance in the case of such small numbers of samples, but it provides a convenient means of reviewing the representative nature of the samples. Omitting from consideration those areas with only slight amounts of medullation, the mean coefficients of variation worked out from these values of Δ are as follows:

in the case of samples of six staples, 20·1 per cent.
in the case of samples of twelve staples 11·1 per cent.

These variations are high, but as it is unknown to what extent the present inaccuracies in the assessment of individual staples are a limiting factor to the agreement between repeated samplings and taking into consideration the very wide range of values being dealt with, the writer is recommending provisionally the selection of six staples per fleece-area as being sufficient for the requirements of the official grading of fleeces for breeding purposes.

When the method of assessing the degree of medullation of a staple has been sufficiently standardised and its accuracy ascertained, this work on fleece sampling will be extended, when it is hoped it will be possible to determine with more precision the limits of error of the various possible sampling methods.

TECHNIQUE OF FLEECE SAMPLING

The technique of fleece sampling has received careful study as it is recognized that time is an important consideration when large numbers of fleeces have to be examined.

It is essential that the whole of the staple should be obtained for a test otherwise misleading conclusions as to the proportion of the staple affected may be reached. Therefore the staples should not be pulled out, but cut off as near to the skin as possible. When large numbers of staples have to be taken, ordinary scissors are not convenient and a special pair of scissors with blades and handles bent almost at right angles to the shafts has been found very suitable for the purpose. (See Fig. 8).

As a means of rapidly packing and labelling each staple as it is cut the following device has proved very useful. The staples as they are cut are placed between the leaves of a small "sample book" made by stapling together an appropriate number of sheets of paper about 8″ × 5″. Each leaf is numbered with the number of the staple, and when filled the book is rolled up, tied with string and labelled with particulars of the animal and fleece area. Samples are thus conveniently secured for transport or storage.

By adopting this technique sheep can be sampled by two workers, selecting eighteen staples per fleece, at the rate of three-four minutes per head. The technical hindrances to the development of fleece-testing on a large scale are thus being rapidly overcome.

SUMMARY

Some of the steps being taken to bring about a decrease in the production of the coarse hairy fibres which have been occurring in a proportion of New Zealand's Romney wool clip are outlined. This work deals with the persistent hairy fibres as distinguished from kemps, and certain conditions affecting their growth are briefly discussed.

A detailed analysis of a typical slightly hairy staple of Romney wool shows it to be very heterogeneous in the composition, and that the examination of impartially selected single fibres, even in large numbers, cannot be relied on to give a true estimation of the degree of medullation of a staple.

A very marked correlation of the rate of growth with both the diameter and degree of medullation of the fibres is noted.

The benzol test, which rapidly and easily detects the slightest trace of air-filled medulla in a wool staple is described.

Two abnormal conditions of the wool fibre which affect the application of the test are mentioned. The first for which the term " smoky wool " is suggested and which is detected by the test, consists of the inclusion throughout the fibre of countless minute cavities, presumably air-filled; the second is an apparent natural infilling of the medulla.

It is suggested that the most useful measure of the degree of medullation of a wool sample is the actual proportion by volume of the medulla to the total volume of fibre. The problem of translating the visual aspect of a staple as seen under the benzol test into an empirical numerical value, which shall be more or less proportional to this actual medulla content, is discussed in detail, and a proposed method is outlined. The development and standardisation of this method is progressing.

The application of the benzol test to fleece examination shows the fleece to be very heterogeneous, great differences occurring between adjacent staples. As a preliminary attack on the problem of fleece sampling, seven Romney ewe fleeces were sampled in great detail, with a view to ascertaining the mode of distribution of medullated fibre over the fleece. Adopting a tentative method of assessing the medulla content of the staples (which is described) these samples were examined by the benzol test and a fleece map drawn for each fleece showing the distribution of medullated fibre. Though selected at random, the fleeces fall into a simple and orderly progression, which suggests the following rule.

With increasing degrees of medullation, as from fleece to fleece, the area affected spreads from the britch only, the flank being invaded before the rump, the rib before the back and the shoulder before the wither, the last named area being the least likely of all to be medullated. Furthermore, no striking differences between the two sides of an animal are indicated.

Based on these results, provisional fleece sampling recommendations are made for the different requirements of breeders testing their own sheep on the one hand, and of wool production research and large scale organised fleece testing on the other hand. In the first case the flank is considered to be critical area for examination. In the second case, the britch, side

Table IV—Results of the repeated sampling of three Romney Two-Tooth Ewe Fleeces.

