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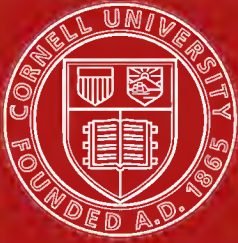


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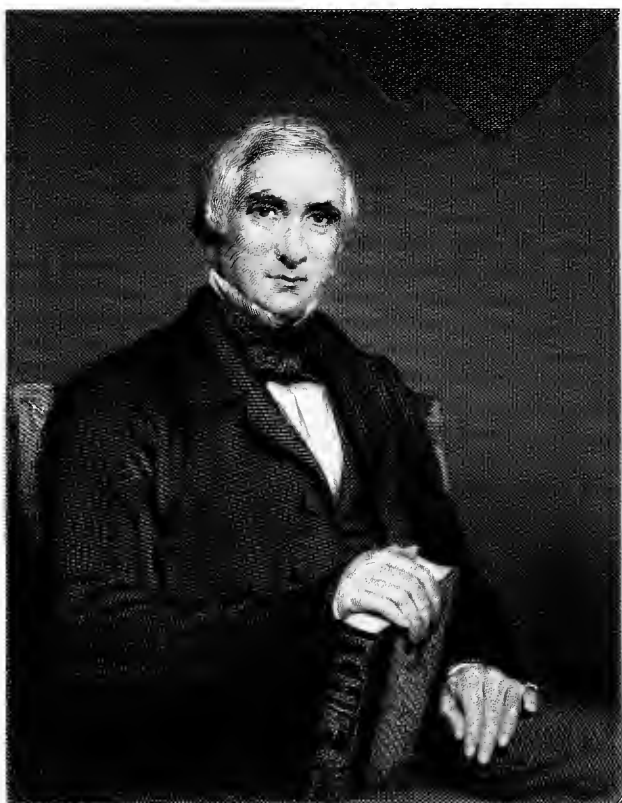
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THE
BOOK OF THE FARM
DIVISION I.

Wherefore come on, O young husbandman !
Learn the culture proper to each kind.

VIRGIL.



Engraving by John Watson Gordon.

C. H. Jones

Henry Stephens

THE
BOOK OF THE FARM

DETAILING THE LABOURS OF THE
FARMER, FARM-STEWARD, PLOUGHMAN, SHEPHERD, HEDGER,
FARM-LABOURER, FIELD-WORKER, AND CATTLE-MAN

BY
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GOREGORETZK IN RUSSIA; OF THE ROYAL AGRICULTURAL SOCIETY OF
SWEDEN; OF THE ROYAL IMPROVEMENT SOCIETY OF NORWAY

FOURTH EDITION

REVISED, AND IN GREAT PART REWRITTEN, BY

JAMES MACDONALD

OF THE 'FARMING WORLD';
AUTHOR OF 'FOOD FROM THE FAR WEST'; JOINT AUTHOR OF
'POLLED CATTLE,' 'HEREFORD CATTLE,' ETC., ETC.

IN SIX DIVISIONS

DIVISION I.

WILLIAM BLACKWOOD AND SONS
EDINBURGH AND LONDON

MDCCCLXXXIX 1889

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PREFATORY NOTE.

NEARLY twenty years have elapsed since the third edition of *The Book of the Farm* was prepared. In that comparatively short period of time British agriculture has undergone a striking change. It has seen its highest point in prosperity and almost its lowest in depression. Since the disastrously wet and sunless year of 1879, bad seasons have in themselves swept away a vast amount of farming capital. Foreign countries, with virgin soil and cheap labour, have flooded our open ports with meat and bread-stuffs; and, in spite of a largely increased population and much greater purchasing power on the part of the consuming public, the prices of nearly all varieties of farm produce have greatly declined.

How serious is the influence which these great movements have exercised upon our beloved country cannot readily be conceived. What they have signified to the farming community itself has, alas! been only too clearly visible. How fundamentally the fabric of British agriculture has been affected will be best understood by a consideration of the figures which represent the movements in imports and prices of agricultural produce, as well as the variations in the cropping and stocking of British farms.

The value of the imports of agricultural produce had grown

in 1887 to the formidable figure of £117,019,064, rather more than 48½ millions sterling in excess of the sum sent abroad for these commodities twenty-one years ago. Reckoned per head of population, the imports now amount to £3, 3s. 9d. for every man, woman, and child in the United Kingdom, or nearly 18s. 6d. per head more than in 1866. And the growth in quantities has been greater than in the value of the imports by from 25 to 30 per cent.

With such a vastly increased volume of foreign competition as these figures exhibit, the prices of farm produce in British markets could not fail to have suffered decline. The falling off in prices has indeed been very great, and it has extended in less or greater extent to almost every article produced on British farms.

It has been greatest in grain, greatest of all in wheat. From about 50s. per quarter in 1866 wheat fell to 31s. in 1887. In the same period barley lost 11s. and oats 8s. per quarter. Wool has fallen from 1s. 9d. to from 10d. to 1s. per lb.

The prices of beef and mutton have had many "ups" and "downs" since 1866. They are now (October 1888) not much below the level they presented then, but are from 15 to 25 per cent below the high range of prices attained between 1870 and 1883.

In sympathy with these alterations in prices, the systems of cropping and general farm management pursued throughout the United Kingdom have naturally undergone, and are still undergoing, considerable modification.

In the extent of cultivated land—arable land and permanent pasture—there has been a substantial increase in the past twenty years,—no less than 2,870,714 acres in Great Britain. But, as the result of the depression, as many as 833,393 acres have in twenty years gone from regular tillage into permanent pasture.

Looking more narrowly into the division of the arable land amongst the various crops, we find that the past twenty years

have introduced changes which are even more significant. The corn crops have lost ground considerably, falling from about 52 per cent of the arable land in 1867 to about 48 per cent in 1887. Green crops and grasses have both grown in proportionate extent—the former by about 7 and the latter by 58 acres in every 1000 acres of arable land. But the most notable change occurs in the area of bare fallow, which has fallen off by nearly 50 per cent. In Ireland similar movements have taken place.

In the relative positions of the individual crops in regard to acreage, the past twenty years have effected some significant changes. Amongst cereals, wheat has had to yield the premier position to oats. Barley has been nearly stationary. Beans have declined by nearly 30 per cent. Turnips are losing ground, potatoes gaining a little. The former is still, of course, by far the most extensively grown of the green crops. Mangels have increased by about 50 per cent.

It is thus obvious that corn-growing has lost its supremacy in the agricultural interests of this country. Increased reliance is placed upon live stock; and although this industry has not escaped the vicissitudes of the recent depression, it has nevertheless made substantial progress during the past twenty years. The progress in that period has not been continuous, and it has not extended to all varieties of farm live stock; yet the national wealth in the live stock of the farm is very much greater now than it was prior to 1870.

Since 1867 the stock of cattle in Great Britain has increased by nearly $1\frac{1}{2}$ million head, and in Ireland by about half a million head. Curiously enough, the stock of sheep has in the same period fallen off by nearly 3 million head in Great Britain and $1\frac{1}{2}$ million head in Ireland. Somehow pig-rearing, although when well conducted it is notoriously profitable, does not find favour with the majority of British farmers, and their stock of pigs has decreased by more than half a million head in the past twenty years. Irish farmers are more kindly disposed towards the pig, and their stock has increased substantially

since 1867. Despite the prediction that the steam-engine would tend to supplant horse-labour, the demand for draught-horses is now greater than ever. The stock of horses is larger than it was twenty years ago; yet it is undoubted that the breeding of horses might be extended with profitable results.

The important circumstances thus briefly indicated have produced something like a revolution in the position and prospects of the British farmer. He can no longer be the easy independent waiter upon Providence that he used to be when wheat was at 50s. per quarter. His life must be a struggle for existence, and he must prepare himself with a scientific and technical knowledge of his work in all its details and departments; must acquaint himself with the latest ideas of the practical and scientific agriculturist, and test them by his own experience and possibilities; and must cast around him in search of information as to how he can make the most of the altered condition of things. It is by knowledge combined with experience that the farmer of the future must make his way. The State has begun to appreciate this fact by establishing means of providing agricultural instruction. But the practical farmer requires more full and special sources of information,—a work which he can with profit make the subject of general study, and which he can with confidence refer to at any moment when he is in want of advice. Such a work, it is hoped, *The Book of the Farm* in its new and enlarged form will prove to be.

In the preparation of this the Fourth Edition of *The Book of the Farm*, the important changes of the past twenty years have been carefully and anxiously considered. To a large extent the work has been rewritten; what remains of the original text has been carefully revised.

Alike in providing the new matter and in revising the old, the great object aimed at has been to adapt the work to the altered and still shifting circumstances and surroundings of the

British farmer. Without neglecting, or turning our back upon, any of the branches of farming which may perhaps be of comparatively less importance than in former times, we have devoted more attention than was given in previous editions to some other interests which have risen in the scale of importance. Prominent amongst these latter is the great subject of stock-rearing, notably the breeding and feeding of cattle. The portions in the new edition relating to this branch of farming consist almost entirely of fresh matter; and so important is it considered, that it has been dealt with more fully and more exhaustively than has ever before been attempted.

Scientific and practical research have thrown fresh light upon the fundamental processes of maintaining the fertility of the soil. An entirely new chapter places the reader in possession of this extended and corrected experience. The system of ensilage, the latest agricultural innovation, and the extension of dairy farming, have received due attention. Every modification and development of great or minor importance, every new or extended influence affecting agriculture, has had careful consideration. A full history and description of all the varieties of British horses, cattle, sheep, and swine also form a new feature; and its interest and usefulness will be enhanced by a full series of high-class animal portraits, which embraces typical animals of all the leading breeds, and which has been specially prepared at great expense for this edition by eminent artists.

The original plan of the work has been in the main preserved. With the view of facilitating reference, some minor changes, such as headings instead of numbers to paragraphs, have been introduced. Much care has been bestowed upon the introduction of these paragraph headings, and they are set forth clearly, so that the reader may learn at a glance the subjects dealt with in any part of the work.

As in the third edition, the work is divided into heads: 1. INITIATION, in which the young man desirous of becoming a farmer is advised to acquaint himself beforehand with certain

branches of science which have a close relation to Agriculture, and is also instructed as to how this knowledge is to be obtained and as to where he can best learn the practice of his art; 2. PRACTICE, which details the entire operations, through the four seasons, of raising crops, and rearing the domesticated animals; 3. REALISATION, wherein the young farmer is advised how to bargain for and stock a farm—how to execute many operations he may have to undertake—how to judge and to conduct the breeding of live stock—and, lastly, how to keep accurate accounts of all his transactions.

It is hoped that the new edition, in its greatly extended and thoroughly revised form, may efficiently help farmers to pursue their occupation with pleasure and profit. Farming, if it is to maintain its importance as an industry, must, like any other business, be conducted at a profit. With reduced prices and other magnified obstacles, it is more difficult than ever to accomplish this. More than ever, therefore, is it important that the farmer should fortify himself with all the guidance, stimulus, and encouragement which *The Book of the Farm* is capable of affording to him. The work is designed as a guide to him in every piece of practical work and every item of farming business he is called upon to engage in. It presents itself as a faithful compendium of the experience of a whole army of agricultural “specialists,”—men who have shown themselves to be proficient in some special branch of practical farming or province of allied science. The work thus aims at forming in itself a compendious professional library for every well-equipped farmer.

In taking up the life-work of the able and respected author of *The Book of the Farm*, I have felt the responsibility all the greater because of the exceptional conditions which at the present moment surround the British farmer. Happily, in the preparation of the new edition, I have had the privilege of the cordial co-operation of a great many of the leading agricultural and scientific authorities of the day, and I feel that I have thereby been enabled to impart to the work a quality

of some special importance,—a comprehensiveness and efficiency which could not otherwise have been attained. It will be sincerely gratifying to me if the work in its new form should be considered worthy the memory of the late Henry Stephens, whose services to the interests of British farmers have earned for his name a lasting place in the annals of agriculture.

When the publication of the work is completed, it will be my duty and pleasure to express my obligations to those who have thus so ably assisted me.

JAMES MACDONALD.

EDINBURGH, 1888.

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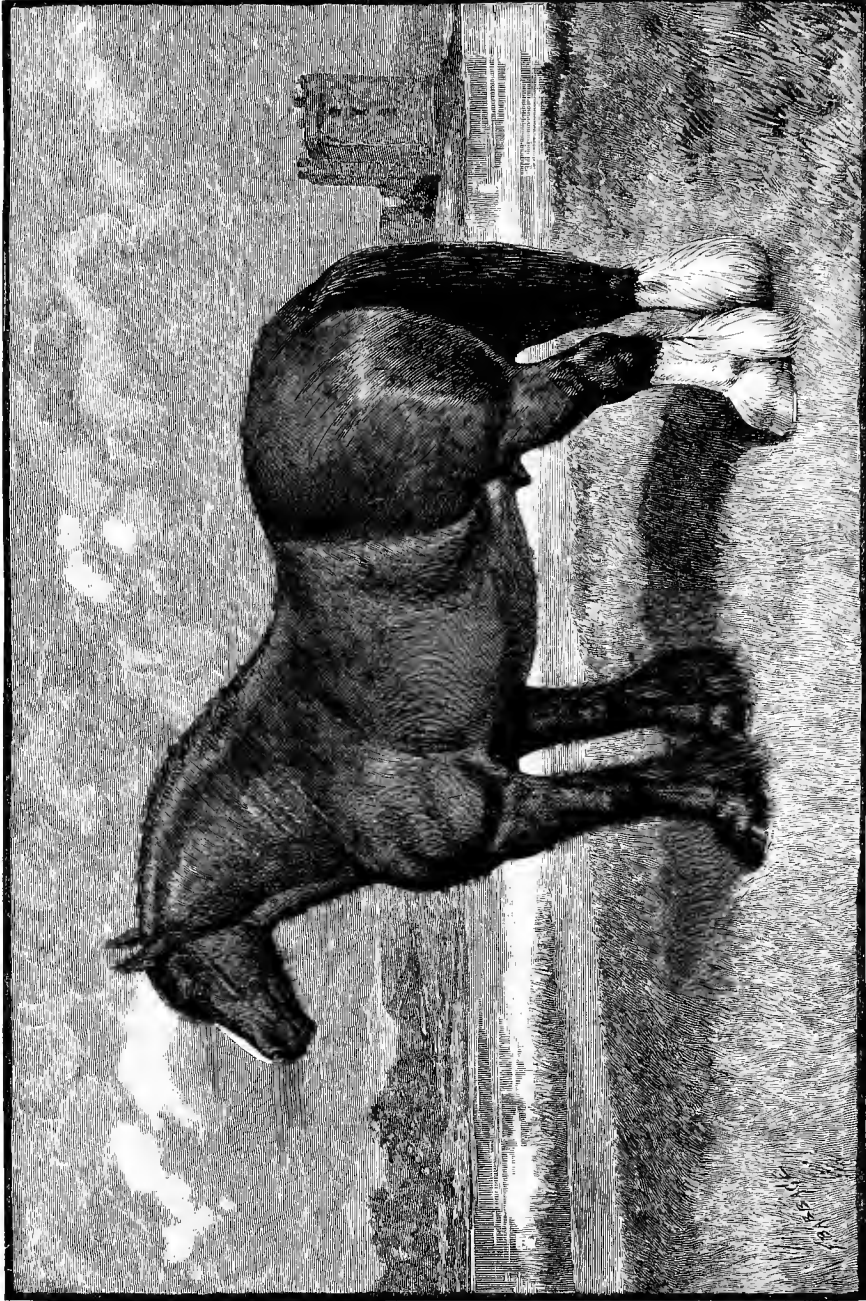
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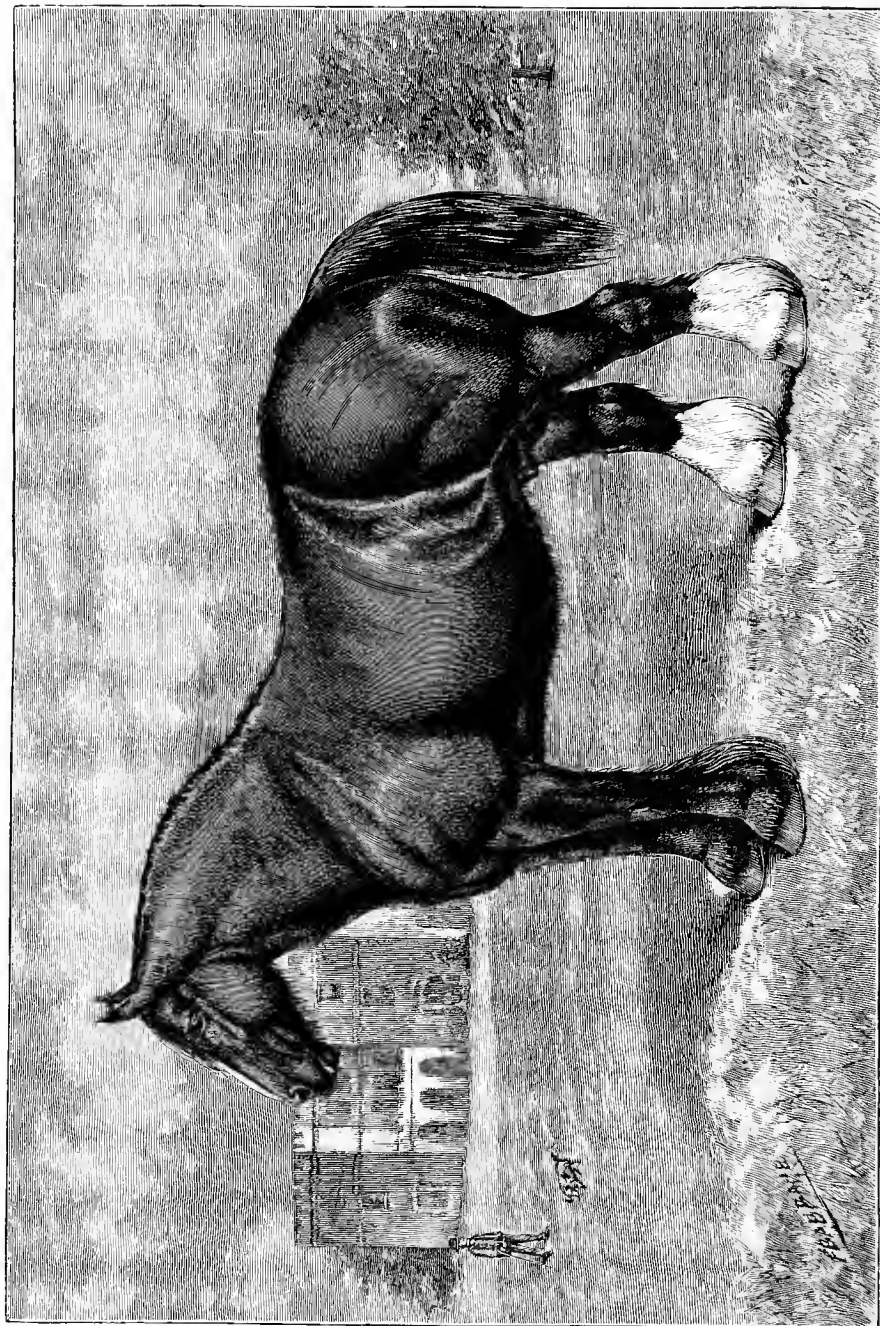
CLYDESDALE STALLION, "MACGREGOR," 1437.