		Right Shoulder	Left Shoulder	Right Side	Left Side	Right Britch	Left Britch	Neck	Back	Rump
FLEECE 3	Number of staples per sample	6	6	6	6	6	6	6	6	6
	Mean of each sample ...	0·8 0·3 0·2	1·3 0·3	34 30 15	20 26 41 32	59 86 73 57	75 95 80 82	0 0 0 0	1 Tr 1 Tr	17 33 23 33
	Mean of all samples ...	0·4	0·8	26	30	69	83	0	0·5	26
	Δ	0·39	0·71	10·0	8·5	13·5	8·6	0	0·57	7·9
FLEECE 4	Number of staples per sample	12	12	12	12	12	12	12	12	12
	Mean of each sample ...	15 14 18	15 5 10	56 46 52	52 49 49	101 100 102	89 80 72	0 0·3 0·3	10 11 12	43 43 49
	Mean of all samples ...	15·7	10·0	51·3	50·0	101·0	80·3	0·2	11·0	45.0
	Δ	2·1	5·0	5·0	1·7	1·0	8·5	0·05	1·0	3·5
FLEECE 7	Number of staples per sample	12	6	12	6	12	6	12	12	12
	Mean of each sample ...	56 57 57	61 38 59	89 83 122	105 113 107	101 101 105	89 78 102	25 29 25	70 75 66	78 73 63
	Mean of all samples ...	56·7	52·7	98·0	108·3	102·3	89·7	26·3	70·3	71·3
	Δ	0·57	12·4	21·0	4·2	2·3	12·0	2·3	4·5	7·6

and shoulder wools must all be sampled according to a standard procedure. These three areas on one side of the animal may be considered to represent the whole fleece.

The question of the number of staples necessary as a representative sample of any one fleece-area has received preliminary investigation by repeatedly selecting from the same areas samples of six or twelve staples. The possible error of the six staple samples appears to be about twice as much as that of the twelve staple samples, but in view of the very wide range of values encountered and until the method of assessment for individual staples is made more accurate, the selection of samples of six staples per fleece-area (see Fig. 3) is provisionally recommended.

Developments in the technique of fleece sampling are described.

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27—REPORT ON A METHOD FOR MEASURING THE RESILIENCE OF WOOL

By C. G. WINSON
(Wool Industries Research Association)

That property of wool known as resilience or springiness or, in some branches of the trade, as loftiness, is a very desirable one to some manufacturers. On the other hand in certain types of cloth manufacture, this particular property is quite undesirable and a wool with less natural springiness is required. Although certain breeds and classes of wool may, in general, be relied upon to possess this particular property in some measure, yet the degree to which they do so varies.

It was therefore thought desirable to investigate any method which offered to place the measurement of this property upon a more precise basis.

In trade practice, the rapidity and the extent to which wool springs back to its original size and formation after hand compression is taken as an indication of its resilience. Such a method does not admit of small discriminations and is scarcely reproducible although commercially reliable if performed by an experienced woolman.

In some earlier work on the compressibility of wool, Mark had made use of a rubber membrane in which to enclose the wool. He had been concerned only with the force required to compress wool by a certain fraction of its volume and not with its power of recovery from such strains which

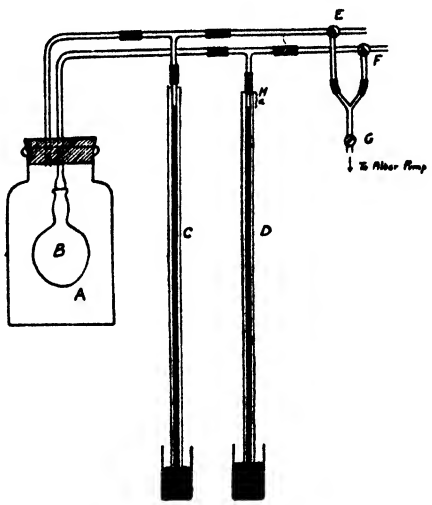

FIG. 1

is mainly the concern of the present work. A similar method has been investigated and seems to be the best yet available for the measurement of the resilience of fibrous materials. The experiments have led to some interesting results.

The apparatus is shown diagrammatically in Fig. 1. It consists essentially of an inner air space and a surrounding outer air space. The inner space is formed by the balloon (B) to which is connected a manometer (D) and a three way stop-cock (F) connecting with the filter pump and

the outside atmosphere. The outer space comprises a large glass jar (A) which is likewise in connection with a manometer (C) and a three way tap (E) which may be put into communication with the atmosphere or the filter pump.

Care had to be taken to ensure that all joints, taps, etc., were air-tight when the internal pressure was of the order 6-7 cms. Hg. When this condition was attained, a blank experiment was performed in order to show that the walls of the balloon were perfectly collapsible and could not therefore exert any independent action when later the balloon was to be filled with fibrous material. The blank experiment was conducted as follows. The taps E and F were put in connection with the filter pump and both the spaces A and B equally exhausted. The tap G was then closed and F turned into the " off " position so that the inner space was completely closed. The manometers C and D were then read, and, of course, gave equal readings. A small amount of air was then slowly admitted into A by means of the tap E. The height of the column C was decreased owing to the increase of pressure in A. This increase of pressure in A caused a partial collapse of the balloon B, until, by diminution of its volume, a position of equilibrium was attained in which the pressure inside the balloon was equal to that outside. Further amounts of air were admitted. The height of the mercury column in D descended at the same rate as that in C until, depending on the original degree of exhaustion, a state of affairs was reached in which the collapsed balloon obstructed the orifice of the tube to which it was attached. Fig. 2 shows the relationship between the external pressure in A (p_e) and the internal pressure in B (p_i) for an empty balloon for two initial degrees of exhaustion.