THE PROPERTY OF ANDREW MONTGOMERY, ESQ., OF NETHERHALL, CASTLE-DOUGLAS.

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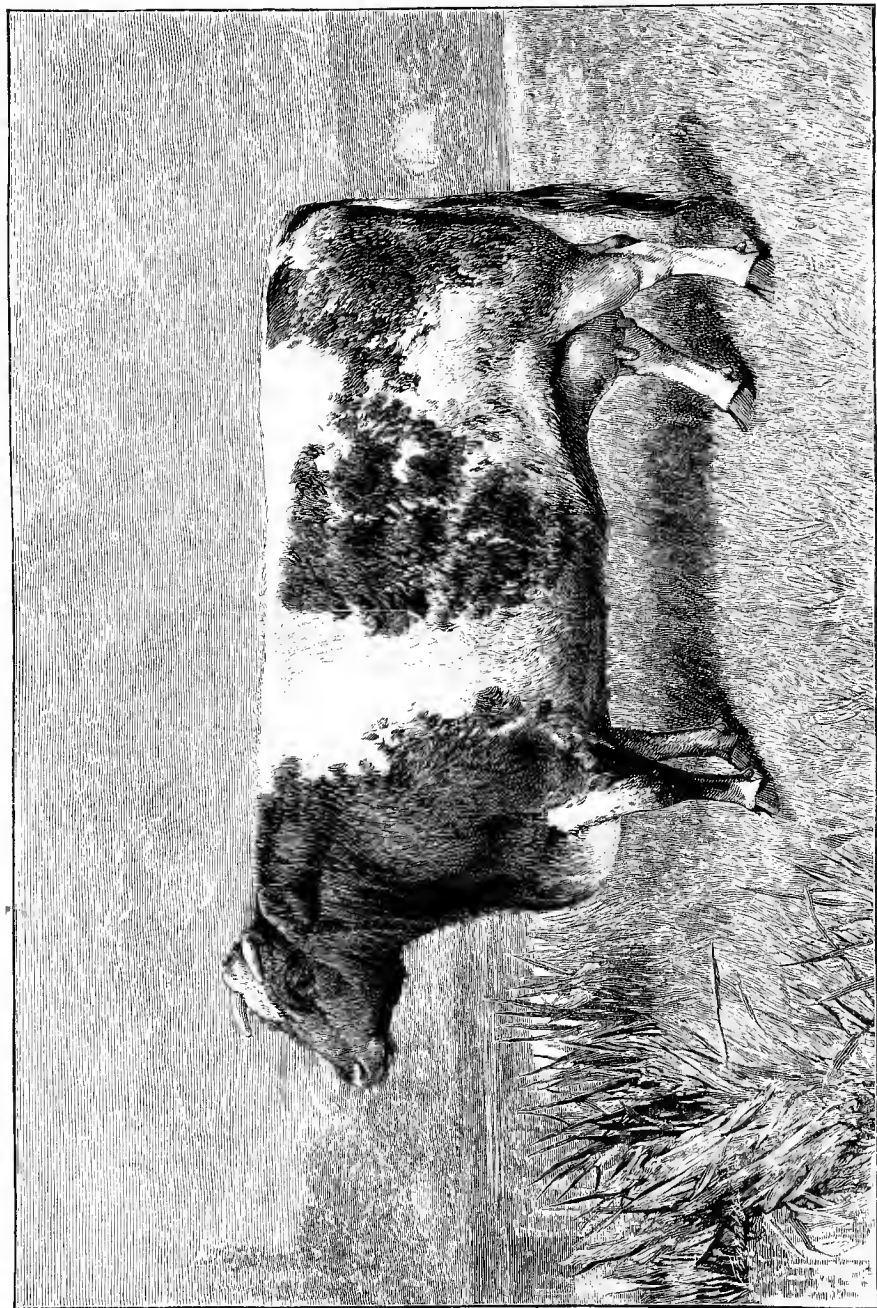
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SHIRE STALLION. "SPARK," 2497.

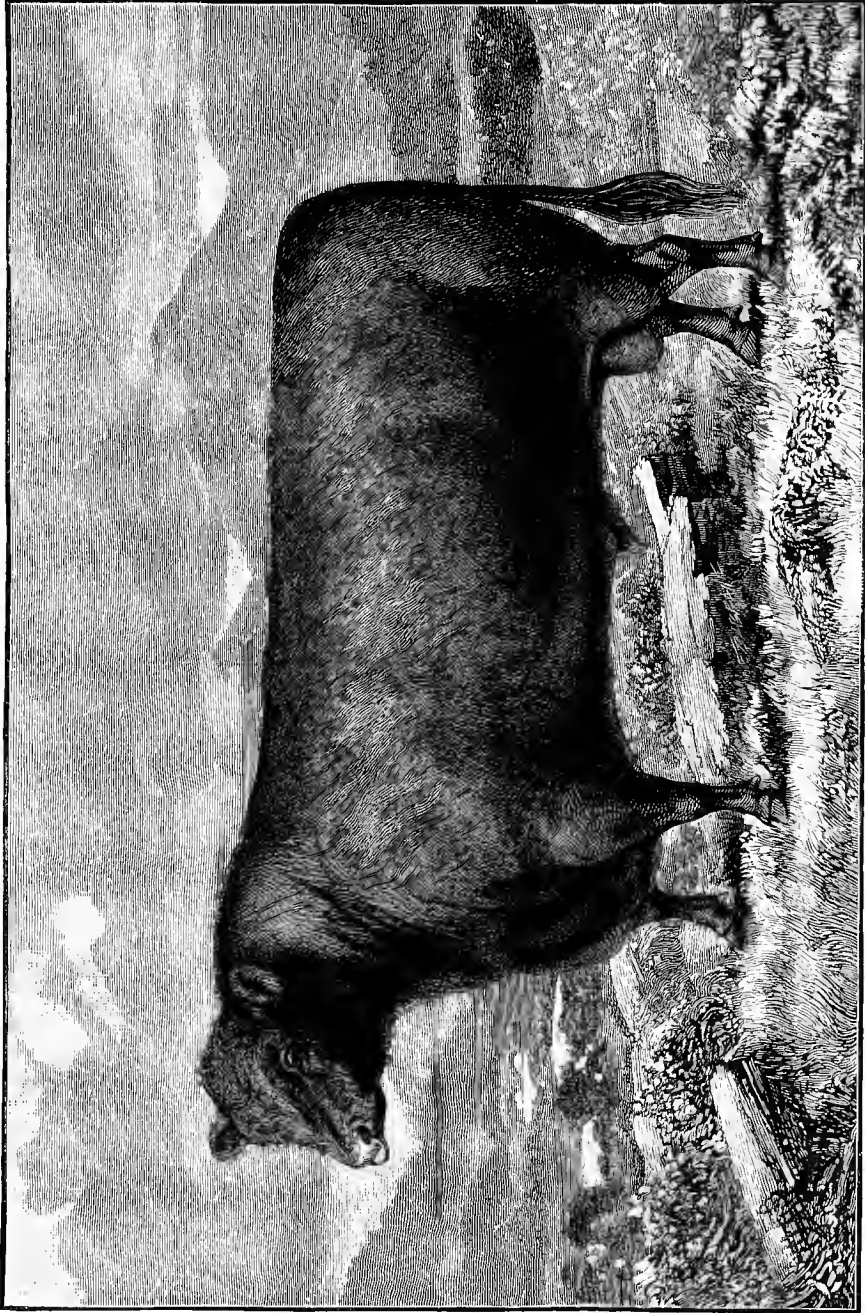
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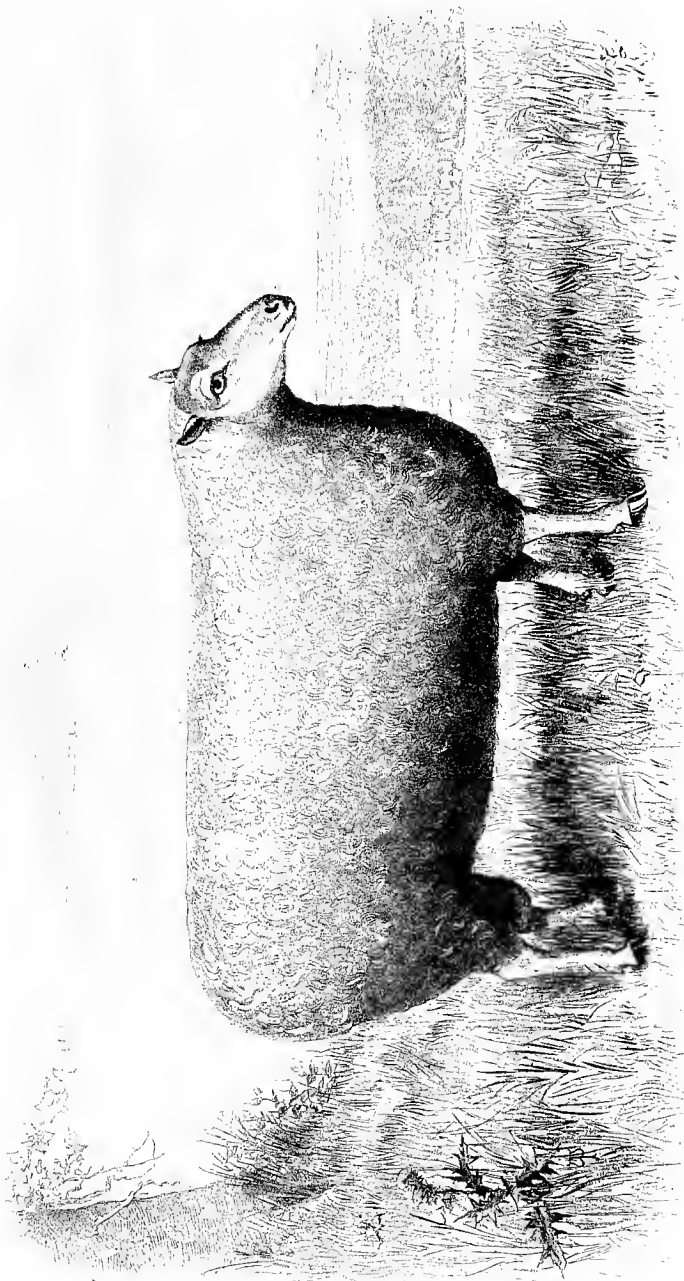
POLLED ABERDEEN-ANGUS BULL, "JUSTICE," 1422,

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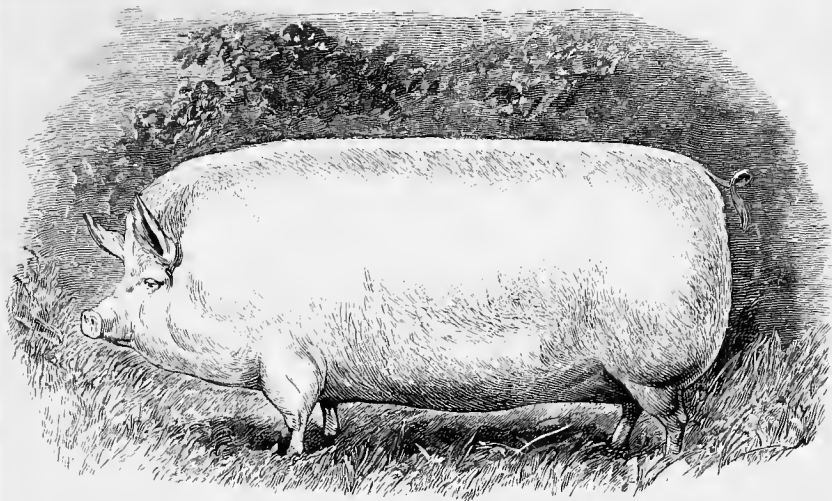
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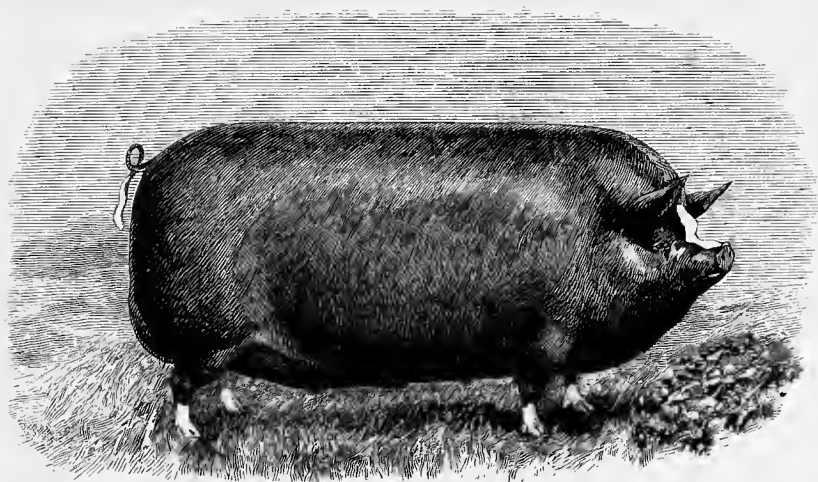
BLACKFACED RAM, "SEVENTY-TWO."

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BERKSHIRE BOAR.

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THE BOOK OF THE FARM.

INITIATION.

METHODS OF ACQUIRING A KNOWLEDGE OF PRACTICAL FARMING.

It must not be taken for granted that any book, however constantly perused, will enable any man to become a practical farmer. It can only be a guide to direct him into the way where he can best acquire practice; be always at his side to indicate what he should look for, and to explain the meaning of what he is witnessing. These items of information he would be a long time of finding out for himself.

The only place a young man can acquire practice is upon a farm, and there he will find the 'Book of the Farm' an instructive companion. And this function which the 'Book of the Farm' essays to fulfil is a very important one, demanding a work of a varied and comprehensive character—one which would not be complete if it did not exhibit itself as a compendium of the writings and doings of those who, in their various spheres, have been prominent in the good work of advancing agricultural knowledge.

Tutor - Farmers. — A tutor-farmer
VOL. I.

should have the reputation of being a skilful cultivator of land, an able breeder, and an excellent judge of stock. He should possess the faculty of communicating his ideas with ease and distinctness. He should occupy a farm, consisting of a variety of soils, and situate in a fair climate.

Hints to Farm-Pupils.—A residence of one year must pass ere the pupil can witness a course of operations on a farm. As all operations are preparatory for certain results, the second year will be employed in studying the progress of works in preparation. In the third year, when his mind is stored with the modes of doing work, and the purposes for which they are performed, the pupil may request to put his knowledge into practice, under the correcting guidance of his tutor; or he may feel confident of being able to manage a farm for himself or for another.

The pupil should come to his tutor at the *opening of the agricultural year—in the beginning of winter*, when all the great operations are *begun*; and, to their being understood, he should *see them begin*.

The first thing the pupil should be-

come well acquainted with is the *physical geography* of the farm—its position, exposure, extent; its fences, whether of wall or hedge; its shelter, in relation to rising-grounds or plantations; its roads, public or private, whether conveniently directed to the different fields or otherwise; its fields, their number, names, sizes, relative positions, and supply of water; the position of the farmhouse and farm-offices. Familiar acquaintance with these particulars will enable him to understand more readily the orders given by the farmer for the work to be performed in any field. A plan of the farm would much facilitate its familiar acquaintance. A *tutor-farmer* should be provided with such a plan; but if not, the pupil can construct a rough one for himself.

Fees for Farm-Pupils.—The fees for pupils vary from £50 to £120 per annum or more, for bed, board, and washing, with the use of a conveyance to occasional markets and shows. If the pupil desire a horse of his own, about £30 a-year more is demanded.

A Word to Guardians of Farm-Pupils.—It is considered impolitic to give a pupil a horse of his own at first. Constant attention to field-labour may be irksome, while exercise on horseback is tempting to young minds. The desire to possess a horse of one's own is so very natural in a young person living in the country, that, were the pupil's inclinations alone consulted, the horse would soon be in his possession; and if he be an indifferent pupil, he will certainly prefer pleasure to duty—such as following the hounds, forming acquaintances at a distance from home, and loitering about towns on market-days in indulgence and extravagance. This consideration should have its weight with parents and guardians, when they are importuned by the pupil for the luxury of a horse. The diligent pupil will daily discover new sources of enjoyment at home, far more satisfactory, both to body and mind, than in jogging along the dirty or dusty highways, until the jaded brute he bestrides is ready to sink under its unworthy burden.

The pupil should provide himself with an ample stock of strong clothing and shoes.

THE DIFFICULTIES IN LEARNING FARMING AND THE MEANS OF OVERCOMING THEM.

The pupil, if left to his own guidance when beginning to learn farming, would encounter many perplexities. The first difficulty that obtrudes itself is the *distribution* of the labour of the farm—the teams are employed one day in one field at one kind of work, and the next day in another field at another kind of work; the field-workers assist the teams one day, and in the next they work by themselves elsewhere.

Variety of Farm-Labour.—Another difficulty is in the *variety* of the labours performed. One day the horses in the plough move in a direction opposite, in regard to the ridges, to what they were in another field. On another day the horses are with a different implement from the plough. The field-workers have laid aside the implement with which they were working, and are performing their labour with the hand. All field-work being *preparatory* to some other work, is the circumstance which renders its object so perplexing to the learner. He cannot foresee what is aimed at. It is not easy for the tutor to make him appreciate the importance of foresight. The pupil only sees the value of an event after it has happened. But in reality, let experience in farming be ever so extensive—or the knowledge of minutiae ever so intimate—unless the farmer guide his experience by *foresight*, he will never be enabled to conduct a farm aright. Both foresight and experience can only be acquired by observation, and though observation is open to all farmers, all do not profit by it. Every farmer may acquire, in time, sufficient *experience* to conduct a farm in a passable manner; but many farmers never acquire *foresight*, because they never reflect, and therefore never derive the greatest advantage from their experience. Conducting a farm by foresight is a higher acquirement than the most intimate knowledge of the minutiae of labour. Nevertheless, a knowledge of the minutiae of labour should be first acquired by the pupil; and by carefully tracing the connection between combined operations and

their ultimate ends, he will acquire *foresight*.

Necessity of Foresight.—The necessity of possessing foresight in arranging the minutiae of labour renders *farming* more difficult of acquirement, and a longer time of being acquired, than most other arts. This statement may seem incredible to those who are accustomed to hear of farming being easily and soon learned by the meanest capacity. In most other arts, no great time usually elapses between the commencement and completion of a piece of work, and every piece of work is continued in hand until finished. The apprentice can thus soon perceive the connection between the minutest portion of the work in which he is engaged and the object for which the work is prosecuted.

The pupil-farmer has no such advantage in his apprenticeship. Many minutiae connected with very different operations in progress claim his attention at one and the same time; and if he neglects one for another, he will suffer a loss. It is a serious misfortune to a pupil to be retarded in his progress by an apparently trifling neglect of any field operation, for he cannot make up his leeway until after the revolution of a year; and though ever so attentive, he cannot possibly learn to anticipate operations in a shorter time than a year, and therefore cannot understand the object of a single operation in the first year of his pupilage. The first year is thus spent almost unprofitably, and certainly unsatisfactorily to an inquisitive mind. One year's residence will therefore not suffice.

Personal Attention by Farm-Pupils.—Formidable as these difficulties may seem, it is in his power to overcome them all. The most satisfactory way of overcoming them is to resolve to learn his business in a truly practical manner—by attending to *every* operation *personally*. Merely being domiciled on a farm is not, of itself, a sufficient means of acquiring farming; for the advantages of residence may be squandered away by idleness, by frequent absence from home, by spending the busy hours of work in the house, or by only casual attendance on field operations. Such habits must be avoided by the

pupil if he desire to become a *practical* farmer.

Training Farm-Pupils.—Much assistance in acquiring knowledge should not be *expected* from the farmer. No doubt it is his *duty* to communicate all he knows to his pupils, and he is willing to do so; but as efficient tuition implies constant attendance on work, the farmer himself cannot be constantly present at every operation, or even explain any, unless his attention is directed to it; and much less will he deliver extempore lectures at appointed times. Reservedness in him does not necessarily imply *unwillingness* to communicate his skill; because, being himself familiar with every operation that arrests the attention of his pupil, an explanation of minutiae at any other time than when the work is in hand, and when only it can be *understood*, would only serve to render the subject more perplexing to the pupil. Should the farmer be absent, the steward, or ploughmen, or shepherd, as the nature of the work may be, will afford information until he associates with the farmer at the fireside.

Farm-Pupils must work.—To be enabled to discover that particular point in every operation which, when explained, renders the whole intelligible, the pupil should put his hand to every kind of work, be it easy or difficult, irksome or pleasant. Experience acquired by himself will solve difficulties much more *satisfactorily* than the most elaborate explanations given by others; and the larger the stock of personal experience he thus accumulates, the sooner will he understand the purport of everything that occurs in his sight. Daily opportunities occur for joining in work: for example, when the ploughs are employed, or when at the farmstead, where the thrashing-machine and winnowing-machine are at work, attendance will be amply repaid by the acquisition of a knowledge of the plough and of the quality of grains. There is no better method of acquiring knowledge of *all* the minor operations of the farm than to superintend the labours of the field-workers, their work being methodical, almost always in requisition, and consisting of minutiae; and its general utility is shown, not only in its own

intrinsic worth, but in relation to the work performed by the teams.

Study Stock-Feeding.—The feeding of cattle in the farmstead, or of sheep in the fields, does not admit of much participation of labour with the cattle-man or shepherd; but either practice forms an interesting subject of study to the pupil, and without strict attention to both he will never acquire a knowledge of feeding, and of computing the value of live stock.

Learn young.—Other considerations in regard to the acquisition of practical knowledge deserve attention from the pupil. It is most conducive to his interest to learn his profession in youth, before the meridian of life has arrived, when labour of every kind becomes irksome.

Advantages of a thorough Training to Farmers.—It is also much better to have a *thorough* knowledge of farming *before* engaging in it, than to acquire it in the course of a lease, when losses may be incurred by the commission of comparatively trivial errors at the early period of its tenure, when farms in all cases are most difficult to conduct. It is an undeniable fact that the work of a farm never proceeds so smoothly and satisfactorily to all parties engaged in it, as when the farmer is thoroughly conversant with his business. His orders are then implicitly obeyed, because a skilful master's directions inspire undisputed confidence in the labourers.

Loss from want of Training.—Let the converse of this state of things be imagined—let the losses to which the ignorant farmer is a daily prey be calculated—and it will soon be evident that it is much safer for a farmer to trust to his own skill than to depend on that of his servants. A trustworthy steward may be found to manage for him; but, in such a position, a steward is placed in a state of temptation; and as servants never regard him as a master, where the master himself is resident, his orders have not the same authority.

A faithful Guide.—Surrounded thus by difficulties, the 'Book of the Farm' should prove a faithful guide to the pupil. On acquiring the contents of

the work from the Index, he has only to consult it as his daily monitor, and receive the desired information on the extent and kind of work being executed at the season of the year, and which will be sufficient information for the time being. The book being divided into the Four Seasons, every operation under each of these may easily be found.

Search for Information.—By thus searching for information, the pupil will acquire as much in the course of the first year as he would in the second by his own observation alone, and thereby saving a year of probationary trial, he will learn in two years what would require three.

THE DIFFERENT KINDS OF FARMING, AND SELECTING THE BEST.

Perhaps the pupil will be surprised to hear of the many kinds of farming there are possessing distinctive characteristics. There are at least six outstanding kinds practised in this country. Soil, situation, and locality determine the respective kinds.

Pastoral Farming.—The simplest kind, the *pastoral*, is determined by situation. It is found in the Highlands and Islands of Scotland; in the Cheviot and Cumberland hills of England; and in Ireland and Wales. In all these districts, farming is principally directed to the breeding of cattle and sheep; and as natural pasture and hay form the principal food of live stock there, very little arable culture is practised. Cattle and sheep are not always reared on the same farm. Cattle are reared in large numbers in the *pastoral valleys* among the mountain-ranges of England, Wales, and Scotland. Sheep are reared in still greater numbers in the *upper parts* of the mountain-ranges of Wales and Scotland, and on the green round-backed hills of the north of England.

One kind of sheep, or one kind of cattle, is usually reared on pastoral farms, though both classes of stock may be found where valleys and mountains are on the same farm. The arable culture practised on them is confined to the raising of provisions for the families who live upon them, and of turnips for

stock during severe weather in winter; the principal winter food being hay, obtained from natural grass on spots of good land on the banks of a rivulet. Pastoral farms are all large, some containing many thousands of acres—nay, miles in extent; but from 1500 to 3000 acres is perhaps an ordinary size.

Stocking a Pastoral Farm.—The *stocking* of a pastoral farm consists of a breeding or flying stock of sheep, or a breeding stock of cattle. A proportion of barren stock is sold and fattened in the low country. A large capital is required to stock at first, and afterwards to maintain such a farm; for although the quality of the land may support a few heads of stock per acre, yet, as the farms are large, the number required to stock them is very considerable. The rent, when consisting of a fixed sum of money, would be of small amount per acre, but often its amount is fixed by the number of stock the land will maintain, and it is calculated at so much money per head.

Pastoral Farmers.—A *pastoral farmer* should be well acquainted with the rearing and management of cattle or sheep, whichever his farm is best suited for. A knowledge of field culture is of little use to him, though he should know how to raise a large crop of turnips and make good hay.

Carse - Land Farming.—Another kind of farming is practised on *carse* land, which consists of deep horizontal depositions of alluvial or diluvial *clay*, on one or both sides of a considerable river, and comprehending a large tract of low country. In all respects, a carse is quite the opposite to a pastoral farm. Soil entirely decides carse farming.

Stocking a Carse Farm.—Being entirely arable, a *carse farm* is stocked with many animals and implements of labour; and these, with seed-corn, require a considerable outlay of capital. Carse land always maintains a high rent, whether solely of money or of money and corn valued by the market price of corn. A carse farm, requiring a large capital and much labour, is never of great extent, seldom exceeding 200 acres.

Carse Farmers.—A *carse farmer* should be well acquainted with the cultivation of grain, and all the stock he

requires are a few cows, to supply milk to his own household and farm-servants, and a number of cattle in the straw-yard, purchased for the winter, to trample down the large quantity of straw into manure, with the assistance of a few turnips.

Suburban Farming.—A third sort of farming is *in the neighbourhood of large towns*. In the immediate vicinity of London and other large cities, farms are appropriated to the growth of garden vegetables for Covent Garden market, and, of course, such culture can have nothing in common with either pastoral or carse farms. In the neighbourhood of most towns, garden vegetables, with the exception of potatoes, are not so much cultivated as green crops, such as turnips, potatoes, and grass; and dry fodder, such as straw and hay, for the use of cowfeeders and stable-keepers. In this kind of farming all the produce is disposed of, and manure purchased in return, constituting a sort of retail trade. The sale of fresh milk is frequently conjoined with the raising of green crops, in the neighbourhood of large towns. When the town is not large enough to consume all the disposable produce in its neighbourhood, the farmer purchases cattle and sheep to eat the turnips and trample the straw into manure, in winter. Pasture grass is kept in paddocks for the accommodation of stock in the weekly market. Locality entirely decides this kind of farming.

The chief qualification of an *occupant of this kind of farm*, is a thorough acquaintance with the raising of prolific green crops, of potatoes, clover, and turnips.

Capital for a Suburban Farm.—The *capital required for a farm of this kind*, which is all arable, is as large as that for a carse one. Being close to a town, the rent is always high, and the extent of land not large.

Dairy-Farming.—A fourth kind of farming is the *dairy*. In it, butter and cheese are made, and fresh milk is sold from it. A dairy-farm is much the better of having a considerable extent of *old pasture*. Stock are reared on dairy-farms only to a small extent of quey (heifer) calves, yearly to replenish the cow stock; the bull calves being fed for veal, or sold

to be reared by others. In many cases, indeed, no cattle are reared. Pigs are reared and fattened on dairy refuse. Sometimes young horses are also reared. Horse-labour being comparatively small, mares rear their young and work at the same time; while old pasture, spare milk, and whey, afford great facilities for nourishing young horses to a large size in bone. Locality establishes this kind of farming.

Stocking a Dairy-Farm.—The purchase of *cows* is the principal expense of *stocking a dairy-farm*, and requires a considerable capital. Such a farm seldom exceeds 150 acres.

What a Dairy - Farmer should know.—A *dairy-farmer* should be well acquainted with the properties and management of milk-cows, the making of butter and cheese, the feeding of veal and pork, and the rearing of horses; and he should also possess as much knowledge of arable culture as to raise large green crops and make good hay.

"Common" Farming.—A fifth mode of farming is that practised in most arable districts, consisting of every kind of soil not strictly carse land, and may be named *common farming*. This method consists of a regular system of cultivating grains and sown grasses, with very partial rearing or wholly purchasing of cattle. No sheep are reared in this system, being purchased in autumn, to be fed on turnips in winter, and sold fat in spring; and hence sheep on it are called a *flying stock*. This system may be said to *combine the professions of the farmer, the cattle-dealer, the sheep-dealer, and the pig-dealer*. Besides the plenishing of the farm, which may be of considerable extent, this system requires a large floating capital, for the purchase of cattle or sheep, or of both.

Mixed Farming.—A decided improvement on this system long ago originated, and is now practised extensively throughout the United Kingdom. The farmer of this improved system combines all the qualifications of the various kinds of farming enumerated. Rearing cattle and sheep, and having wool to dispose of, he is a stock-farmer. Cultivating grains and the sown grasses, he possesses the knowledge of the carse farmer. Converting milk into butter and cheese after the

calves are weaned, he passes the autumnal months as a dairy-farmer. Feeding cattle and sheep in winter on turnips, he attends the markets of fat stock as well as the common farmer; and in many cases he breeds and rears the greater portion of his live stock. Thus raising and retaining all his produce until they arrive at maturity, he derives whatever profit they are capable of yielding.

This system of *mixed husbandry* ensures a mutual dependence and harmony of parts between crops and stock. Such a variety of products demands more than ordinary attention and skill; and accordingly, it has made its farmers the most skilful and intelligent in the kingdom.

This system cannot very advantageously be conducted within narrow bounds, and therefore *mixed farms* are generally large in extent—from 150 to 500 acres or more. The capital required to furnish live stock and the means of arable culture is considerable. The rents are large in amount, although not per acre. Mixed husbandry is determined by no peculiarity of soil and locality, but has a happy constitution in adapting itself to most circumstances in an arable district.

Selecting a System.—One of the above systems the pupil must adopt for his profession. If he succeed to a family inheritance, his farming will most probably depend on that pursued by his predecessor, which he will learn accordingly; but when free to choose for themselves, most pupils adopt the mixed husbandry, as it contains within itself all the requisites for a farmer to know, and is the safest farming under most circumstances.

Mixed husbandry is in ordinary circumstances the safest, because, should his stock be much lowered in value, the farmer has the grain to depend upon; and should the grain give a small return, the stock may yield a profit.

THE PERSONS WHO CONDUCT AND EXECUTE THE LABOUR OF THE FARM.

The persons who give their labour to a farm constitute the most important part of the staff. They are the farmer, the steward or grieve, the ploughman, the hedger or labourer, the shepherd, the

cattle-man, the field-worker, and the dairymaid.

The Farmer.—And first, the *farmer*. It is his province to determine the period for commencing and pursuing every operation,—to give orders to the steward, when there is one, and when none, to the ploughmen, for the performance of every field operation,—to have a superintending eye over the field-workers, to see the cattle cared for,—to watch the state of the crops,—to guide the shepherd,—to direct the hedger or labourer,—to sell the surplus produce,—to purchase the materials for the progressive improvement of the farm,—to disburse expenses,—to pay the rent to the landlord,—and to fulfil the obligations incumbent on him as a residenter of the parish. He is his own master,—makes bargains to suit his own interests,—stands on an equal footing with the landlord on the lease or agreement,—has entire control over the servants. Such a man occupies both an independent and responsible position.

Farm Steward.—The *steward*, or *grieve*, as he is called in some parts of Scotland, and *bailiff* in England, receives instructions from the farmer, and sees them executed by the people under his charge. He exercises a direct control over the ploughmen and field-workers, but in most cases he has no control over the shepherd or hedger. The farmer reveals to the steward alone his plans of management; intrusts him with the keys of the corn-barn, granaries, and provision stores; delegates power to act in his absence, and has confidence in his integrity and skill. In return for such confidence, the steward studies the interest of his master as if it were his own. A faithful steward is a very valuable servant.

On most large farms, the steward has no staid labour with his own hands. He should, however, never be idle. He should deliver the daily allowance of corn to the horses, keep accounts of the workpeople's time, and of the quantity of grain thrashed, consumed on the farm, and delivered to purchasers. He overlooks the reapers at harvest, and directs the filling of the stackyard. On small farms he works a pair of horses like a common ploughman; and when

he has no horses, he sows the corn, superintends the workers, builds the stacks, and prepares the corn. It is objectionable to employ a steward to work horses, as these nicer operations must then be intrusted to an inferior person.

Duties of Ploughmen.—The duties of *ploughmen* are to take charge of a pair of horses, and work them at every kind of labour for which horses are employed on a farm. Horse-labour on a farm is various. It is connected with the plough, the cart, the sowing-machines, the roller, and the thrashing-mill, when horse-power is employed. In the fulfilment of his duties, the ploughman has a long day's work to perform; for, besides expending the appointed hours in the fields with the horses, he must groom them before he goes to the field in the morning, and after he returns from it in the evening, as well as attend to them at mid-day—that is, except, as in parts of England, where the care of the horses when not at work is intrusted to a servant specially employed for the purpose. When, from any cause, his horses are not working, the ploughman must himself work at any farm-work he is desired. There is seldom any exaction of labour from the ploughman beyond the usual daily hours of work, these occupying at least 10 hours a-day for 7 months of the year, which is sufficient work for any man's strength to endure. But occasions do arise which justify a greater sacrifice of his time, such as seed-time, hay-time, and harvest. For such demands upon his time at one season, many opportunities occur of repaying him with indulgence at another, such as a cessation from labour in bad weather. Ploughmen are seldom placed in situations of trust; and having no responsibility beyond the care of their horses, there is no class of servants more independent. There should be no partiality shown by the master or steward to one ploughman over another. When one displays more skill than the rest, he is sufficiently honoured by being intrusted to execute the most difficult kinds of work, such as drilling; and such a preference gives no umbrage to the others, because they are as conscious of his superiority in work

as the farmer himself. The services of ploughmen are required on all sorts of arable farms, from the carse farm to the pastoral, on which the greatest and the least extent of arable land is cultivated.

Hedgers.—The *hedger*, the *spade-hind*, the *spadesman*, as he is differently called, is a useful servant on a farm. He is strictly a labourer, but of a high grade. His principal duty is to take charge of the hedge-fences and ditches of the farm, and cut and clean them as they require in the course of the season. He also renews old fences and makes new ones. He cuts channels across ridges with the spade, for the surface-water to find its way to the ditches. He is the drainer of the farm. He is dexterous in the use of the spade, the shovel, and the pick, and he handles the small cutting-axe and switching-knife with a force and neatness which a swordsman might envy. As the principal business of a hedger is performed in winter, he has leisure in the other seasons to assist at any work. He can sow corn and grass-seeds in spring; shear sheep and mow the hay in summer; and build and thatch stacks in autumn. He can also superintend the field-workers in summer, and specially in the weeding of the hedges. The hedger is a very proper person to superintend the making of drains, which, when done on a large scale, is often executed by hired labourers on piece-work. The hedger is thus an accomplished farm-servant.

Hedgers are not required on all sorts of farms. They would be of little use on pastoral farms, where fences are few, and most of them at an elevation beyond the growth of thorns; nor on farms whose fences are stone walls; nor on carse farms, which are seldom fenced at all. On carse farms they might be usefully employed as ditchers and makers of channels for surface-water. In the combination of arable with stock culture, the services of the hedger are indispensable. Still, the farm that would give him full employment must necessarily be of large extent. A *small* farm cannot maintain him.

Shepherds.—The services of *shepherd*, properly so called, are only required where a flock of sheep is constantly

kept. On carse farms, and those in the neighbourhood of large towns, he is of no use; and on those farms where sheep are brought in to be fed off turnips in winter, he is of course required only at that season of the year. On pastoral farms, on the other hand, as also those of the mixed husbandry, his services are so indispensable that they could not be conducted without him. His duty is to undertake the entire management of sheep; and when he bestows the requisite pains on the flock, he has little leisure for any other work. His time is occupied from early dawn, when he should see the flock before they rise from their lair, during the whole day, to the evening, when they again lie down for the night. To inspect a large flock three times a-day over extensive bounds, implies the exercise of walking to fatigue. Together with this daily exercise, he has to attend to the feeding of the young sheep on turnips in winter, the lambing of the ewes in spring, the washing and shearing of the fleece in summer, and the bathing or smearing of the flock in autumn. And besides these major operations, he has the minor ones of weaning lambs, attending the milking of ewes, drafting aged sheep; not to omit keeping the flock clean from scour and scab, and repelling the attacks of insects. The shepherd takes charge of the pastures, to see that they adequately maintain the stock upon them.

As no one but a shepherd, thoroughly trained, can attend to sheep in a proper manner, there must be one where a breeding flock is kept, whatever be the extent of the farm. On *large* pastoral or mixed husbandry farms more than one shepherd may be required. The establishment then consists of a *head* shepherd, and one or more young men training to be shepherds, who are placed under his control. The office of head shepherd is one of great trust. Sheep being individually valuable, and in most instances reared in large flocks, a misfortune happening to a number, from whatever cause, must incur great loss to the farmer. On the other hand, a careful and skilful shepherd maintains his flock in good health and full number throughout the year. The shepherd

acts the part of butcher in slaughtering the animals used on the farm; and he also performs the part of the drover when any portion of the flock is taken to a market for sale. The only assistance he depends upon in personally managing his flock is from his faithful collie dog, whose sagacity in many respects is little inferior to his own.