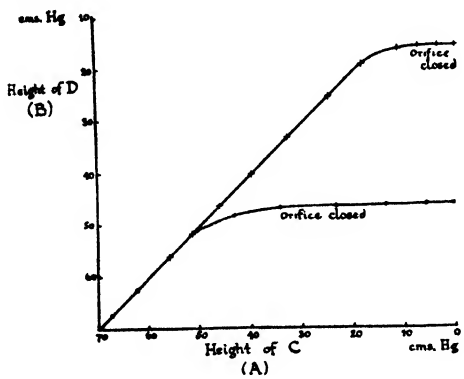

FIG. 2

From this it is quite evident that until the orifice is obstructed the rubber membrane transmits perfectly the pressure between A and B. Consider now the experiment to be performed with B filled with a compressible fibrous material. On the admission of air to the space A, the pressure rises and exerts a force on B causing it to shrink. The degree to which it shrinks, however, is governed by the resistance to compression of the fibrous material it contains. Consequently, being unable to shrink to the same extent as when empty, the pressure of the air in the balloon remains less than that in the outside space A. The height of the column D is thus greater than that of C.

Theory of the Instrument

Let V = volume of inner space to the mark H (exclusive of balloon).
α = addition to the volume of the inner space due to position of mercury level below H.
β = volume of the balloon at any instant.
v_0 = volume of actual wool substance (Mass/Density).
p_e = pressure in the external space (A) at any instant.
p_i = pressure in the internal space (B) at any instant.

After the preliminary exhaustion of both spaces A and B, the tap F is turned to the " off " position and the mass of air in the inner space remains constant over the whole of the experiment. As air is admitted into A slowly, we may assume that the temperature remains constant. Applying Boyle's Law to the inner space

$$(V + \beta_1 - v_0 + \alpha_1)p_{i1} = (V + \beta_2 - v_0 + \alpha_2)p_{i2}$$

where the suffixes 1 and 2 denote two different states of the inner space. V is a constant of the apparatus and is easily determined by calibration with mercury. Similarly the volume per unit length of the tube D may be found and therefore α is known when the position of the top of the mercury column is known (this is easily read off on the scale); p_{i1} and p_{i2} are also recorded directly. If, therefore, the volume of the balloon in one of its states (say β_2) is known, its volume at any other pressure may be calculated.

It was found convenient in practice to measure the volume of the balloon when the outside pressure was atmospheric. The rubber bung was gently removed from the jar which was lowered an inch or two. Water was then run into the jar until it was level with a mark made on the neck of the balloon corresponding to the end of the tube. The level of the water was carefully recorded on a strip of paper pasted on the side of the jar, and at the same time the height of the column D was recorded. This gave p_{i2}. The jar was then lowered several inches further until the balloon was quite clear of the water surface. Drops of water still clinging to the balloon were shaken off by the simple expedient of allowing the balloon to become inflated. Water was then run in from a burette until the decrease in volume due to the withdrawal of the balloon was made up. The volume of water drawn from the burette was the external volume of the balloon. The volume of the actual membrane of the spherical portion of the balloon had been previously determined by a displacement method and when this quantity was subtracted from the external volume the true internal volume of the balloon was obtained.

The actual pressure exerted on the wool enclosed in the membrane is the difference of the external and internal pressures, i.e., $p_e - p_i$. The work outlined above has been directed towards finding the value of the volume β of the fibrous material for all values of p_i. Knowing the values of pe corresponding to those of p_i, we may now plot curves showing the relationships between the volume of the mass of wool (β) and the pressure to which it is submitted ($p_e - p_i$). These curves take the form of Fig. 3 and show, as might be expected, that under increasing pressure the volume of the wool decreases rapidly at first and then much more slowly. Such curves show only the compressibility of the material enclosed in the balloon. The question arises as to what will happen when the pressure on the wool is released. It is here that the property of resilience enters.

In carrying out the experiments, therefore, after the difference in pressure between A and B had reached approximately 50 cms. of mercury, the tap F was opened to the filter pump for a few seconds at a time and in this way the pressure in A was reduced. The heights of C and D were recorded