The Cattle-man.—The services of *cattle-man* are most wanted at the steading in winter, when the cattle are housed in it. He has the sole charge of them. It is his duty to clean out the cattle-houses, and supply the cattle with food, fodder, and litter, at appointed hours every day, and to make the food ready, when prepared food is given them. In summer and autumn, when the cows are at grass, it is his duty to bring them into the byre or to the gate of the field, as the custom may be, to be milked at appointed times; and it is also his duty to ascertain that the cattle in the fields are plentifully supplied with water. The cattle-man also sees the cows served by the bull in due time, and keeps an account of the reckonings of the time of the cows' calving. As his time is thus only occasionally employed in summer, he is a suitable person then to undertake the superintendence of the field-workers. In harvest, he is usefully employed in assisting to make and carry the food to the reapers, and to lend a hand at the taking in of the corn. An elderly person makes a good cattle-man, the labour being neither constant nor heavy, though regularly timed and methodical. He ought to exercise much patience and forbearance towards even the most capricious of the cattle under his charge.

Field-Workers.—These are indispensable servants on every arable farm. They consist chiefly of young women in Scotland, and of men and boys in England; but the manual operations of the field, such as cutting and planting sets of potatoes, gathering weeds, picking stones, collecting the potato crop, and filling carts with turnips, are better performed by women than men. The operations with the smaller implements are, pulling turnips and preparing them for storing, performing barn-work, carrying seed-corn, spreading manure upon the

land, hoeing potatoes, singling turnips, and weeding. They work in a band, and work most steadily under superintendence. The steward, the hedger, or cattle-man superintends them when the band is large; but when small, one of themselves, capable of taking the lead in work, may superintend them, having a watch to mark the time of work and rest. Field-workers at times work along with the horses. Some farmers set aside the horses, in order to employ the ploughmen rather than field-workers. This may avoid a small outlay of money, but it is not true economy.

Dairymaids.—The duties of *dairymaid* in Scotland are to milk the cows, to manage the milk in all its stages, bring up the calves, and make into butter and cheese the milk obtained from the cows after the weaning of the calves. Others assist her in milking the cows and feeding the calves, when there is a large number of both. In England, the dairymaid's duties are usually confined to those operations which are conducted within the dairy, especially where the making of butter and cheese is pursued extensively. Should any lambs lose their mothers, the dairymaid brings them up with cow's milk until the time of weaning, when they are restored to the flock. Should any of the ewes be scant of milk at the lambing season, the shepherd has his bottles replenished by the dairymaid with new cow's milk. In many cases she attends to the poultry, feeds them, sets the brooders, gathers the eggs daily, takes charge of the broods until able to provide for themselves, and sees them safely lodged in their respective apartments every evening, and puts them abroad every morning. In some cases, too, it is the dairymaid who gives out the food for the reapers, and takes charge of their articles of bedding. On large dairy farms, however, the dairymaid has enough occupation in attending to the particular duties of the dairy, without extraneous work.

These are the respective classes of servants found on farms. They are not all required on the same farm. A pastoral farm has no need of a steward, but a shepherd; a carse farm no need of a shepherd, but a steward; a farm in the

neighbourhood of a town no need of a hedger, but a cattle-man; and a dairy farm no need of a shepherd, but a dairy-

maid; but on a large farm of mixed husbandry there may be need for them all.

SCIENCES APPLICABLE TO AGRICULTURE.

Agriculture has often been defined as an art founded on scientific principles, a definition which is perfectly correct so far as it goes. There is no such thing as a science of agriculture in the sense that we speak of the science of geology, botany, or chemistry. But all farming operations are capable of being explained on scientific principles, and no one can thoroughly understand farm work, or know all its bearings, or the capabilities of its development, who is not acquainted with certain teachings of modern scientific research.

It is, of course, not to be supposed that a merely scientific man will certainly make a good farmer. There have been now and then notable failures of theoretical men, though this is not the fault of science, but of those who professed a knowledge of it.

Science with Practice.—What is really required is a knowledge of *both* the practice and theory of the ancient art of agriculture, to enable a man to cope with the many difficult questions and circumstances which are incident to landholding in the present day, even during prosperous times, and which are aggravated during seasons of depression in trade and industry.

Practical men have hitherto looked askance at what they have designated "book-farming," and no doubt, in many cases, with good reason. But the opinion is now gradually gaining ground that the man who, in addition to the practical knowledge common to most tenant-farmers, has a knowledge of the scientific principles of his operations, is in a better position to achieve success than the man who, without knowing the reason why, merely does things because it is the custom of his district, or because his father did it before him. Practical work alone is pretty much of an empirical matter—that is, it is without

rule, or system, or reason. Experience has shown the farmers of a particular locality, in the course of years, what style of work is the best to pursue, and thus they "get along somehow," without knowing the why and wherefore of a single operation.

But immediately they shift to a new locality, or a state of markets and trade arises which necessitates a change of practice, they are quite at a loss how to proceed, and often commit ruinous blunders. Experience has taught them what to do under a given set of circumstances, but immediately those circumstances are changed they are thrown "out of harmony with their environment," and it is a chance whether they fail or succeed.

In many cases a knowledge of the anatomy and physiology of the plants and animals they cultivate, of the composition of foods and manures, of the geological structure of the country and its surface formations (soil), and of the laws of the health and disease of living beings, would have enabled them to steer clear of dangers, and use their practical knowledge to much better effect. Even those who are successful practical men would be still more successful if on to their practice there were grafted a knowledge of science.

Science growing in favour.—But in recent years there has been a great awakening throughout the agricultural world in these matters, and it would be perhaps rare to find now any intelligent farmer, whose opinion is worth anything, who is an opponent of scientific teaching for farmers, though he may not be much acquainted with it himself. This could certainly not have been said at one time, and not so very long ago, and it is a pleasing fact that there has been this change of feeling with regard to the matter. It is certainly a hopeful sign for the future.

Sciences applied to Agriculture.—

It is not intended in this work to give a complete treatise on the various sciences which have a bearing on agriculture. Its object is rather to explain and describe minutely the practical details of the working of a farm, leaving the scientific aspects to be treated of in books devoted to their own special departments. At the outset, however, it is desirable to give an outline of the principal subjects with which it is essential nowadays that a farmer should acquaint himself, and to point out their bearing on farm management, and also to give some guidance to the farm-pupil as to acquiring a knowledge of these at the least expense of time and money.

Prominence given to Chemistry.—

To those who have only a superficial knowledge of the matter, the one subject which will most readily occur to their minds as the representative of scientific farming is Chemistry. This is not the least to be wondered at when we recollect that this is not only the first subject to be studied as an introduction to all the others, but that it was also the first to be applied to the unravelling of the mysteries of nature met with on a farm every day; and also from the fact that many of the best-known names, both of the present and a preceding generation, in the scientific world, have been associated with this subject, or with its special department, Agricultural Chemistry.

It has been reserved for our day, however, to demonstrate that if chemistry has not been overrated, it is certainly only one of half-a-dozen branches of science which are of almost equal importance to a farmer in helping him to fill his pockets, or—what is perhaps as great a matter—in preventing them from being emptied.

Scientific Education widening.—

This fact is gradually being recognised, and we may hope soon to see as much attention paid to the study and development of other departments of research as there has been in the past to chemistry.

Our various agricultural societies have from time to time given practical shape to this growing feeling by the appointment of experts in other subjects besides chemistry, and it is gratifying to find that those so appointed do not lack em-

ployment. The Royal Agricultural Society of England, besides their well-known chemist, Dr John Voelcker, have their consulting botanist, engineer, and veterinary surgeons, in addition to Miss Eleanor Ormerod as entomologist. The Highland and Agricultural Society has its chemist, botanist, engineer, and veterinary professors. The British Dairy Farmers' Association has both a chemist and a botanist.

It is worthy of note, however, that whenever any farmers' society becomes important enough to employ a scientific man, it is always chemistry which is first patronised. This is no doubt right and proper, because one of the matters in which farmers need most help and advice is in the purchase and use of artificial manures and feeding-stuffs; and it is the business of a chemist to know all about these. Another reason is, that although a man might have the knowledge necessary to enable him to analyse these materials, yet he cannot do so without the necessary apparatus and conveniences, so that it is usually better for him to employ a professional man to do it for him. On the other hand, a farmer can carry all the information in his head necessary to be able to identify a plant, or a disease among his cattle, so that he has less often to call in the aid of an "expert" for these purposes.

Nevertheless, as time goes on there will be more and more need for the others, and we may even expect to see the appointment of men skilled in additional departments of knowledge, and their advice freely asked for.

The sciences which have a bearing on agricultural matters are almost innumerable—in fact, there are none of those which are known as the "natural sciences" which are not more or less necessary for the full explanation of everything about a farm, so far as our present knowledge enables us to go; while a large number of those which are designated mathematical, physical, and experimental, are all more or less valuable.

A feature of modern scientific research is specialism. One investigator takes up only one branch of his subject, and devotes himself to the study and development of it, so that many which at one

time were studied as a whole have now become split up into a large number of minor sciences, each of which has its votaries.

Sciences to be studied by Farmers.

—We may say, however, that there are six or eight principal subjects, some knowledge of which is essential to every farmer who aims at being well posted up in matters relating to his business; and we may further state that these are the ones prescribed for the various diplomas and degrees granted by those bodies which are empowered to examine candidates for honours in agricultural science, of which more will be said further on. Those sciences are Chemistry, Biology, Geology, Engineering, Natural Philosophy, and Veterinary Hygiene. It must not be supposed that these exhaust the list of subjects which are useful and necessary to a farmer, but they are the principal ones, and all others might almost be included under these headings.

An effort will now be made to show the farm-pupil in what manner a knowledge of each one will be useful to him, and how they explain the *minutiae* of intelligent practical work.

CHEMISTRY.

This subject has often been called the “handmaiden of the sciences.” It has been described thus from the fact that whatever other science is taken up, it is almost always necessary to refer back to the composition of all material substances when we come to study them. This is true of all except those mental or mathematical branches of knowledge which are more or less mere conceptions of the mind. Chemistry, therefore, ought to be studied first by all those who wish to become acquainted with science, whether for farming or any other purpose. So much so is this held to be the case, that many public schools teach it as a part of their ordinary curriculum, in common with classics or mathematics, while it is very often prescribed as a subject in the entrance examination in “general education” in many of our colleges and universities.

Chemistry investigates and compares the properties of all the various kinds of

matter, and endeavours to account for the difference in these properties. Very early in the history of man’s inquiry into the phenomena of the material world around him it became necessary to know what things were made of; and as one man here discovered a little, and another one there evolved some new fact, gradually a system of analysis was built up. It was found that the vast majority of things which we meet with on the surface of the globe are *compounds*—that is, made up by the union or chemical combination of two or more separate bodies. As investigation and experiment went on, it was found that compound bodies were always capable of being split up into two or more certain well-defined constituents, which resisted any further attempts to reduce them. These constituents are called the “elements,” and every form of matter of which the human senses can take cognisance is made up of one or more of these, united or combined in different proportions. The number of elementary bodies known to chemists has varied from time to time. As chemical research has gone on new ones have been brought to light, while some that were considered elementary have been reduced to component parts. At present sixty-four are recognised, but it is quite within the bounds of probability that some of these may turn out to be compounds some day, when subjected to improving means of investigation. It is of course manifest that a large proportion of these are of no practical interest, at least to farmers, and some of them are indeed little more than scientific curiosities. But with others, again, we are coming into daily and hourly contact, and no inquiring mind can abstain from seeking information regarding them.

Chemical Elements important to Farmers.—The elementary bodies which particularly concern us as farmers are some eighteen in number, and of these there are only about twelve of importance. They are as follows:—

Metals.

Potassium.	Aluminium.
Sodium.	Iron.
Calcium.	Manganese.
	Magnesium.

Non-metals.

Oxygen.	Bromine.
Hydrogen.	Fluorine.
Nitrogen.	Sulphur.
Carbon.	Phosphorus.
Chlorine.	Silicon.
	Iodine.

The young farmer must make himself particularly well acquainted with the chemistry of these, from an agricultural point of view. But before doing so, he must have some knowledge of the theoretical part, which is usually classed as *General Chemistry*. This he must acquire before he takes up the special department of *Agricultural Chemistry*. In colleges and institutions where these subjects are taught, they usually form the subject of separate courses of lectures, the student taking the former first in order. It may be objected that a farmer ought to confine himself to his own special department, and not waste time in studying a whole subject in its general aspects. To this the answer is, that "before we can apply a science successfully to any special art, whatever that art may be, we must thoroughly master the elementary and essential principles of the science, thus securing a solid basis. Before a man can apply chemistry to any practical end, such as farming, he must know the simplest facts about the various kinds of matter with which he meets on all sides; something about the changes which they suffer and the forms they assume; something about what they are and what they seem to be. He must know not only how to separate one kind of matter from others, but how to recognise it when separated. And besides all this knowledge, necessary before the conclusions of chemistry can be appreciated, he must, in order successfully to adapt and apply these conclusions in his own department and for his special ends, have become in some measure practically acquainted with the modes of chemical manipulation. In order to show how intimately and how invariably chemical processes are involved in agricultural operations, it would be necessary to trace the successive steps in, say, plant culture, in all of which this connection is more or less clearly displayed. To talk of carbonic acid, of nitric acid, of ammonia, of lime

and potash, of silica and phosphates, and of their sources natural and artificial, their uses and their changes in the marvellously complex operations of vegetable growth, without knowing whether these chemical substances are simple or compound, solid, liquid, or gaseous, soluble or insoluble, liable to be lost by evaporation, washed away by water, or locked up in some unavailable form, is like looking for fruit on a tree which has not flowered—like pointing out the variations of a species before that species has been itself described."¹

General Chemistry.—General Chemistry is usually divided into the two departments of Inorganic and Organic,—divisions which, although not absolutely correct, are very handy for the purposes of study. The former treats of the composition of matter as we meet with it in the mineral world—simple, or compounded from the action of the laws of chemical affinity or of crystallisation, and apart from all life. The latter studies it as it occurs in organic bodies, plant or animal, and as the result of living force. It is a curious fact that the one element carbon is found in every organic compound, and in by far the largest proportion, so that "organic chemistry" and the "chemistry of the carbon compounds" are synonymous terms.

Agricultural Chemistry.—Having mastered the elements of the general subject, the farm student is then in a position to attack his own particular branch of Agricultural Chemistry, and from the preliminary training of the former, he should be able to grasp freely the facts of the latter.

Soils, manures, plants, animals, and foods all involve so many chemical changes—actions, reactions, combinations, &c.—that many eminent men have found it profitable to spend their lives in the study of these, and in experimenting for the elucidation of problems, many of which still remain unsolved. The vast subjects of manuring our soils to raise maximum crops at the least expense, and of feeding our cattle economically and efficiently, fall largely under the subject of the chemistry of

¹ Prof. Church.

the farm. But it is hardly necessary to say any more on a subject about which all are agreed as to its importance to practical men.

It is not necessary or desirable that a young man should go to all the trouble and expense of becoming an analyst for the purpose of being able to inquire into the composition of his soil, manure, or feeding-stuffs. When he has a farm of his own, it will generally pay him better to "play the overseer" rather than raise bad smells and waste both time and chemicals in a rough-and-ready laboratory. Some practical work in the laboratory while a learner is of immense benefit, but by private reading and attending lectures he can gain information which will be of the greatest service to him in the everyday work of the farm.

BIOLOGY.

This is the name given to the study of *Life*—whether that is manifested in plants or animals—and it includes the two definite sciences of Botany and Zoology. Sometimes it is looked upon as a special subject in itself, and taught as such, as a general introduction to these two branches. But for our purpose it will be sufficient to show the value of these latter to a farmer, leaving the classification and the mode of acquiring a knowledge of them to be settled by individual circumstances.

The discoveries of modern science have shown that it is a very difficult matter to separate the animal from the vegetable kingdom; that, in fact, we can scarcely define an animal in such terms as shall not equally well apply to a plant. This, of course, seems strange to those who have never gone any deeper than the surface of things, and there may seem no difficulty in knowing the difference between a horse and the hay which he eats; but when we go down to the lowest organisms and study the beginnings of life we find a great deal of difficulty in saying to which kingdom they belong, although many of them are of vast importance in the economy of nature or of a farm.

For this reason, therefore, the life-history of these lowly organisms is

sometimes studied as the science of Biology, with the study of plants and animals proper as a continuation of the same.

BOTANY.

Botany, shortly defined, is the study of plants, their structure, functions, and habits. There has been an opinion current among the uninitiated that botany was merely the naming and classification of plants. As a matter of fact, this is only a very small and unimportant part of the subject, for "a man might be a profound botanist and not know the names of half-a-dozen plants." As a proof of this, we may take the case of many gardeners. Their business leads them to make themselves acquainted with all the Latinised names and divisions of the long list of varieties and sub-varieties of florists' flowers; and though all gardeners know these, it is only now and again we meet with one who is really a botanist, and has studied their anatomy and physiology.

There is, no doubt, a vast deal of drudgery to be encountered in commencing the study of this science. The structural parts—especially if microscopic—have no common English names, and therefore it was necessary to invent names derived from Latin or Greek. Many of these names must be mastered before any progress can be made in the subject, or before we can tackle the plants themselves. Once they are mastered, however, botany becomes one of the most pleasant studies, apart altogether from its usefulness. It is a subject that particularly lends itself to the life of a farmer, who is always in the fields, and who has the opportunities above every one else for the prosecution of it. It does not require any expensive apparatus or fittings, like practical chemistry, for a pocket-lens is sufficient to enable one to go a great length into it.

Of course, it is the botany of the cultivated crops which especially concerns farmers; but as the working of a farm is directed quite as much to the keeping down or counteracting the evil influence of weeds or wild plants, it behoves him to know almost as much about the latter as the former. In fact,

a knowledge of the habits and peculiarities of native plants will often give hints as to the capabilities of soil or climate or pasturage which could otherwise be learned only by expensive experience.

Classification of Plants.—For ease of reference and study, plants have been classified into what are called "Natural Orders." All the plants which have the general arrangement of their parts similar to one another, the structure of the flowers especially being on the same plan, are classed together. All the known plants on the face of the earth have thus been grouped into between 200 and 300 "Natural Orders."

Plants of the Farm.—The farm plants of this country, however, occur in about twelve only of these. They may be tabulated as follows:—

<i>Graminaceæ</i> . . .	Wheat, barley, oats, rye, grasses, &c.
<i>Leguminosæ</i> . . .	Beans, peas, vetches, clover, sainfoin, lucerne, &c.
<i>Cruciferae (Brassicæ)</i>	Turnips, swedes, rape, cabbage, kohl-rabi, mustard, &c.
<i>Solanaceæ</i> . . .	Potato, tobacco.
<i>Umbelliferae</i> . . .	Carrot, parsnip, caraway.
<i>Chenopodiaceæ</i>	Mangel, beet.
<i>Linaceæ</i>	Flax.
<i>Urticaceæ</i> . . .	Hops, hemp.
<i>Boraginaceæ</i> . . .	Comfrey.
<i>Dipsacaceæ</i> . . .	Teazle.
<i>Polygonaceæ</i>	Buckwheat.
<i>Compositæ</i>	Artichokes, chicory.

The first half-dozen of these contain the most of the plants cultivated in the ordinary farming of this country, the others being grown only under special circumstances. As, however, almost every plant native to a locality will be found on or about a farm, and may have some possible influence on the management thereof—either as one likely to be eaten by the domestic animals, or as a weed infesting the land,—the young farmer who wants to dip into the heart of things will not rest content with knowing these outstanding ones, but will try his best to know something about all that come under his notice.

Germs.—Further, many of the diseases which attack our crops are fungoid growths—such as the potato disease, smut, mildew, &c.; and many of the diseases of animals are also due to the presence of these low vegetable organisms, to which is given the general name of "germs"—such as anthrax, tubercle, fowl cholera, &c.—so that there is

scarcely any department which does not concern him.

Scope and Necessity for Botanical research.—A good book on Agricultural Botany has yet to be written, and in the absence of that the student must be content to work up the subject from some one of the many general text-books in existence. A list of the particular plants native to his district is usually to be found in some of the "Floras" issued for different localities.

There is quite as much scope for investigation and the finding out of fresh facts in the field of Agricultural Botany as there is in any, and much more than in some other branches. It is not that one who is constantly in the fields has an opportunity of finding out merely a new "habitat" for some species, but we are only as yet partially acquainted with the peculiarities and special food or other value of the hundreds of plants which go to make up our meadows and pastures, not to mention other crops. Out of some thirty species of grasses which are cultivated in this country, we do not yet thoroughly know which are relished most by horses, or cattle, or sheep, or which will yield the most beef or the best milk. Again, a difference of soil or climate has often such an effect, that one species which may be acknowledged good at one place, may be almost worthless at another. The famous blue grass of Kentucky (*Poa pratensis*), for instance, is only reckoned second or third rate quality in Britain. A farmer, therefore, who has the necessary botanical knowledge, and who will take the trouble to investigate these matters, might not only gain information of importance to himself, but also of value to all.

ZOOLOGY OR NATURAL HISTORY.

This other great department of Biology is limited to the study of the comparative anatomy and life-histories of animals. A farmer is, of course, interested mainly in knowing all he can about the six or eight animal species which are "domesticated," and which form the live stock of the farm. But it is well worth his while to extend his study a good deal beyond these, for many of the lower forms, which are not very con-

spicuous to the eye in themselves, can yet make or mar the fortunes of the cultivator, from the losses produced by them among stock or crop.

The special study of the domestic animals—their comparative anatomy, physiology, diseases, and treatment—forms the subject of *Veterinary Science*, which is thus in this sense a branch of Zoology, or of Biology, and will be touched upon later on.

Animal Parasites.—There is a great deal, however, concerning certain of the lower organisms which is of interest to the farmer quite as much as to the veterinarian. A great many of the diseases which afflict our domestic animals are due to the presence of parasites, the life-history of which, and position in the scale of animal life, it is the province of Zoology to inquire into. Such, for instance, are the parasites which cause “measly pork,” “sturdy” and “liver rot” in sheep, “hoose” in calves, &c., &c.

ENTOMOLOGY.

There is, again, the wide and important subject of *Entomology*—the study of insects—which is usually raised to the dignity of a special science by itself, but which falls to be classed as a department of Natural History. When we consider the vast amount of damage that is done to both stock and crops by the ravages of insects, it is hardly necessary to use arguments to convince farmers of the necessity of giving some attention to this matter. Some few of the most prominent ones alone—such as the turnip-flea beetle, the wheat-midge, green-flies, warble-flies, maggot-flies, &c.—are sufficient of themselves to cause a loss of millions of pounds annually to the British farmer. Many years ago the Royal Agricultural Society of England appointed the late Mr Curtis to systematically investigate the subject of farm insects. The result was a portly volume, which long remained the standard authority on the matter. Lately, the accomplished lady scientist, Miss E. A. Ormerod, has been appointed as entomologist to the above Society; and our knowledge of the life-history of many insects, and the ways and means of preventing or mitigating their attacks,

has through her exertions been greatly increased.

There is thus great benefit to be obtained by the general study of Natural History, giving, of course, the most attention to those animals, or classes of animals, which are connected with the farm.

VETERINARY SCIENCE.

This is a very general name given to the study of those subjects which relate to the anatomy, physiology, and diseases of live stock. Long ago it was raised to the dignity of a profession. A regularly qualified Veterinary Surgeon has to go through a course of training and attendance at classes occupying from two to three years, having separate courses of lectures and practical work on such subjects as Chemistry, Botany, Anatomy, Physiology, *Materia Medica*, &c.; while, after those preliminary subjects have been mastered, special attention is given to the diseases and treatment of live stock under the names of Horse and Cattle Pathology, Veterinary Surgery, &c.

There is no doubt that a veterinary surgeon has got a sufficient knowledge of, at least, one half of the scientific subjects which relate to farming, and has had a specially good chance of gaining a knowledge of live stock. But it is not necessary that a farmer should go through the whole course of this training, unless he also wishes to become a professional “vet.” A great deal less than this will be sufficient for a young farmer to give his attention to, for it must be remembered that the department which specially concerns him is more the prevention of disease than its treatment. Once trouble has crept into his stock, it is generally desirable to call in the services of a qualified man, whose experience and ability in this line must necessarily be greater than his own. The few shillings charged for advice by most country practitioners is a small matter compared to the loss or deterioration of an animal.

Prevention better than Cure.—It is, however, to the prevention of disease that a farmer ought to give his attention. To be able to do this thoroughly, he must know something about the

structure and vital processes of the bodies of the animals he owns. Respiration, digestion, and reproduction are the three general functions performed by all living beings; and if we can keep these always going on naturally and properly, it would enable us to escape the greater number of the diseases which infest our live stock. In order to do so, a farmer ought to lay himself out to understand not only how these functions are carried on, but also to study such matters as ventilation, sanitation, and dieting, as these fall properly within the bounds of "preventive medicine." It reflects credit on the veterinary profession that the researches by its members have been quite as much directed to the prevention as to the cure of diseases, and advice has been freely given to this end.

Studying Minor Ailments.—Notwithstanding the utmost vigilance and care, however, animals will turn unwell now and again, and there are a large number of what might be called minor diseases affecting our live stock, some of which are of almost daily occurrence. Such ailments as colds of all kinds, sprains, purging, affections at parturition, foot-rot, hoven, and colic, are sure to arise now and again, so that a farmer is compelled to gain some knowledge of these, whether he desires it or not. It is out of the question to think of seeking professional advice on each and every little occasion, any more than a human being would think of calling in the doctor every time he had a headache or a cut finger.

It is, therefore, of the first importance that a farmer study these minor ailments, and thus be able to check what might otherwise develop into something serious.

Veterinary Guide-Books.—There is this difference between Veterinary science and the last two touched upon—Botany and Zoology—that whereas these latter have no books extant on them specially intended for farmers, the former has no end of works devoted to its different subjects, and written in a popular style which can be "understood of the people," in contradistinction to the technical works intended for professional readers.

Without, therefore, attempting to become any more than an amateur at the

subject, every one who has anything to do with live stock should endeavour to make himself acquainted with their rational treatment and common ailments.

ANATOMY AND PHYSIOLOGY.

Apart altogether, however, from the treatment of diseases, there are the two branch sciences of Anatomy and Physiology, a knowledge of which would be of the greatest service to every one who is buying and selling or judging stock. It is manifest, for instance, that one who thoroughly understands the arrangement of the bones and ligaments which comprise the hock of a horse, will be better able to give an opinion as regards this point on the merits of any animal placed before him than one not so well informed; or if he understands the structure and working of a cow's udder, he will have a better idea of her capabilities in the absence of actual trial. Instances might be multiplied of the usefulness of such knowledge—knowledge, too, which a farmer has ample opportunities of acquiring.

GEOLOGY.

The study of the rocks which form the surface of the earth, their various modifications and arrangements, and the ways and means by which the surface of the country has been sculptured out into hill and dale, stream and lake, is known as the science of Geology. It is not much more than a generation ago since it first became reduced to a systematic science, and the men who first brought it into prominence, and made the great initial discoveries in it, are not long dead. Very early, of course, in the history of mankind, when people began to move about from one country to another, they must have noticed the different features of the land in different places,—a hard dark-coloured rock prevalent in one place, and a white soft one in another; poor moory ground here, and deep fertile soil there; while the exposure of beds or strata on the faces of cliffs, &c., would show the regular superposition of several varieties one on the top of the other.

It was reserved for our times, however, to explore these matters, and eliminate a system which would explain all the phenomena met with in the "crust of the earth." In fact, Geology is one of the youngest of the sciences, although it has made gigantic strides forward in the comparatively short time it has been studied.

At first sight it might appear that, as it is only the surface soil of the country which a farmer cultivates, he need not therefore trouble himself about going any deeper, but may confine himself to the "surface geology" of his district. But as the outside appearance and conformation of an animal depend on the internal structure of the same, so does the varied features of a district depend on the geological formations which constitute its anatomy; and we all know that these general features have as much to do with farming as the soil actually cultivated.

For convenience, the different strata have been grouped into what are called "systems," divided from one another by some natural gap or "unconformity"; and the rocks which make up each system are known as "formations." It is a curious and interesting fact that nearly all the formations are represented in Great Britain, so that the farming which is conducted on the top of these must be very varied, and must take notice of them all.

It is of course in the study of the soil that geology can materially aid a farmer—its formation and mineral composition; and every one who has mastered the principles of the science has got a key to the soils of not only this country, but also to all those which have had their rocks mapped out.

Formation of Soils.—The portion which we cultivate is composed of two parts—the mineral or inorganic, and the vegetable or organic. The latter is the product of the decayed roots, &c., of plants which have previously grown on the surface, while the former is simply equivalent to so much powdered and weathered rock. Whenever a part of a formation becomes exposed, the natural forces of rain, frost, and atmospheric action immediately attack it, with the result that large quan-

ties become detached and weathered down, and this *débris* forms the greater part of a fresh piece of soil, either at the place where it was separated from the parent rock, or it is washed away, mixed up with others, and redeposited somewhere else. This is how most of our soils have been formed; and though in this country the greater part have been due to the washing away and mixing-up process—and are thus seldom derived from the rock lying immediately below—yet the subjacent material usually gives the "character" to a soil, and at any rate can explain all the other features of a locality.

The most of the accumulations of material above the solid strata are usually designated "drift," and the different varieties and arrangements of these go under such names as "boulder-clay," "glacial drift," &c., and the occurrence of these gives rise to the existence of stiff clay in one place, loamy soil in another, and gravel in a third. The drifted material is really a formation itself, and forms the surface part of a large proportion of Great Britain, especially the northern parts. Still it is always influenced by the strata below. In red sandstone regions the soil is of a red sandy nature, while shaly or clayey rocks give a stiff character to the accumulations above.

Each particular formation or group of formations has got its own special kind of soil, and it therefore follows that the varieties of soil and of farming are almost as many and as varied as the former. All of them are crowded into the narrow limits of the British Islands. In many districts abroad the same formations and the style of farming extend for many hundreds of miles. In the old province of Perm in Russia—which gives its name to the Permian rocks—these formations cover an area almost as large as France, so that there cannot be any great variety in the farming for hundreds of miles. But here, where things are on a smaller scale and there are changes every few miles, several different formations with as many different soils may exist within the limits of one farm, or even one field.

It is, of course, when a farmer is moving into a strange locality that a

knowledge of its geology would help him to understand its farming. One who has resided on and worked a particular farm for several years, has generally found out from experience far more about that farm than any map or general geological knowledge could tell him; but if he removes to a strange part, a sketch of the geology of that district—read aright—would give him a vast amount of useful knowledge relating to the soil, and the most suitable style of farming to pursue. But even in a familiar place, when it becomes necessary to do such work as draining or sinking wells for water, it is seldom that a knowledge of geology will not be helpful.

Geological Survey.—Happily in this country there is ample opportunity of acquiring this knowledge at little trouble or expense. The Government Geological Survey is almost completed, and coloured sheets representing the “solid” strata of each district can be had for a few shillings. Like most Government undertakings relating to farming, the agricultural part—the “surface” or “drift”—has been left to the last, so that it has not progressed very far as yet. Every farmer, however, ought to procure the sheets issued for his locality, and learn to read them.

Relation of Geology to Animals.—But it is not only in the soils or cultivation of a farm that geology can give useful information. There is not the least doubt that the many distinct breeds of our domestic animals, which have been brought to such perfection in these days of pedigrees and shows, owe their typical or primitive and more natural characteristics to the geological features of their native districts. Thus the Southdown sheep has been developed on the chalky hills of south-eastern England, the Welsh and Highland cattle on the rugged Silurian and granitoid formations of Wales and Scotland—and so on. True, man’s interference has had much to do with these in later times, but the soil had, and still has, much influence. We are only on the threshold of a great deal of information which awaits us in this direction, and therefore there is great need as well as many inducements for a young man to give his attention to it.

In short, a farmer who has some knowledge of the subject sees many reasons for the differences of farm practices which never occur to one not so well informed.

NATURAL PHILOSOPHY.

We now come to a consideration of those subjects which are of a mathematical or experimental nature, differing from the matters already touched upon, in that they do not treat of life or living bodies, but rather of the forces which affect matter, and the manifestations of which can be reduced to calculation.

Natural Philosophy or *Physics* is the general name given to a very wide subject—or group of subjects—the object of which is to discover the laws of Nature,—the properties of matter and the forces which act upon it. It has been separated into over a dozen different sciences, each of which treats of one particular department, but all of which are related to one another as they treat either of different aspects of the same force or the same matter. Every one is familiar with at least the names of those separate departments, the principal ones being, Heat, Light (Optics), Sound (Acoustics), Electricity, Magnetism, Hydrostatics, Mechanics, Meteorology, Chemical Affinity, Astronomy, &c. &c. This list might be almost indefinitely increased, as the whole of the phenomena of inanimate Nature—from the laws which regulate the motions of stars and planets to those which govern the molecular building up of crystals—are included in the general term “*Natural Philosophy*.” Each department is capable of being studied as a definite and extensive science by itself, though related more or less to all the others. It is of course apparent that the majority of those mentioned above are not of any particular interest or use to the farmer. Nowadays, however, every one who pretends to have a good general education is expected to have some knowledge of these subjects; and the perusal of such text-books as Professor Balfour Stewart’s *Elementary Physics* will give one almost as much information about them as is

necessary for those who do not require to study them deeply.

Two or three of these branches the farmer must study thoroughly, as they are of the utmost use in the everyday work of the farm, and these we may consider a little more fully.

METEOROLOGY.

This is the "science" of the weather. In an open-air business like farming, where so large a part of the work is done in the fields, and where the state of the soil and the successful growing of crops and management of stock depend so largely on atmospheric conditions as regards rain, frost, wind, &c., it does not require much argument to prove that anything relating to these ought to be of the first importance. Meteorology is not a science in the usual sense of the term, because as yet its facts have been little more than collected together, and no "laws" have been enunciated which will explain and connect all, and enable us to foretell to a certainty what is going to happen with regard to aerial phenomena. At the same time, there is perfect certainty as regards some points—such, for instance, as why the wind blows, why the clouds form and rain falls, why dew is deposited, and so on,—the uncertainty being in not knowing *when* these things are to happen, or what originates the changes which result in the particular weather of each day. The Meteorological Office has for many years had observers all over the country who have kept an exact record of the rainfall, direction of wind, height of barometer, &c. &c., and these have been collected and tabulated, and results worked out, so that the average kind of weather and climate of any particular place is now pretty well known. What the weather is to be for any particular day, however, is quite another matter, though this also is a subject which, as time goes on and experience increases, is being brought to greater accuracy.

Weather Forecasts.—Most readers of newspapers will have noticed the column which gives the daily "forecasts" of the weather issued by the above office. These have been in the

past so often right, or partly right, that they are most valuable to those who have to pay attention to the state of the atmosphere, and it is likely that they will become more and more correct as observations extend and improved means are devised. As the whole of the British Islands, however, are parcelled out into only eleven "districts," it is manifest that the forecast issued for any one of these must be very general, and might not apply to a particular spot within a district. There is such a thing as local weather—as there might be heavy rain in one place, and a bright sunshiny day in the next valley a few miles distant.

There is not the least doubt that if a man could find out the kind of weather that would be experienced on his farm twenty-four hours—or even twelve—beforehand, it would be of immense use to him, and save him many a pound, especially in haymaking and harvest time. We have not arrived at such perfection of detail as yet, and therefore there is all the more need of farmers making themselves acquainted with the facts and laws of weather and climate, so far as these have been worked out.

Most people keep a barometer hanging up somewhere about their house, and call it a "weather-glass," and believe that its use is to foretell when to expect rain and when fine weather. Few, however, know that its object is simply to show variations in the weight of the atmosphere, whether these are due to the presence of moisture, or height above sea-level, or the effects of the wind. A great deal, no doubt, is to be learned from a proper use of the barometer, hygrometer, thermometer, &c., and it is part of the object of meteorology to show how they are to be used, and the reasons why, while more extended and general observation would be likely to increase our knowledge of this important subject.

There is an abundance of handy text-books devoted to the subject, while it is usually treated of in works on general physics, and no farmer will regret making himself acquainted with it. It is by no means a narrow or contracted science, as it may be said that it not merely affects us here in Britain, but the weather and climate within several thou-

sands of miles of us has its influence on our atmosphere, so that the study of it is world-wide. More than this, there is great reason to believe that the sun has much influence on our atmosphere, and that from it issue the initial changes which rule our weather. The spots which occur on the face of the sun have a maxima every ten or eleven years, and it is asserted by those who have studied what is jocularly called the science of "sun-spottery," that the weather runs in corresponding cycles. It has been further found that when a "magnetic storm" occurs on the photosphere of our luminary, there are corresponding perturbations of the needle of the compass, with atmospheric changes producing changes of weather. The subject thus embraces some knowledge of astronomy and magnetism, and there is reason to believe that we are on the threshold of important discoveries, which will give the key to the whole, and make the matter an exact science like the others.

MECHANICS.

Generally stated, the principles of machinery is the subject embraced by the science of mechanics. It is usually divided into the two branches of *statics* and *dynamics*, the former of which treats of the forces which act on bodies at rest, and the latter relates to forces causing motion in bodies—*dynamics*, indeed, being sometimes all that is included in "mechanics" proper.

One of the principal features of modern farming is the extensive use of machinery in everyday work, which still continues to extend, so that it is quite as necessary for a farmer to know something about the "iron horse" and machinery in general, as about the horse of flesh and blood which has done his work so long.

The object of these notes has been to point out the benefit to be derived from the study of the scientific *principles* which underlie and explain all our practical work, and Mechanics is emphatically one of those subjects which are thus of the greatest value. An implement or machine which is constructed on wrong principles can never work with any degree of satisfaction, if, indeed, it work at

all; and every one who has made himself acquainted with the mechanical laws can see again and again how often the machinery exhibited in an agricultural show-yard infringes them. It is to be presumed that those who invent and make our implements are acquainted with those principles, but some do not appear to know anything about them; therefore when a farmer requires to invest in machinery, there is great need for him to know which to take and which to avoid.