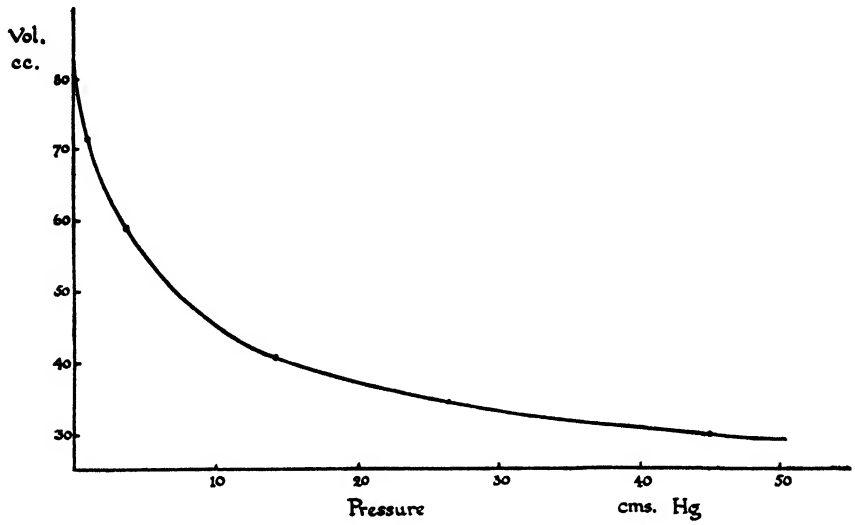

FIG. 3

after each drop in pressure when, after a minute or so, they had attained equilibrium values. In this way the return half of the compression cycle was accomplished. For a perfectly resilient material the curve of decreasing pressures should exactly retrace that of increasing pressures, but this was not found to be the case. As the pressure was decreased, the volume did not return to the value it had on being compressed at that particular pressure, but remained definitely below it, until all pressure was removed, when it returned to its initial volume. In other words a complete loop was formed by plotting increasing and decreasing pressures against corresponding volumes. These loops are shown in the succeeding diagrams.

Preparation of the Sample

Raw wools only were used in the test as it was felt that any processing might interfere with their natural springiness. The samples were cleaned in three lots of benzene heated to about 60° C. After drying they were put through three rinsings of distilled water and finally allowed to dry in the open air of the room. The dried locks were then carefully teased apart by hand until all parallelisation of the fibres was destroyed and a tangled fibrous mass remained. Using blunt-ended forceps this was inserted, a little at a time, into the balloon until the spherical part of the membrane was first filled without distension. For one balloon used in this series of experiments the amount of wool taken every time was 5 gms. Unfortunately with wear the balloon developed weak places, became imperfectly air tight and was discarded. The capacity of the second balloon used in this series was 4 gms. The cubic capacity of the two balloons was of the order 80 cc and 65 c.c. respectively.

Experimental Procedure

The balloon was fitted on to the tube which was made to be in contact with the wool at the base of the neck. In this way it was ensured that there should be no danger of the balloon collapsing and obstructing the orifice of the tube. The glass jar was then placed in position and both taps E and F opened to the filter pump until the pressure in the spaces A and B was reduced to about 10 cm. Hg. Both taps were then closed and F remained closed for the remainder of the experiment. The heights of both manometers were read and recorded. E was then opened to admit a small amount of air. The height of the mercury column in C fell through a cm. or so and that of the column in D through a less amount. Again both heights were recorded when the levels of mercury became stationary, which occurred very soon. This procedure was repeated until there was a difference of 50 cm. in the readings of the manometers. This point was always taken to mark the end of the compression. The gradual release of the pressure was accomplished by withdrawing air from the space A, by means of the pump as previously indicated and in the same way as before, records were made at short intervals of the heights of C and D. The reading of the barometer was taken and the readings of C and D translated into absolute pressures.

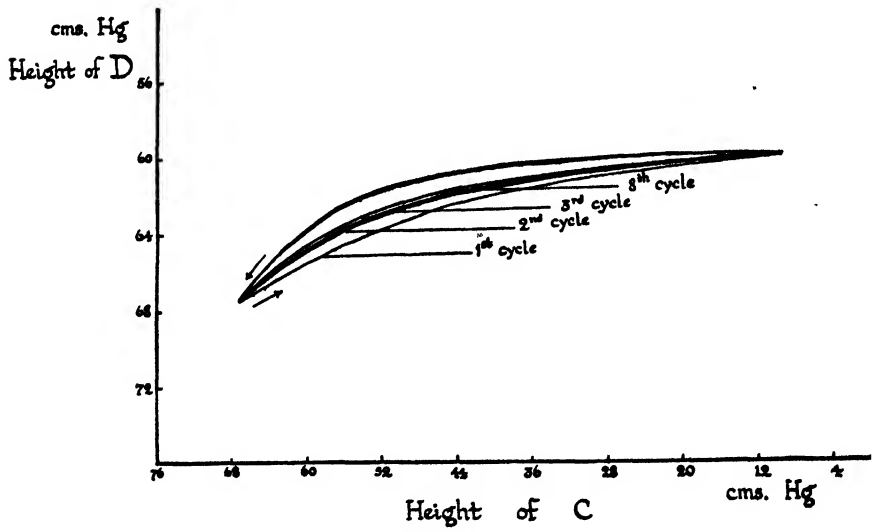

FIG. 4

In practice it was found desirable to take the material under investigation through a number of compression cycles before commencing to take readings. The reason for this was that the first and second cycles usually differed somewhat but after that the material behaved more uniformly, and gave repeatable results. This phenomenon is illustrated in Fig. 4, which shows the relation between the internal and external pressures for the 1st, 2nd 3rd and 8th compression cycle. After the 8th cycle there was no detectable variation. It is interesting to note that the recovery curves for all the cycles lie very close together.

It has already been indicated how, in any one experiment, from a knowledge of the value of β (the volume of the balloon) corresponding to a definite value of p_i (the internal pressure), the value of β corresponding

to any other value of p_i may be calculated. This was done in every experiment for a series of values of p_i and the corresponding values of p_e (the external pressure), both for increasing and decreasing pressures, was obtained from graphs similar to Fig. 4. It was then a simple matter to plot curves to show how the volume of a mass of wool varied according to the pressure (p_e—p_i) to which it was subjected. This, of course, was done both for ascending and descending pressures. In order to facilitate comparison between different samples it was thought to be more satisfactory to plot, against the pressure the ratio of the volume at any given instant (β) to the initial volume under zero pressure (β_0). The subsequent curves thus show β/β_0 plotted against p_e—p_i.

One point must be noted. In the apparatus as at present designed no attempt has been made to control the humidity of the inner space which of course is sensibly equal to that of the neighbouring part of the room. To have done so would have involved a more elaborate apparatus than perhaps was justified before a preliminary survey of the problem had been made. There is no doubt, however, but that humidity conditions affect the springiness of the wool. This drawback was obviated as much as possible by submitting the wools to test in pairs between which comparisons had to be made. These were always cleaned and dried together and exposed to the air of the laboratory for the same length of time. Also their examination was concluded within as short a space of time as possible.

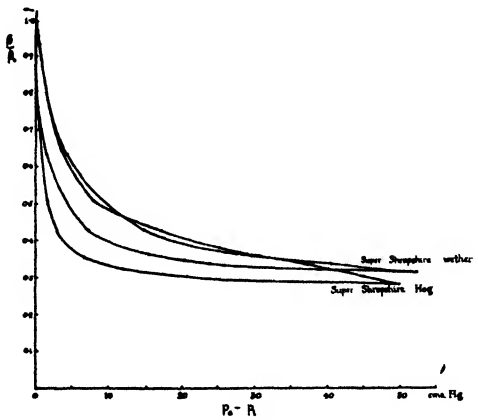

FIG. 5

Fig. 5 shows the curves for samples of Super Shropshire wether and Super Shropshire hog. Both are naturally springy wools and of the two, expert opinion assessed the wethers' wool as being a trifle more springy owing to the fact that it was very slightly coarser. If we take as a criterion of springiness or resilience the area of the loop and regard a narrow loop as evidence of great resilient properties and a wide one as evidence of a deficiency of such properties, the results of the experiment confirm this opinion. There seems to be good reason for supposing that resilience may be measured, to some extent, at any rate, by this method for the width of the loop is a measure of the degree to which the wool has failed to recover its former volume when the pressure has been partially removed.

In Fig. 6 are shown the results for two other samples of Super Shropshire wether and Super Shropshire hog together with a 50's N.Z. wether. The latter was comparable in fineness with the other two, but in the opinion of the trade was perhaps a little "softer" in handle. These curves lie very

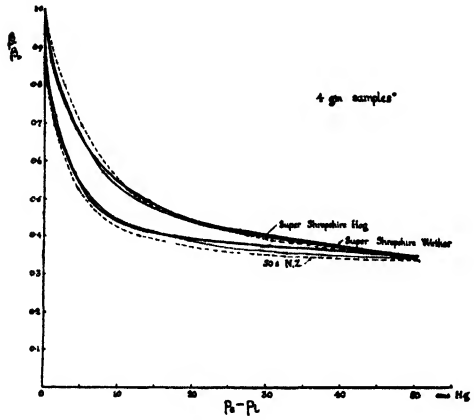

FIG. 6

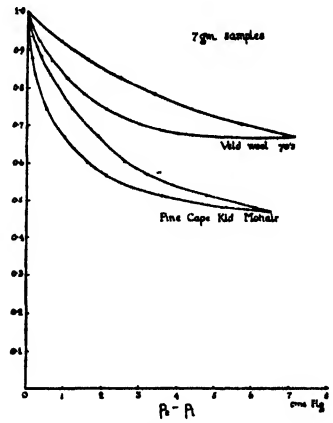

FIG. 7

close together. The areas of the loops when measured in arbitrary units by a planimeter are Super Shropshire hog 21·1, Super Shropshire wether 22·6 and 50's N.Z. wether 30·2. The first two are so close that the difference probably lies within the experimental error of the method, but there is no doubt they are both more resilient than the 50's N.Z. wether.

Fig. 7 shows the difference in behaviour between 7 gm. samples of mohair and merino (S.A. Veld) wool. These were experiments performed when only small pressures (of the order 7 cm. Hg.) were applied to the wool. Nevertheless there was a marked difference in behaviour of the samples. The springier mohair gave a much smaller compression loop.