Mechanics usually has for an introduction information about "force," "energy," &c., and then it is shown how these are practically applied in what we call the "mechanical powers." If a young farmer masters the principles of these powers, he will find them of the utmost benefit to him whenever he has anything to do with a machine. They are six in number, and well-known, as the Lever, Pulley, Wheel and Axle, Inclined Plane, Wedge, and Screw. The lever and the inclined plane are the principal ones, as the others are, in a sense, only modifications of these. Every implement, machine, or tool used on a farm, or anywhere else, is simply a variety or combination of these, so that an acquaintance with them enables a man to understand better what he is doing, to select the best at the beginning, to work it properly, to see faults and suggest improvements. How often, for instance, we see ploughs far too short in the stilts to give a man sufficient leverage power to hold steadily, drills with two steerage wheels where there should only be one, and cultivators and other implements with low wheels where they ought to be high! and so on—mistakes which this science points out.

Unfortunately our patent laws are rather against the production of perfect machines, though, no doubt, they protect the inventor and manufacturer. It often happens that there are both good and bad points in a particular implement made by different firms: if all the good parts were combined into one article, the product would be better than any at present in the market, but the interests of different patentees are opposed to this. However, a farmer who understands the principles of the matter is in a position to

suggest improvements to makers of implements which he can verify for himself, and is thus not solely dependent on others.

The above two subjects are those of most importance to farmers in Physics; but where steam is so largely used as a motive power at present, with the possibility of electricity in the future, it is more than likely that the subjects of heat and electrical science will, as time goes on, become quite as necessary as the others. All of them are interesting and useful, whether they have a direct bearing on farming or not, as they relate to the ordinary phenomena of nature occurring every day around us.

ENGINEERING.

Engineering might almost be called the practical application of the principles of the various branches of Natural Philosophy to the arts of construction and to the performing of work. All that has been said regarding Mechanics is applicable to this branch of science, with the addition of a great deal more.

It has hitherto been popularly divided into two departments, Civil and Mechanical—the former of which treats of such matters as levelling, surveying, and designing structures and works; while the latter is confined to machinery, or “applied mechanics.” In the full sense of the term, Engineering takes in a vast deal more than is comprised within the limits of a farm; and the knowledge necessary to lay off a railway or design a bridge is, of course, far beyond what is required by a farmer.

In this again, however, it is principles which are to be attended to in the first place, and much of the work done about a farm lies quite as much within the province of Engineering as is the making of a railway.

The laying out of a farm, or equipment of an estate, falls within this subject, and these are matters which farmers have often to undertake, and which cannot be exactly called part of farm work. The draining of a field, the making of a mill-dam for water-power, the procuring of a water-supply or the laying out of a water-meadow, the building of a steading, &c., all fall within the province of the

engineer, and no farmer can undertake these with thoroughly satisfactory results who has not given some attention to such matters as mensuration, levelling, surveying, building construction, drawing, &c. It is seldom that a professional engineer is called in to superintend these operations, unless they are on a larger scale than is to be found within the confines of a farm, and therefore there is all the more reason for a farmer to be able to do something at them himself, more especially since the passing of the Agricultural Holdings Act. Even the ability to measure a field, or part of one, to find out the acreage, implies some “engineering” knowledge.

In the department of “Applied Mechanics,” as has been already pointed out above, we learn all about the construction and working of machinery—knowledge which will enable us to improve our present farm implements, and work them to greater advantage. Farmers do not generally make, and only sometimes repair, such, but they might often be able to prevent breakages, and make tear and wear less, if they understood the principles of such things as “strains,” “strength of material,” “mill-work,” &c., &c.—matters which belong to the province of mechanical engineering. It might almost, in short, be said, that all the improvements included in Sections I. and II. of the Agricultural Holdings Act belong more to the domain of the civil engineer than the farmer, and in order to carry these out satisfactorily and make good a claim for compensation, the farmer must make himself more or less acquainted with engineering matters.

The various branches of science, a knowledge of which is essential to the well-educated farmer, have thus been indicated. It may perhaps be useful to append the following general notes which appeared in the previous edition, and which convey interesting information upon points embraced in the important sections of science enumerated.

The Atmosphere.—The atmospheric air surrounds the entire surface of our globe to a height, it was said, of 50

miles, now said of over 200 miles, although at the greater height it is much rarer. It presses with considerable force upon the surface of the earth, and upon every object thereon. The weight of 100 cubic inches of air, at 60° Fahrenheit, and the barometer at 30 inches, has been computed at 30,679 grains. With this weight, and a height of 50 miles, the air exerts a pressure on every square inch of surface of 15 lb. At this rate its entire weight has been computed at 5,367,214,285,714,285 tons, or equal to that of a globe of lead 60 miles in diameter. The surface of an ordinary-sized man contains 2000 square inches, so that such a person sustains a pressure of 30,000 lb., which would be sufficient to crush him to death in an instant, were it not that, in obedience to the laws of equal and contrary pressure of the air without and within the body, the catastrophe is prevented.

The air consists in 100 parts of—

	By Measure.	By Weight.
Nitrogen	77.5	75.55
Oxygen	21.0	23.32
Carbonic acid	0.08	0.10
Watery vapour	1.42	1.03
	<hr/> 100.00	<hr/> 100.00

These constituents are not chemically combined, but only mechanically mixed, and yet their proportions never vary—although both animals and vegetables use the air, and change these proportions: the powerful agency of the sun's heat and light evolves an abundant supply of oxygen from the luxuriant vegetation in the tropics, whilst the predominant existence of animals in the colder regions affords a large supply of carbonic acid.

The Barometer.—The gravity of the atmosphere is measured by the well-known instrument, the *barometer*. Its short column of mercury of 30 inches is as heavy as a column of air of the same diameter of 50 miles of height, and of water 33 feet in height.

The wheel barometer is very popular with farmers, because it shows the deviations of pressure very obviously, by the index traversing the circumference of a large circle. Containing a somewhat clumsy machinery, it is liable to

go wrong, and the circle, large as it is, is not large enough to indicate extreme elevations and depressions of the mercury.

A much better instrument is the common upright barometer, fig. 1, in which the deviations in the height of the mercury in the scale are marked by means of a screw at top. When desired to move the barometer to another place, the mercury is pushed up to the top of the tube by means of the screw at the bottom.

This barometer should be suspended quite perpendicularly. It should not be exposed to the direct rays of the sun or to the heat of a fire. In making an observation, the frame should be gently tapped by the fingers, and in bringing the eye on a level with the mercury in the tube, the index is brought to that by the screw.¹

The barometer was invented in Italy by Torricelli, a pupil of Galileo, in 1643.

The Aneroid.—The *aneroid* barometer, which means “with-

out moisture,” fig. 2, is the most portable of all barometers, and is therefore most suitable for tourists, especially since it is now made as small as a large watch. The principle on which it depends is the varying pressure of the atmosphere upon an elastic metallic chamber partially exhausted of its air, and so constructed that by a system of levers a motion is given to a pointer which travels over a graduated dial. The usual form is



Fig. 1.
Barometer.



Fig. 2.—Aneroid.

¹ It is unnecessary to give a description of the common upright barometer so well known to every one, but those desirous of having a knowledge of the varieties of this instrument may be referred to Buchan's *Handy Book of Meteorology*.

about 4 inches in diameter. It is read exactly like the wheel barometer. The chief objection to it is its liability to change from the hand shifting by a shake, or in some other way. If it chances to go wrong, it can easily be reset by a turn of the screw at the back of the instrument. With proper care it may go correctly for years, but opportunity should be taken from time to time to compare it with some barometer whose accordance with the standard may be relied on, since, owing to the principle of its construction, it cannot be depended on like the mercurial barometer, fig 1. The indicator is *a*, fig. 2, the marker by the hand is *b*. Mr Belville, of the Royal Observatory, Greenwich, has made many experiments with the aneroid, and he found its movements always consistent. It is a delightful companion, may be carried in the pocket, in a steamboat, a carriage, in the hand in mounting elevations, without the chance of being injuriously affected. It is therefore highly useful, its indications preventing many an excursion which would have ended in disappointment. The tourist should never travel without it; and the seaman will find it a safe guide when the motion of the mercurial column renders the marine barometer almost useless.

Common Sucking - Pump.—The pressure of the atmosphere explains the action of the *common sucking-pump*. The plunger, by its upward movement, withdraws the air from the chamber of the pump, and the air, pressing on the water in the well, causes it to rise and fill the chamber vacated by the air. The air cannot force the water higher than 33.87 feet theoretically, but practically not more than 30 feet.

Force-Pump.—The *force-pump* acts both by the elasticity and pressure of the air. The pressure causes the water to be lifted to a height not exceeding 30 feet, but the elastic force of the air in the condenser causes it to rise to a very considerable height. It is on this principal that the fire-engine causes the water to rise to the roofs of houses.

The Siphon.—The *siphon* operates by the pressure of the air, and is useful in withdrawing liquids in a quiescent state from one vessel into another, or the water

from a lake to a river or to a lower ground. Water from a quarry may sometimes be removed better by the siphon than by any other means. The efficiency of this instrument depends on the greater difference of length between its two limbs.

Wind.—*Wind* is occasioned by a change in the density of the atmosphere, the denser portion moving to occupy the space left by the rarefied. The density of the atmosphere is chiefly affected by the sun's heat raising the temperature of the earth in the tropics to a great degree, and the heated earth, in its turn, rarefies the air above it by radiation. The air, on being rarefied, rises, and is replaced by cold currents from either pole, and these currents, being constant, constitute the well-known and useful *trade-winds*. The great continent of Asia is heated in summer, and the cool air of the Indian seas moves north to occupy the displaced air above the continent. In winter, on the other hand, the water of this ocean, together with the land in the same latitude, are heated in like manner, and the cool currents from the great continent move south to replace the air rarefied by them, and these two currents constitute the half-yearly *monsoons*.

Land and Sea Breezes.—The air over the entire coasts and islands of the ocean is rarefied during the day and condensed in the night, and these two different states of the air give rise to the daily *land and sea breezes*.

Weathercock.—The direction of the wind is best indicated by the *wind-vane* or *weathercock*, a very useful instrument to the farmer. It should be erected on a conspicuous part of the steading, that it may be readily observed from one of the windows of the farmhouse. The cardinal points of the compass should be marked with the letters N. E. S. W. The vane should be provided with a ball or box containing oil, which may be renewed when required. There is no neater or more appropriate form for a vane than an arrow, whose dart is always ready to pierce the wind, and whose butt serves as a governor to direct the dart into the wind's eye. The whole apparatus should be gilt, to prevent rusting.

Force of the Wind.—The *force* of the wind is measured by an instrument called the *anemometer*, or measurer of the wind's

intensity. Such an instrument is of little value to the farmer, who is more interested in knowing the direction than the intensity of the wind, as that has great effect on the weather. The intensity of the wind has, however, a material effect in modifying the climate of any locality, such as that of a farm elevated upon the gorge of a mountain-pass. Still, even there its direction has more to do in fixing the character of the climate than its intensity.

The *velocity* of the wind is measured by Robinson's hemispherical cupped anemometer, but its indications are not to be depended on in the higher velocities. The measurement is effected by a series of discs, as in a gas-meter.

Principles of Ventilation.—The principle of *ventilation*, whether natural or artificial, lies in a change of the density of the air. "We may be filled with admiration," says Dr Arnott, "on discovering how perfectly the simple fact of a lighter fluid rising in a heavier, provides a constantly renewed supply of fresh air to our fires, which supply we should else have to furnish by the unremitted action of some expensive blowing apparatus. But the operation of the law is still more admirable as respects the supply of the same vital fluid to breathing creatures. The air which a man has once respired becomes poison to him; but because the temperature of his body is generally higher than that of the atmosphere around him, as soon as he has discharged any air from the lungs, it ascends away from him into the great purifying laboratory of the atmosphere, and new takes its place. No act or labour of his, as by using fans and punkas, could have done half so well what this simple law unceasingly and invisibly accomplishes, without effort or attention on his part, and in his sleeping as well as in his waking hours."¹

This process of natural ventilation necessarily goes on in every stable and byre; and were the simple law allowed to take its course, by giving the heated and vitiated air an opportunity of escape by the roof, and the fresh air to enter by a lower point, the animals inhabiting those dwellings would be much more

comfortably situated than they usually are.

Weight of Fluids.—*Hydrostatics* treat of the laws which govern the *weight* of fluids. The application of the physical pressure of fluids to the purposes of domestic economy and the wants of civilised life are extremely important, and afford some valuable objects of study to the mechanic and engineer, and with many of these it would be the interest of farmers to become acquainted.

Fluids are subject to the operation of gravity. A cubic foot of pure water weighs 1000 ounces, or $62\frac{1}{2}$ lb., and an English pint 1 lb.

Water in a vessel exerts a twofold pressure, on the base and on the sides of the vessel. The pressure on the *base* is in the direction of gravity. Suppose that the height of water is measured by 100 drops arranged one above the other, the lowest drop will exert on the base a pressure equal to the weight of the 100 drops. Every drop touching the *side* of a vessel presses laterally on the point of contact with a force equal to the weight of all the drops above it to the surface of the fluid. The lateral pressure of water thus varies as its depth. Bodies immersed in water are pressed by it in all directions with a force increasing as the depth.

Specific Gravity.—The *specific gravity* of bodies having equal bulks is the proportion subsisting between their absolute weights in air and in water. It is consequently found by dividing the body's absolute weight by the weight it loses in water. The specific gravities of a few common and useful things, distilled water being considered as 1.000, are these:—

Of Rain-water	1.0013
Sea-water	1.027
Beef-bones	1.656
Common earth	1.48
Rough sand	1.92
Earth and gravel	2.02
Moist sand	2.05
Gravelly sand	2.07
Clay	2.15
Clay and gravel	2.48
Siliceous sand	2.653
Sandy clay	2.601
Loamy clay	2.581
Brick clay	2.560
Pure grey clay	2.533
Pipe clay	2.540

¹ Arnott's *Elem. Phys.*, i. 412—*Pneumatics*.

Arable soil	2.401
Garden mould	2.332
Humus	1.370
Flint, dark	2.542
Do., white	2.741
Lime, unslaked	1.842
Basalt, whinstone 2.8 to	3.1
Granite 2.5 "	2.66
Limestone 2.64 "	2.72
Porphyry 2.4 "	2.6
Quartz 2.56 "	2.75
Sandstones (meau) 2.2 "	1.5
Stones for building 1.66 "	2.62
Brick 1.41 "	1.86
Iron, wrought 7.207 "	7.788
Lead, flattened	11.388
Zinc, rolled	7.191
Rock-salt	2.257

	Fresh-felled.	Dry.
Alder	0.8571	0.5001
Ash	0.9036	0.6440
Aspen	0.7654	0.4302
Birch	0.9012	0.6274
Elm	0.9476	0.5474
Horse-chestnut	0.8614	0.5749
Larch	0.9206	0.4735
Lime	0.8170	0.4390
Oak	1.0754	0.7075
"	1.0494	0.6777
Spruce	0.8699	0.4716
Scots fir	0.9121	0.5502
Poplar, Italian	7.9634	0.3931
Willow	0.7155	0.5289 ¹
The Swede turnip in December		1.035

It is heaviest in April, about the shooting of the new leaves; and in June, after the development of the flower-stalk, it is

White Swede turnip	0.9940
Tweeddale purple-top yellow 980 to	1.022
Yellow bullock	1.000
White globe	0.940
Carrot	0.840
	0.810 ²

Hydraulic Press.—Water being almost incompressible, any pressure exerted against its upper surface is immediately communicated throughout the entire mass. Bramah's *hydraulic press*, for compressing hay and other elastic substances, and for uprooting trees, is a practical application of this principle. If the cylinder of the force-pump is half an inch in diameter, and that of the press 20 inches, the water will exert a pressure on the piston of the ram 40 times that on the force-pump. If the arms of the lever are as 1 to 50, and that of the force-pump is worked by a man with a force of 50 lb., the piston of the pump will descend with a force of

2500 lb., and the ram will rise with one of 100,000 lb.

Motion of Fluids.—*Hydraulics* treat of the laws which govern the *motion* of fluids. If two vessels communicate with each other, and the height at which the water stands in the one exceeds the height of the other, then the water will flow into the second vessel until there remains as much water in the first as its height shall be equal to the height of the second. It is on this principle that water is supplied from reservoirs and cisterns to towns and villages and farmsteads, and that it rises from springs at a higher level into wells, whether of the common or Artesian form.

Velocity of Water.—The *velocity* of water issuing from an orifice is as the square root of its altitude. Thus, calling the velocity issuing 1 foot below the surface 1, that escaping from a similar orifice 4 feet below the level will be 2; at 9 feet, 3; at 16 feet, 4; and so on. From this we learn, that of water issuing from two similar vessels, it will issue, from similar orifices, from the one kept constantly full, twice as fast as from the other. A *short* tube will assist the issue of water from an orifice to the extent of half as much more.

Water-Ram.—It has been long observed that, when a cock at the end of a pipe is suddenly stopped when water is issuing out of it, a shock and noise are produced. A leaden pipe, even of great length, is often widened or burst in this way. The forward pressure of an arrested stream has been used as a force for raising water, and the apparatus has been called a *water-ram*. The ram may be described as a sloping pipe in which the stream runs, having a valve at its lower end, to be shut at intervals, and a small tube rising from near that end towards a reservoir above, to receive a portion of the water at each interruption of the stream. Water allowed to run for one second in a pipe 10 yards long, 2 inches wide, and sloping 6 feet, acquires momentum enough to drive about half a pint, on the shutting of the cock, into a tube leading to a reservoir 40 feet high. Such an apparatus, therefore, with the valve shutting every second, raises about 60 half-pints or 4 gallons in a minute. The

¹ Peschel's *Elem. Phys.*, i. 157-187.

² Keith's *Agric. Rep.*, 302.—*Aberdeen*.

valve is ingeniously contrived so that the stream works it as desired, and it is called a *sniffing valve*. This ram would supply water from a rivulet to cisterns in the farmhouse or steading standing at a height beyond the power of a force-pump.

Embankments against a Stream.

—The effect produced by moving water depends on the quantity of water that strikes in one minute of time against the surface of the opposing body, and on the velocity with which the collision takes place. If the collision happens in a direction vertical to the surface of the body, its effect is equal to the pressure of a column of water, having for its base the surface impinged on, and an altitude equal to that of the column which generates the velocity of the stream. If the water impinges obliquely on the surface, the force may be resolved into two others—one parallel to the side of the body, and the other perpendicular to it. The latter alone is effective, and is proportional to the square of the sine of the angle of incidence. From this law we learn to calculate the amount of resistance required in an embankment against the force of a stream.

Water-Wheels.—The motive power of water is usefully applied to drive machinery by means of *water-wheels*. When water-power can be obtained to drive the thrashing-machine or other fixed machinery of a farm, an immense advantage is gained over the employment of horses. It is found that water-power, in the thrashing of grain alone, saves the work of one pair of horses out of every five pairs. Any form of water-wheel, therefore, is more economical than horses.

Undershot Water-Wheel.—When a wheel with float-boards merely dips its lower part into a stream of water, and is driven by its momentum—that is, by the bulk and velocity of the water—it is called an *undershot* wheel. This wheel is employed in low falls with large quantities of water. To have a maximum of effect from undershot wheels, they are generally made to turn with a velocity about one-third as great as that of the water.