Experiments were made to determine the effect on the resilience of the length of the fibres comprising the fibrous mass. An experiment was performed with a 4 gm. sample of N.Z. wether in the usual way. A

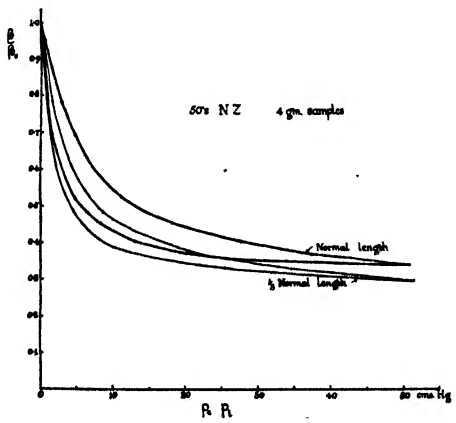

FIG. 8

further 4 gm. sample was prepared with the staple cut into three equal lengths each a little over an inch long. The curves for the short and the

wool of normal length are shown in Fig. 8. For a mass of this size at any rate the resilience of the whole is increased by having shorter fibres. A similar result was obtained with a 48's N.Z. wool in which the staple was cut into four equal lengths. See Fig. 9.

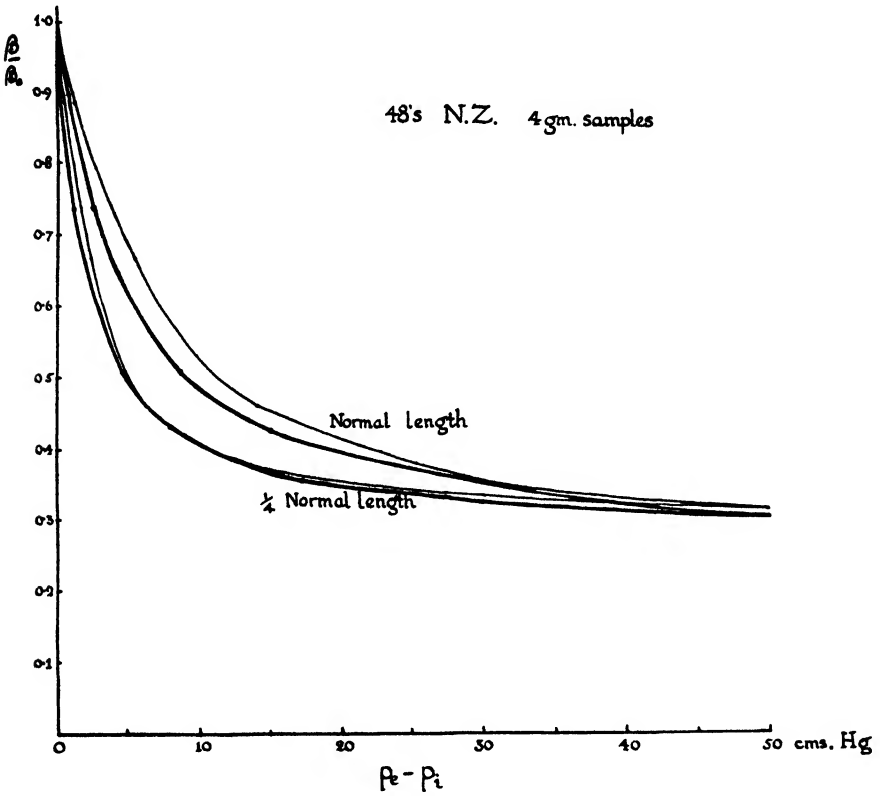

FIG. 9

SUMMARY

An attempt has been made to measure the resilience of a volume of wool by enclosing it in a thin spherical rubber membrane and submitting it to the mechanical action of a surrounding atmosphere whose pressure is made to vary in a cyclic manner.

The area of the loop relating the pressure and volume of the mass of wool (expressed as a fraction of the initial volume under zero pressure), seems to serve as a measure of the resilience of the wool. This measure is in fair agreement with expert opinion.

The work does not claim to be exhaustive but was designed to investigate the possibility of measuring resilience with accuracy. Many difficulties have still to be overcome in order to make the method thoroughly reliable. In particular the following points should be enquired into.

(1) The effect of humidity and conditioning on resilience.
(2) The effect of length.
(3) The effect of previous treatment of the wool with various reagents.
(4) The effect of stretching of the fibres.

Received 29/7/32.

28—A PSYCHO-TECHNICAL INVESTIGATION OF WORSTED YARNS MADE FROM SHORT WOOLS, NOILS AND WASTES*

By HENRY BINNS, F.T.I.

A cloth produced on the Bradford system of Worsted Manufacture is strong and durable, because it is made from long and relatively expensive wool fibres. It has, however, a thinner and harder handle, and is of leaner appearance than similar cloths made on the Continental system. The foreign product has not the intrinsic value of the Bradford product, but it possesses a soft, full handle the result of employing short wool fibres which make it sufficiently good and attractive to satisfy the requirements of consumers, particularly where fashion or superficial appearance and handle are more important than length of wear.

Professor Eber Midgley, Head of the Department of Textile Industries, Bradford Technical College, conceived the idea of utilising the noils thrown off by the combs and other waste materials, now either exported or used in the woollen trade of Great Britain. After repeated experiments, he finally succeeded in producing even, full, round and soft handling worsted yarns from the shorter and cheaper fibres by a system which involves fourteen processes in place of the twenty-three at present employed on the long wools. This new method of manufacturing should effect a considerable saving by the reduction in processes.

There is no recognised measurement in the trade for degrees of difference between the appearance, handle, and superficial values of wools, yarns, or fabrics; in other words, their selling values to the consumer. This is a psychological problem. The aim of the writer is to provide impartial evidence concerning these superficial values, showing the relative differences in smartness of appearance, softness of handle, and commercial values of six samples in two forms; one in yarns, the other knit-goods. The technical data for these is given in Table I.

Judgments were asked of:—Five spinners or manufacturers; five men and five women retail buyers; five men and five women consumers; five boys and five girls, age 10-11 years; and five were given by the writer, by means of touch alone on yarns and fabrics.

The instructions given to the five trade experts were to state the quality and the market price on the day of testing. To the remainder the following: "Please arrange these six materials in your order of preference from the best to the worst" on:—

1. Smartness of Appearance: In the order in which you prefer them for smartness of appearance. (Materials handled by the writer.)
2. Softness of Handle: In their order judged by softness of handle. (Eyes closed.)
3. Price: In the order in which you would buy them if all were offered at the same price. (Complete liberty allowed.)

*Presented at the Tenth International Congress of Psychology, Copenhagen, August,

Table I—Bradford (Long Wool) v. Continental (Short Wool) Methods of Manufacture

1. Identical Counts of Yarn and Knitted Textures.

2. Turns per inch according to length of fibres to give the best results in each instance.

Samples	Counts	Type of Material	Variations in Length of Fibres	Average Length of Fibres	Method of Manufacture
A	2/16s 7 × 4 turns	Buenos Aires 44's	1 cm. to 32 cm.	17 cm.	Bradford and Flyer Spun
B	2/16s 9½ × 6 turns	Buenos Aires 44's: Backings	1 cm. to 11 cm.	4 cm.	Continental and Ring Spun
C	2/16s 11 × 7 turns	Buenos Aires 44's: Noil	1 cm. to 10 cm.	2 cm.	,,
D	2/16s 11 × 7 turns	New Zealand 44's Noil	1 cm. to 10 cm.	4 cm.	,,
E	2/16s 7½ × 6 turns	Monte Video 50's Lambs	1 cm. to 11 cm.	4 cm.	,,
F	2/16s 11 × 7 turns	Shoddy 50's Re-manufactured wool	1 cm. to 11 cm.	3 cm.	,,

Spearman's Footrule formula which has been shown to be of great value in practical use has again* been employed for the correlations. As the number (n) is the same throughout, the probable error is ±·18. The gradings of materials have been obtained by averaging the placings, one to six, of each group of subjects.

An analysis of the average gradings of yarns by producers and distributors is shown in :—

Table II. Technical Judgment of Yarns (Undyed).

	Qualities						Average of 10 inter-correlations of 5 judgments	Correlation with Criterion of 10 retail buyers
	A	B	C	D	E	F		
Cost of raw materials	3	4	5	2	1	6	Market Price at Date	·00
Quality and price of yarns	6	5	3	4	1	2	·81	·99
Levelness of yarns ...	4	1	2	3	5	6	·41	−·26
Softness of handle by the writer	2	3	5	4	1	6	·92	·00
Criterion derived by these tests from 10 judgments of experienced retail buyers	5	5	2	4	1	3	·82	

*J. Text. Inst., 1926, Vol. 17, T618—T619.

There would appear to be no significance in the levelness factor, and in any case accurate measurements are possible by instruments. Accepting the average full judgments of ten retailers as a criterion, the raw material costing has a zero relationship thereto. Continued experimenting by touch and trade experience probably accounts for a correlation of ·89 between the cost of raw material and softness of handle by the writer.

The average judgments on Appearance are as follow :—

Table III—Smartness of Appearance of Dyed Knit-Fabrics. (Sight alone)

		Qualities						Group Inter-correlation	Criterion
		A	B	C	D	E	F		
Retail Buyers	Women	6	5	3	4	1	2	·98	·99
	Men	6	5	2x	4	1	2x	·86	1·00
Users	Women	6	5	3	4	1	2	·90	·99
	Men	6	4x	3	4x	1	2	·83	·95
Children	Girls	6	5	3	4	1	2	·72	·99
	Boys	6	5	2	4	1	3	·92	1·00

The average judgments of Softness are:—

Table IV—Softness of Handle of Dyed Knit-Fabrics. (Touch alone)