Breast Water-Wheel.—When the

water reaches the wheel near the middle of its height, and turns it by falling on the float-boards of one side as they sweep downwards in a curved trough fitting them, the modification is called a *breast-wheel*. This form is employed in moderate falls commanding a large supply of water.

Overshot Water-Wheel.—When the float-boards are shut in by flat sides, so as to become the bottoms of a circle of cavities or buckets surrounding the wheel, into which the water is allowed to fall at the top of the wheel, and to act by its weight instead of its momentum, the modification is called the *overshot* wheel. This form requires a high fall, but comparatively a small supply of water, and is most desired when circumstances will permit its adoption. Overshot wheels usually have their circumference turning with a velocity of about 3 feet per second.

Turbines.—The turbine is an ingenious and most useful modern invention for utilising water-power. The principles of its working will be explained in a later section.

Velocity of Streams.—*Friction* affects the motion of streams of water very sensibly. The velocity of a stream is greater at the surface than at the bottom, in the middle than at the sides; and the water is higher along the middle than at the sides. But for the retarding power of friction, the water in open channels and ditches would acquire so great a momentum as to destroy their sides, and to overflow them at every bending. Rivers issuing from a high source, but for friction and the effect of bending, would pour down their waters with irresistible velocity at the rate of many miles per hour. As it is, the ordinary flow of rivers is about 3 miles per hour, and their channels slope 3 or 4 feet per mile.

To measure the *velocity of a stream at the surface*, hollow floating bodies are used, and the space they pass over in a given time—one minute—is observed by the watch. It is very difficult to ascertain the true velocity of an irregular stream. To learn what quantity of water flows in a stream, its breadth and depth are first measured at various places to obtain a mean of both; and

the sum of these constituting the section of the stream is then multiplied by the velocity, and the product gives the number of cubic feet per minute.

A more exact method usually employed is to dam up the stream with boards or planks and allow the water to flow over a rectangular or triangular "notch," where the speed and dimensions can be accurately measured.

Horse-Power.—It may be useful to know the rule for calculating the number of *horse-power* any stream may exert if employed as a motive power. It is this: multiply the specific gravity of a cubic foot of water, $62\frac{1}{2}$ lb., by the number of cubic feet flowing in the stream per minute, as ascertained by the preceding process, and this product by the number of feet in the fall, and divide by 33,000 (the number of pounds raised 1 ft. high in 1 min. by a "horse-power"); the product is the answer.

Thus,—Multiply the number of cubic feet flowing per minute in the stream—suppose . . .	350
By the weight of a cubic foot of water $62\frac{1}{2}$ lb.	$62\frac{1}{2}$
	<hr/>
	21,875
	<hr/>
And then multiply the product by the number of feet of fall available—suppose . . .	12
	<hr/>

Divide the remainder by 33,000 $262,500(7.9$ horse-power.
And the quotient, 7.9, gives the number of horse-power

This is, of course, the theoretical horse-power, of which only a proportion can really be utilised, varying from 35 per cent in undershot wheels to 75 per cent in turbines.

Electricity.—Electricity is universally present in nature. This is proved not only by its being set free by friction, but by almost every form of mechanical change to which any substance can be submitted, mere pressure being quite sufficient for the purpose. It is in a latent state—in a state of quiescence and equilibrium; but this equilibrium is very easily disturbed, and then a series of actions supervenes, which continues until the equilibrium is restored.

It has been found that certain bodies possess the property of conducting electricity, whilst others are incapable of conducting this form of matter, however subtle. On this account, bodies have been divided into two great groups—conductors and non-conductors of electricity; the conductors, such as metals, being termed *analectrics*, because they cannot produce sensible electricity; and the non-conductors, such as wax or glass, *idio-electric*, because they can.

The atmosphere is the part in which electricity, liberated by various processes, accumulates; it constitutes, in fact, the great reservoir of sensible electricity, our solid earth being rather the field in which this mighty power is again collected and neutralised. Sensibly, electricity is found in the atmosphere at all times and in every state, but varies both in kind and intensity.

Wheatstone announced his important discovery of the velocity of the electric force to the Royal Institution of London in 1835, and that it is 288,000 miles per second.

Electro-Culture.—The very general distribution of electricity through every substance, the ease with which it can be excited into activity, and the state of activity it displays around plants in a state of healthy vegetation, have led to the belief that were means devised to direct a more than usual quantity of electricity through plants when growing, their growth might be much promoted. It was conceived that metallic wires might be so placed as to convey this increased quantity; and accordingly experiments were made so as to direct it through given spaces of ground into the plants growing upon them; and this process has been named *electro-culture*. The results having been contradictory and discouraging, the process has been relinquished.

Humus is valuable by its union with oxygen in supplying carbonic acid and electricity to vegetables in all their stages. During the time it is in the soil, it is a greater attracter and retainer of moisture.

All the *inorganic* substances of plants are non-conductors, and therefore valuable as retaining electricity for the use of vegetation.

Heat.—Heat may be regarded as the antagonistic force to gravity. Were gravity to act alone, every object would become a confirmed solid, and there would be no such existence as life. It is the property of heat to part asunder the atoms of all bodies, and these remain or change into solids, liquids, and gases, as their atoms are more nearly or remotely placed from each other—the farther they are separated, the weaker the attraction being between them.

Thermometers.—Whenever heat becomes sensible or free, it alters the form of bodies by dilation; and the measure of this increase has given rise to a class of useful instruments called *thermometers*.

The common *mercurial thermometer* is nearly a perfect instrument, and has been the means of establishing important facts to science; but being a mere measurer of temperature, it is incapable of indicating changes of the atmosphere, as the barometer, and is therefore a less useful instrument to the farmer. Regarding the ordinary temperature of the atmosphere, the feelings can judge fairly well; and as the state of the productions of the farm indicates nearly whether the climate of the particular locality can bring them to perfection, the farmer almost seems independent of the thermometer. Still, it is useful for him to know the lowest degree of temperature in winter to put him on his guard, as certain kinds of farm produce are injured by the effects of extreme cold, which the feelings are incapable, from want of habit, of estimating. For this purpose, a thermometer self-registering the lowest degree of cold will be found a useful instrument on a farm; and as great heat seldom occurs in our climate, a self-registering thermometer of the greatest heat is not so useful an instrument as that which registers the greatest cold.

Reaumur Scale.—Reaumur was the first to propose the use of mercury as the expansive medium for the thermometer. This liquid metal has many advantages over every other medium; it has the power of indicating an extensive range of temperature, and expands very equally. On its adoption, the melting-point of ice was taken as a fixed point, and the divisions of the scale were made

to correspond to $\frac{1}{1000}$ th parts of the parts of the capacity of the bulb.

Fahrenheit Scale.—It was left for the ingenious Fahrenheit¹ to fix another standard point—that of boiling-water under the mean pressure of the atmosphere, which is given on his scale at 212° ; the melting-point of ice at 32° . This scale of division has universally been adopted in Britain, but not on the Continent. The zero of this scale, adopted by Fahrenheit, from the erroneous idea that the greatest possible cold was produced by a mixture of common salt and snow, has favourable advantages for a climate like ours. The other divisions of the thermometer, between the two fixed points of freezing and boiling water in general use, are those of Reaumur² and Celsius.³ Reaumur divides the space into 80 equal parts; the division of Celsius is into 100 parts. In both these scales the zero is placed at the melting-point of ice, or 32° Fahrenheit.⁴

The rule for converting the Reaumur scale into that of Fahrenheit is—multiply the degrees of Reaumur by $2\frac{1}{4}$, and add 32° . For example, take 12° Reaumur, which multiply by $2\frac{1}{4} = 27$; and add $32^{\circ} = 59^{\circ}$ Fahrenheit.

The rule for converting the Celsius or centesimal scale into that of Fahrenheit is—multiply the degrees of Celsius by $\frac{9}{5}$, and add 32° . For example, take 12° Celsius, which multiply by $\frac{9}{5} = 21.6^{\circ}$; add $32^{\circ} = 53.6^{\circ}$ Fahrenheit. Also, $\frac{4}{5}$ multiplied by Celsius = Reaumur, and $\frac{5}{4}$ multiplied by Reaumur = Celsius.

Fahrenheit Thermometer.—The common Fahrenheit thermometer, fig. 3, is too well known to need description. Its tube is filled with mercury. It may be purchased for 1s. and upwards, but so very low-priced

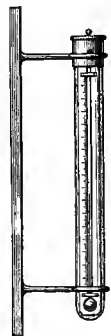


Fig. 3.
Fahrenheit
Thermometer
mounted.

¹ A Danish philosopher who experimented in Iceland. Born 1686, died 1736.

² A French philosopher. Born 1683.

³ A Swedish philosopher. Born 1670, died 1756.

⁴ *Jour. Agric.*, iii. 5.

ones are worse than useless, errors of 1° , 2° , and even 8° , being of frequent occurrence. It is mounted with iron pins screwed into a window-sash.

Minimum Thermometer.—The *minimum* thermometer, fig. 4, registers the



Fig. 4.—*Minimum Thermometer.*

greatest cold during the night. The tube is filled with spirit of wine, in which a small index *a* floats, which, being drawn down by the fluid towards the bulb as the temperature falls, is left

undisturbed as it rises, indicating the lowest point to which the temperature has fallen. The reading is taken from the head of the index farthest from the bulb. This instrument gets out of order by the column of spirit breaking up into parts, but fortunately they can be reunited by striking the bulb-end of the frame firmly and repeatedly against the palm of the hand, or by raising it over the head and rapidly and forcibly swinging it downwards, to force the spirit towards the bulb. After this it may be left a short time in a slanting position to drain more completely. To adjust this instrument, slope it so as to make the head of the float come to the end of the column of spirit of wine.¹

Stack Thermometer.—

The thermometer, fig. 5, is useful in ascertaining the temperature of the hearts of stacks, to determine whether heating has begun or not, and the temperature in the interior of dung-heaps. It consists of a long glass tube, cased in a strong metal tube of brass, tin, or zinc, pierced with small holes at the bottom.



Fig. 5.—*Stack or Dung Thermometer.*

Placing Thermometers.—Thermometers of all kinds, when fixed up for observation, should be placed out of the reach of the direct rays of the sun, or of any reflected heat. If at a window or against a wall, the thermometer should have a northern aspect, and be kept at a little distance from either. The common thermometer is fixed perpendicularly, the minimum horizontally, but loose, so as to allow the float index to be adjusted. The maxima of temperature are generally indicated too great, from the near contact in which the instrument is usually placed with large ill-conducting masses, such as walls—the temperature of the night thus being kept up, and the minima also.

As thermometers are usually placed, they cannot indicate the temperature received by growing crops. To attain that knowledge, the thermometer should be exposed day and night as the crops are—to sunshine, cloud, and night; and it is only in this way that the vicissitudes of temperature during the twenty-four hours can be correctly ascertained.

Air-Engine.—Bodies, on receiving heat, expand generally more rapidly than the temperature increases; and the expansion is greater as the cohesion in the particles becomes weaker from increased distance—being considerably greater in liquids than in solids, and in airs than in liquids. Thus solids gain in bulk 1 part in from 100 to 400; liquids, in from 9 to 55; and all gases and vapours gain 1 part in 3. It is this dilating property of air which prompted some persons to employ the force of expanding air as a motive power: the same quantity of heat that would produce one cubic foot of common steam would double the volume of 5 cubic feet of atmospheric air. The air-engine is now an accomplished fact; and it has been proved that this power may be much more economically employed than steam.

Steam-Engine.—In expanding on the reception of heat, bodies receive it in different quantities ere they exhibit a given increase of temperature; and this difference marks their different capacities for heat. It is this property which renders steam so powerful and economical a force to be employed in moving machinery; and as a motive power the *steam-engine*

¹ See Buchan's *Hand. of Meteo.*—"Thermo."

at present stands unrivalled. As it came from the hands of Watt, the steam-engine may almost be said to be endowed with human intelligence, as may be seen on perusing at length Dr Arnott's well-expressed encomium on this wonderfully simple machine. "It regulates with perfect accuracy and uniformity," he observes, "the *number of its strokes* in a given time—*counting or recording* them, moreover, to tell how much work it has done, as a clock records the beats of its pendulum; it regulates the *quantity of steam* admitted to work—the *briskness of the fire*—the *supply of water* to the boiler—the *supply of coals* to the fire; it *opens and shuts its valves* with absolute precision as to time and manner; it *oils its joints*; it *takes out any air* which may accidentally enter into parts which should be vacuous; and when anything goes wrong which it cannot of itself rectify, it *warns its attendants* by ringing a bell:—yet with all these talents and qualities, and even when exerting the powers of six hundred horses, it is obedient to the hand of a child; its aliment is coal, wood, charcoal, or other combustible; it consumes none while idle; it never tires, and wants no sleep; it is not subject to malady, when originally well made, and only refuses to work when worn out with age; it is equally active in all climates, and will do work of any kind; it is a water-pumper, a miner, a sailor, a cotton-spinner, a weaver, a blacksmith, a miller, &c.; and a steam-engine in the character of a *steam-pony* may be seen dragging after it, on a railroad, a hundred tons of merchandise, or a regiment of soldiers, with greater speed than that of our fleetest coaches. It is the king of machines, and a permanent realisation of the *genii* of Eastern fable whose supernatural powers were occasionally at the command of man."¹

Steam-Power on Farms.—The steam-engine is becoming daily more useful to the farmer in working his machines. Windmills, and water-wheels scantily supplied with surface-water are being laid aside when worn out, and the steam-engine substituted in their stead. This power, at command at all times, in

all seasons, and to any extent, is also employed to cut straw and hay, and bruise corn and cake. The steam-engine is a befitting motive power for the plough; but in the form of a locomotive, it is yet too delicate a machine for all the varieties of ploughing in the different states of the ground incidental to farms. In the locomotive form, it becomes an attendant anywhere on the thrashing-machine.

Hygrometers.—Instruments intended to show the quantity and condition of vapour in the atmosphere are called *hygrometers*; when they merely indicate the presence of aqueous vapour, without measuring its amount, they are called *hygroscopes*.

The measurement of the humidity of the atmosphere by a hygrometer is no better, as a foreteller of humidity, than is the thermometer, which only tells the existing heat.

The *conservatory hygrometer*, fig. 6, is of some use to the farmer in deter-

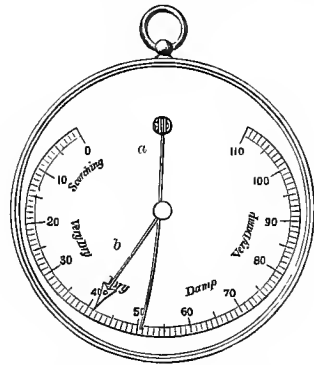


Fig. 6.—Conservatory Hygrometer.

mining roughly the wetness or dryness of the atmosphere. The pointer *a* is made of two pieces of wood so glued together that, as the humidity increases, it twists successively through 60°, 70°, 80°, to 100°; and as the dryness increases, it twists back through 40°, 30°, 20°, 10°, to zero. The movable index *b* marks the last observation. A little practice will soon enable the intelligent farmer to assign definite values to the indications of these thermometers and hygrometers, and draw practical conclusions from them. They are of par-

¹ Arnott's *Elem. Phys.*, i. 383—"Pneu."

ticular value when taken in connection with the barometer in predicting the changes of the weather. For a rising barometer with increasing dryness and heat are a pretty good indication of dry weather, and a falling barometer and thermometer with increasing humidity are almost a certain indication of rain.

"Hygrometers were made of quills by Chiminello, which renders it probable that birds are enabled to judge of approaching rain or fair weather. For it is easy to conceive that an animal having a thousand hygrometers intimately connected with its body, must be liable to be powerfully affected, with regard to the tone of its organs, by very slight changes in the dryness or humidity of the air; particularly when it is considered that many of the feathers contain a large quantity of blood, which must be alternately propelled into the system, or withdrawn from it, according to their contraction or dilation by dryness or moisture."¹ May not this strong hygrometric feeling in birds be an exciting influence for their migration?

The vapour issuing from the funnel of a locomotive steam-engine may be regarded as a hygrometer. When the air is saturated with vapour, it cannot absorb the spare steam as it is ejected from the funnel, and hence a long stream of white steam, sometimes 400 yards in length, is seen attached to the train. When the air is very dry, the steam is absorbed as it issues from the funnel, and little of it is seen.

It is the influence of external pressure that keeps the particles of water from being evaporated rapidly into the atmosphere. Even at 32°, the freezing-point, if placed in a vacuum, water will assume the form of vapour, unless constrained by a pressure of 1 ounce on each square inch of surface, and at higher temperatures the restraining force must be greater: at 100° it must be 13 ounces; at 150°, 4 lb.; at 212°, 15 lb.; at 250°, 30 lb. Whenever the restraining force is much weaker than the expansive tendency, the formation of steam takes place so rapidly as to produce the bubbling and agitation called *boiling*.

Boiling-Point.—An atmosphere less heavy than our present one would have allowed water to burst into vapour at a lower temperature than 212°, and one more heavy would have had a contrary effect. Thus, the ebullition of water takes place at a lower temperature the higher we ascend mountains, and at a higher temperature the deeper we descend into mines. The boiling-point may thus be made the measure of altitude of any place above the sea, or of one place above another. Dr Lardner has given a table of the medium temperature at which water boils at different places at various heights above the sea.² It appears that, at such an elevation as to cause the barometer to indicate 15 inches of atmospheric pressure, or at half the ordinary pressure of the atmosphere, water will boil at 180°. As a general rule, every tenth of an inch which the barometric column varies between the limits of 26 and 31 inches, the boiling temperature changes by one-sixth of a degree.

Fuel.—The comparative value as *fuel* of different kinds of carbonaceous substances has been found by experiment to be thus:—

1 lb. of charcoal of wood melts	95 lb. of ice.
" good coal	90 "
" coke	84 "
" wood	32 "
" peat	19 "

It is thus seen how valuable good coal, and how very inferior peat is, as a generator of heat—the latter not being much above half the value of wood. Good coal is thus the cheapest kind of fuel where it is abundant.

"It is wasteful to wet fuel, because the moisture, in being evaporated, carries off with it as latent, and therefore useless heat, a considerable proportion of what the combustion produces. It is a very common prejudice, that the wetting of coal, by making it last longer, is effecting a great saving; but while, in truth, it restrains the combustion, and, for a time, makes a bad fire, it also wastes the heat."

"In close fireplaces—viz., those of great boilers, as of steam-engines, &c.

¹ *Edin. Ency.*, art. "*Hygro*."

² Lardner *On Heat*, 413.

—all the air which enters after the furnace-door is shut must pass through the grate and the burning fuel lying on it, and there its oxygen is consumed by the red-hot coal before it ascends to where the smoke is."

"A smoke-consuming fire would be constructed on a perfect principle, in which the fuel was made to burn only at the upper surface of its mass, and so that the pitch and gas disengaged from it, as the heat spread downward, might have to pass through the burning coals where fresh air was mixing with them; thus the gas and smoke, being the most inflammable parts, would burn first and be all consumed."¹ Or the fresh fuel might be introduced at the bottom, and thus the gaseous matter would be consumed while passing through the hot fuel above. When smoke, which is vapour and coal-dust, has accumulated at the throat of the chimney, it cannot thereafter be consumed.