		Qualities						Group Inter-correlation	Criterion
		A	B	C	D	E	F		
Retail Buyers	Women	6	5	3	2	1	4	·88	·89
	Men	6	5	2	3	1	4	·61	·99
Users	Women	6	5	3	1x	1x	4	·71	·82
	Men	6	4	3	2	1	5	·37	·73
Children	Girls	6	4	2	3	1	5	·82	·89
	Boys	5	4	3	2	1	6	·39	·53
Writer		6	5	2	3	1	4	·96	·99

Judgments by touch are usually found to be less reliable than by sight. The correlation of ·99 between intensive training of the writer and the empirical training of retailers points to a fixed factor within the materials. Sight and touch judgments of retailers correlate at ·89 which is accounted for mainly by the fact that the re-manufactured wool " F " takes a 2·2 place for appearance and 3·8 for softness. This would be anticipated by the trade. But as a commercial deal is based on a full judgment this significant cause is merged in a placing of 2·9. Another important trend revealed in psychological tests by touch is that of the particular form in which material is judged. In top and yarn form, the fibres are parallel and judgments are made as the hand passes along the lengthways of fibres. In woven fabrics yarns are laid at right angles, but judgments are usually made along the weft yarns, influenced to some extent by the harder warp yarns. In knit goods fibres are laid in all directions and in consequence judgments are made by the hand passing across, as well as along the fibres. It is usual to find the inter-correlations higher in females than in males on touch judgments.

The following gradings are in the order of preference if all were offered at one price :—

Table V—Full Judgment of Dyed Knit-Fabrics.

		Qualities						Group Inter-correlation	Criterion
		A	B	C	D	E	F		
Retail Buyers	Women	6	5	3	4	1	2	·93	·99
	Men	6	5	2	4	1	3	·71	1·00
Users	Women	6	5	3	4	1	2	·96	·99
	Men	5	4	3	6	1	2	·68	·73
Children	Girls	6	5	4	3	1	2	·63	·89
	Boys	6	5	2	4	2	2	·66	·99

Again, the intercorrelations show more uniformity in the women than in the men, due, no doubt, to sensory factors. It will be noted that the gradings of women buyers, women users, and girls, from dyed knit goods, are almost identical and that these, in turn, are identical with the long-drawn-out and calculated judgments of trade experts from yarns in the grey ; all show a zero relationship with the cost of the raw materials.

CONCLUSIONS

1. The technical judgments of trade experts ; the trained judgments of retail buyers ; the experienced judgments of adults, and the natural judgments of children all show beyond doubt that their preferences are in the following order from the same wool in yarns and fabrics made from C (2 cm.) B (4 cm.) A (17 cm.). The more recent growth and consequently shorter wools are also usually finer. This result seems to be to confirm the claim of Professor Midgley from the purely psychological standpoint.

2. In these tests full judgments are biassed more by appearance than by handle ; the sight plays a more important part than touch.

3. As the 50's Monte Video Lambs' Wool is unanimously a first choice, that quality might be claimed as a criterion for market value. If, for example, at a given date this wool (E) were worth in yarn 21¾d. a lb. and the 44's Buenos Aires Long Wool (A) 16¼d., then the 44's Buenos Aires Noil (C) would be worth 19¾d. as calculated from the average placings of ten retailers and confirmed by trade experts. This shows a selling value of 3½d. a lb. in favour of the cheaper and waste material as against long wool of the same commercial quality.

4. The methods suggested give a practical and sufficiently exact means of determining the selling price differences between materials and of explaining the reasons why, as in the case of the re-manufactured wool F, the balance between sight and touch in a full judgment is disturbed.

5. The writer attaches considerable importance to the average inter-correlations of group judgments as a reliable indication of the value to be placed on the results obtained under test conditions. As an illustration ; the probable error in these tests is amply covered in 17 out of the 19 group averages.

The inexperienced men and boys provide, on the touch tests, the only results which are worthless as evidence ; these are the groups which an experienced investigator of textile judgments would expect to be sub-normal.

6. With intercorrelations of ·92 x ·96 respectively in undyed yarns and dyed knit-goods the writer's touch judgments show a zero (·00) relationship with each other.

The yarn judgments follow closely (·89) the cost of raw material whilst those of the knit-goods are almost exactly the same as the judgments of the retailers (·99).

It is significant that when fibres are handled lengthwise as in worsted yarns the longest gave the softest handle—or it may be a confusion with smoothness. But this feature is reversed when the same yarns are knitted and the hand passes over fibres laid parallel within the yarn but placed in all directions by the knitting process.

CORRIGENDUM

23—THE BEHAVIOUR IN CHEMICKING OF MATERIALS DYED WITH SOME VAT AND INSOLUBLE AZO DYES

By D. A. DERRETT-SMITH and C. R. NODDER

The Director of the Linen Industry Research Association, referring to the above paper in our *November* issue writes:

Our attention has been drawn by the Director of the British Launderers' Research Association to the statement on page T308 of the JOURNAL, sixth line from the bottom, referring to a "bleach in the boil" process. It should, of course, read "bleach in the wash" process.

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TRANSACTIONS—NAME INDEX

In this Index (C) indicates that the matter is the subject of a Communication.

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