Weather Axioms.—The changes which the atmosphere daily undergoes being necessarily the changes which constitute the weather, renders *meteorology* one of the most important studies that can occupy the attention of the farmer. Who of us does not pride himself on the possession of a few weather axioms, by which we think to foresee the coming changes? Some of these axioms are sound; others are essentially true, but are often misapplied; while a large portion are false. That the latter should be a large class is obvious, because the casual observer is too apt to draw general rules from particular cases, without taking into account all the accidental circumstances that may be present. The only means we possess of eliminating these sources of error, and arriving at the general laws which govern atmospheric phenomena, is a course of faithful and unwearied observation, followed by sound and accurate deduction. The scientific world have been awakened to the importance of this course; and very efficient means are now in progress toward the attainment of the object in view.

Weather and Farm Work.—The

weather has the power to modify, if not entirely to alter, the operations of the farm. It may oblige the farmer to pursue a different and much less efficient treatment of the land than he desires, and the amount and quality of its produce may be very seriously affected by such a change of treatment.

Now, when such a change is, and may in any season be, imposed upon the farmer, it is a matter of prudence to become as much acquainted with ordinary atmospheric phenomena as to be able to anticipate the nature of the ensuing weather. As particular changes of weather are forerunners of results, the farmer, by observation, might anticipate them, and arrange his operations accordingly. Shepherds and sailors have long been famed for possessing the faculty of forecasting the weather, and there is nothing to prevent farmers doing the same if they would but bestow their attention on atmospheric phenomena.

Judging Weather.—*Atmospherical phenomena being the great signs by which to judge of the weather*, the barometer and thermometer are instruments which might direct our judgment. If the mercury in the tube of the barometer (fig. 1) be convex, the mercury is on the rise, and indicates fair weather; if concave, the mercury is on the fall, and foul weather may be looked for; and if the rise or fall goes on steadily, the weather indicated may be relied upon. The cause of these forms of the mercury is the friction against the sides of the tube which retards the rise or fall, while the centre of the column is more free to move. A great and sudden fall indicates a storm somewhere in 24 hours. Alternate short elevations and depressions of the mercury indicate unsteady weather. An E. and N.E. wind elevates the mercury, while a W. or S.W. wind depresses it. The extent of range affected by these winds may be from $\frac{1}{10}$ to $\frac{2}{10}$ of an inch. The barometer at sea is a good indicator of wind, but not of rain. No attention should be paid to the words fair, rain, stormy, often marked on the face of the barometer or aneroid; for the condition of the mercury at any particular place is no indication of what it is at any other place situated higher or lower.

¹ Arnott's *Elem. Phys.*, ii. Part I., 149—"Heat."

A rise of temperature indicated by the thermometer tells of a drier state of the air, and a fall is indicative of damp. Observation has established that the hour of the day of minimum temperature is 5 in the morning, and the maximum temperature at 40 minutes past 2 in the afternoon. Also, that there are hours of the day when the mean temperature for the whole year was equal to the mean of the whole 24 hours.

Dew.—Invisible evaporation sends a large quantity of vapour into the lower stratum of the atmosphere, which never ascends so high as to form clouds, but is deposited in *dew*, in drops, upon the points of objects having a rough surface, such as the blades of grass and other suchlike plants.

Dr Wells's theory of dew, therefore, is, "that the cold observed with dew is the previous occurrence, and consequently, that the formation of this fluid has precisely the same immediate cause as the presence of moisture upon the outside of a glass or metallic vessel, where a liquid considerably colder than the air has been poured into it shortly before." As an obvious application of this theory, the experiments of Dr Wells, which led to its establishment, evince, that of all natural substances, grass is peculiarly adapted to the exhibition of dew, inasmuch as it becomes, under ordinary circumstances, colder than the air above it, by the radiation of more heat towards the heavens than it receives in any way; and accordingly, whenever the air is calm and serene, dew may be seen on grass when it may not be observed on other substances.

Hoar-Frost.—*Hoar-frost* or *rime* is just frozen dew. What is a remarkable phenomenon in regard to rime is, that its congeries of crystals differs on different kinds of plants, but the congeries is the same on the same kinds of plants.

Vapour.—At all temperatures, at all seasons, water is converted into *vapour* and carried up into the atmosphere; and when the air has acquired as much as it can unite with at the temperature it then possesses, it is then said to be saturated with vapour. The quantity of vapour attains its *minimum* throughout the year, in the morning before sunrise. At the same time, on account of

the low degree of temperature, the humidity is at its *maximum*. In proportion as the sun rises above the horizon, the evaporation increases, and the air receives every moment a greater quantity of vapour. But as the air increases in its capacity for vapour as the temperature rises, it becomes farther and farther removed from the point of saturation, and the relative humidity becomes more and more feeble. The rate continues without interruption until the moment when the temperature attains its *maximum*.

Vapour being thus the result of the action of heat on water, it is evident that its quantity must vary at different hours of the day, in different seasons, in different parts of the globe, and at different heights of the atmosphere. It is supposed that the medium quantity of vapour in the atmosphere is $\frac{1}{70}$ of its bulk.

Moist and Dry Winds.—Daily experience has long taught us that the air is not equally moist with every wind. When the farmer wishes to dry his corn or his hay, or the housewife spreads out her wet linen, their wishes are soon satisfied if the wind blows continuously, but a much longer time is required with a W. wind. Certain operations in dyeing do not succeed unless during E. winds.¹

Weight of Vapour.—This table gives the weight in grains of a cubic foot of vapour, at different temperatures of 10°, from 0° to 90° Fahrenheit; and clearly shows that the higher the temperature of the air, the greater is the quantity of vapour held in solution in it.

Temperature in degrees.	Weight in grains.	Temperature in degrees.	Weight in grains.
0	0.856	50	4.535
10	1.208	60	6.222
20	1.688	70	8.392
30	2.361	80	11.333
40	3.239	90	15.005

Clouds.—When by any cause the temperature of the air is reduced, its

¹ Kaemt's *Meteo.*, 88-97.

particles approach nearer each other, and so do those of the vapour held suspended in the air; and as steam becomes visible when mixed with atmospheric air, so vapour becomes visible when it suffers condensation by a reduction of temperature, and then becomes *clouds*. These differ much in altitude and size.

It would appear that their altitude extends from 1300 to 27,000 feet above the sea. That clouds exist at different heights is easily proved while ascending mountains, and when seen to move in opposite directions at the same time.

It is natural to suppose that the lighter clouds—those containing vapour in the most elastic state—should occupy a higher position in the air than the less elastic, and hence only fleecy clouds are seen over the tops of the highest Andes. Clouds, in heavy weather, are seldom more than half a mile above us, but in clear weather from 5 to 6 miles.

Clouds are often of enormous size, 10 miles each way, and 2 miles thick, containing 200 cubic miles of vapour; but sometimes they are even ten times that size. The size of small clouds may be easily estimated by observing their shadows on the ground in clear weather in summer. The shadows of larger clouds may be seen resting on the sides of mountain-ranges, or spread out upon the ocean.

Among the objects of nature, there are few more certain premonitors of change in the weather than the clouds, and as such they are worthy of attentive study by the farmer. In a casual glance at the clouds, exhibiting as they seemingly do so great a variety of form, it can scarcely be believed that they all originate from three forms. The three forms are *Cirrus* or curl-cloud, *Cumulus* or heap-cloud, and *Stratus* or lay-cloud. The combinations of these three forms are the *cirro-cumulus*, the heaped curl; the *cirro-stratus*, the lay curl; the *cumulo-stratus*, the heaped layer; and the *cumulo-cirro-stratus*, the heaped-curl-lay-cloud, or *nimbus*, or rain-cloud.

The suspension of clouds in the air is a phenomenon that has not yet been satisfactorily explained; and when we see a cloud pour out thousands of tons of water upon the ground in a small space, we cannot comprehend how it can

float in the atmosphere. Condensed vapour—water—cannot float in air, while in the state of vapour it can, being then specifically lighter than air.

Study the Clouds.—It is desirable to impress upon pupils and even upon farmers to devote their attention, when in the open air, to every change in the aspect of the clouds, as they are sure prognosticators of change in the weather. It may be remarked as general prognostics, that when clouds attach themselves to others or to mountain-tops they indicate rain. When they form and soon disappear, fair weather ensues. Ragged edges of clouds indicate a moist state of air; when much ragged, wind may be expected. When the edges are well defined, the air is in a dry state; when they are much rolled up, a discharge of electricity may be looked for. It is unwholesome weather when clouds of all denominations have undefined edges. The *most wholesome weather* is when W. winds and day cumuli prevail—when a stratus evaporates as the sun rises—on the formation of well-defined cumuli throughout the day, most abundant in the afternoon, and disappearing in the evening, succeeded by strong dew. In these circumstances the barometer is always steady, and the thermometer high.

Fog or Mist.—The phenomenon of *fog* or *mist* occurs at all seasons, and it appears always under the peculiar circumstances explained by Sir Humphry Davy. His theory is, that radiation of heat from land and water sends up vapour until it meets with a cold stratum of air, which condenses it in the form of mist, that naturally gravitates towards the surface. When the radiation is weak, the mist seems to lie upon the ground; but when more powerful, the stratum of mist may be seen elevated a few feet above the ground. Mist, too, may be seen to continue longer over the water than the land, owing to the slower radiation of vapour from water; and it is generally seen in the hollowest portions of ground, on account of the cold air, as it descends from the surrounding rising-ground, mixing with the air in the hollow, and diminishing its capacity for moisture.

Mist also varies in its character accord-

ing to its electric state: if negatively affected, it deposits its vapour more quickly, forming a heavy sort of dew, and wetting everything like rain; but if positively, it continues to exist as dry fog. Thin hazy fogs frequently occur in winter evenings after clear cold weather, and they often become so permanently electric as to resist for days the action of the sun to disperse them.

The prognostic regarding fog is, that if it creep towards the hills it will be rain, but if it goes to the sea it will be fine weather.

Rain.—The life of plants and animals depending as much on moisture as on temperature, and their development being greatly modified by the dryness or humidity of the atmosphere, the cause and effects of *rain* become important objects of study to the agricultural student.

Although the actual quantity of rain that falls in a given part of a country is not an exact measure of the dryness or humidity of its climate, that being chiefly determined by the frequency and not the quantity of rain that falls; still it is interesting to know the quantity of rain that falls in any given locality. The rain that falls is measured by a *rain-gauge*.

Rain-Gauge.—A simple gauge has been proposed, whose measure, if lost or broken, may be easily reproduced. It consists of a simple funnel of metal, *a*, fig. 7, of 4.697 inches diameter, and a fluid ounce measure of metal, *b*. This funnel is fitted into the mouth of a bottle or jar placed in the ground,



Fig. 7.—Funnel Rain-Gauge.

into which the rain-water falls. For every fluid ounce of the rain-water thus collected one tenth of an inch of rain has fallen. The fluid ounce measure may be graduated with as much niceness as may be desired. This simple rain-gauge will be found to be a convenient and useful one to farmers. Japanned tin remains long free of rust.

Position of the Rain-Gauge.—A most important point in connection with the rain-gauge is its position. It should never be placed on a slope, nor near the edge of a terrace, but on a level piece of

ground at a distance from shrubs, trees, walls, and buildings, at the very least as many feet from their base as they are in height. The rim of the gauge should be perfectly level, even a quarter of an inch from the horizontal producing sensible errors. The rim should be from 3 inches to a foot above the surface of the ground. If it exceeds a foot, the quantity of rain collected will be proportionally diminished. It should be immediately surrounded by old grass kept constantly cropped.

Gauging Snowfalls.—"In cases of snowstorms the rain-gauge may not give a correct quantity, as a part may be blown out, or a greater quantity have fallen than the mouth will contain. In such cases, the method of knowing the quantity of water is, to take any cylindrical vessel and press it perpendicularly into the snow [on the ground], bringing out a cylinder of snow with it equal to the depth; and this, when melted, will give the quantity of water by measurement. The proportion of snow to water is about 17 : 1, and hail to water 8 : 1. These quantities, however, are not constant, but depend upon the circumstances under which the snow or hail has fallen, and the time they have been upon the ground."¹

Theory of Rain.—The *theory* proposed by Dr Hutton, that rain occurs from the mingling together of great beds of air of unequal temperature differently stored with moisture, is that which was adopted by Dalton, Leslie, and others, and is the current one, having been illustrated and strengthened by the clearer views of the nature of deposition which we now possess, and which teach that as the S. to S.W. winds bring the vapour, so the upward current of the atmosphere carries it to a lower temperature, when an immediate precipitate takes place of the vapour in the form of rain, and especially great upon mountains.

Buchan remarks that whatever tends to lower the temperature of the air is a cause of rain. Various causes, he says, may conspire to effect this, but it is chiefly brought about by the ascent of air into the higher regions of the atmosphere.

¹ *Jour. Agric.*, iii. 13.

On the connection of rain with the *fall of the barometer*, Mr Meikle has shown that the change of pressure may be a cause as well as an effect; for the expansion of air accompanying diminished pressure, being productive of cold, diminishes the elasticity of the existing vapour, and causes a deposition.¹

Distribution of Rainfall.—Taking a general view of the rain that falls over the globe, it is found that the tropical region is subject chiefly to *periodical rains*—that is, large quantities falling at one time of the year, while at other times none falls for months. In portions of the globe no rain falls at all, and they are, in consequence, called the “rainless districts,” which comprehend part of the desert of Sahara and Egypt, part of Arabia, Persia, the desert of Gobi, Tibet, and Mongolia, and part of Mexico and Peru.

On each side of the tropical zone, towards the poles, is the zone of “constant precipitation,”—not that rain constantly falls, but that it may fall in any day of the year, and is always accompanied with electrical explosions. Captain Speke described this zone as containing the most luxuriant vegetation he had seen in Africa.

Amount of Rainfall.—The annual amount of rain that falls in the Old and the New World is as follows :—

The annual amount of rain	
Under the tropics of the New World	115 inches.
" " " Old World	76 "
Within the tropics generally	95½ "
In the temperate zone of the New	
World (United States)	37 "
Of the Old World (Europe)	31¼ "

There are general laws which affect the distribution of rain over the globe, and these are—“The amount of rain decreases as we recede from the equator to the poles; thus, while under the tropics the yearly average amount of rain is 95½ inches, in Italy it is less than a half, or 45 inches; in England about one-third, or 30 inches; in the north of Germany, about one-fourth, or 22½ inches; and at St Petersburg, only one-fifth, or 17 inches.”

The number of rainy days increases from the equator to the poles; so that, where the most rain falls, there are the

fewest rainy days. According to the observation of M. Cotte, the numbers stand thus :—

From N. Lat. 12° to 43°	there are 78 rainy days.
" " 43° to 46°	103 "
" " 46° to 50°	134 "
" " 50° to 60°	161 "

Rainfall in Great Britain.—At places at some distance from hills, and in some inland situations, the annual fall is much diminished. For instance, in the west of Great Britain, away from hills the rainfall is from 30 to 45 inches; while in the east of the island it is only from 20 to 28 inches. In the immediate neighbourhood of high hills in the west of Great Britain and Ireland the fall is as great as from 80 to 150 inches, occasionally even higher. At Seathwaite, in Cumberland, in 1861, it was no less than 183½ inches.

“The amount of rain decreases in the direction from the coasts to the interior of continents, and this is exemplified by the difference between the coasts of the Atlantic Ocean and the countries of Eastern Russia. The western coasts of Great Britain, France, and Portugal have an annual average of from 30 to 35 inches. Bergen, in Norway, has 80, and Coimbra, in Portugal, 111 inches of rain; while in central and eastern Europe, in Bavaria, and through Poland and Russia, it falls to 15 inches. At Iekatrinburg, in the Ural Mountains, it is only 13 inches, and in the interior of Siberia it is still less.

“In both hemispheres, within the temperate zone, the west coasts are proportionally more moist than the east. In this quarter of the globe, it is explained by the prevalence of the W. winds, which, before arriving in Europe, become charged with vapour in passing over the Atlantic Ocean; whilst those which blow from the E. pass over the interior of the continents of Europe and Asia, where the dryness of the air increases rapidly. . . . The determining causes of the distribution of rain in Europe are thus seen to be the predominance of W. winds, with the existence of a vast ocean on one side and a great continent on the other.”²

¹ Roy. Inst. Jour.

² Johnston's Phys. Atlas—“Meteo.”

Weight of Rainfall per Acre.—

A statement by the English Registrar-General, written in February 1865, gives the following interesting information in respect to rainfall: "Rain fell in London to the amount of 43 inches, which is equivalent to 4300 tons of rain per acre. The rainfall during last week (Feb. 1865) varied from 30 tons per acre in Edinburgh to 215 tons per acre in Glasgow. An English acre consists of 6,272,640 square inches; and an inch deep of rain on an acre yields 6,272,640 cubic inches of water, which at 277.274 cubic inches to the gallon makes 22,622.5 gallons; and as a gallon of distilled water weighs 10 lb., the rainfall on an acre is 226,225 lb. avoirdupois; but 2240 lb. are a ton, and consequently an inch deep of rain weighs 100.993 tons, or nearly 101 tons per acre. For every 100th of an inch a ton of water falls per acre. If any agriculturist were to try the experiment of distributing artificially that which nature so bountifully supplies, he would soon feel inclined to 'rest and be thankful.'"

Ammonia in Rain.—Foreign matter is brought down from the air, gaseous as well as mineral. "The nitrogen of putrefied animals," says Liebig, "is contained in the atmosphere as ammonia, in the state of a gas, which is capable of entering into combination with carbonic acid, and of forming a volatile salt. Ammonia, in its gaseous form, as well as all its volatile compounds, is of extreme solubility in water. Ammonia, therefore, cannot remain long in the atmosphere, as every shower of rain must effect its condensation, and convey it to the surface of the earth. Hence, also, rain-water must at all times contain ammonia, though not always in equal quantity. It must contain more in summer than in spring or in winter, because the intervals of time between the showers are in summer greater; and when several wet days occur, the rain of the first must contain more of it than that of the second. The rain of a thunderstorm, after a long-protracted drought, ought for this reason to contain the greatest quantity conveyed to the earth at one time.

"As regards the quantity of ammonia thus brought down by the rain,—as

1132 cubic feet of air, saturated with aqueous vapour at 59° Fahrenheit, should yield 1 lb. of rain-water, if the pound contain only one-fourth of a grain of ammonia, a piece ground of 26,910 square feet—43,560 square feet being in an acre—must receive annually upwards of 80 lb. of ammonia, or 65 lb. of nitrogen, which is much more nitrogen than is contained in the form of vegetable albumen and gluten in 2650 lb. of wood, 2500 lb. of hay, or 200 cwt. of beetroot, which are the yearly produce of such a piece of ground; but it is less than the straw, roots, and grain of corn, which might grow on the same surface, would contain."¹

Prognostics of Rain.—These are regarded as general prognostics of rain: When cattle snuff the air and gather together in a corner of the field with their heads to leeward, or take shelter in the sheds—when sheep leave their pastures with reluctance—when goats go to sheltered spots—when asses bray frequently and shake their ears—when dogs lie much about the fireside and appear drowsy—when cats turn their backs to the fire and rub their faces—when pigs cover themselves more than usual in litter—when cocks crow at unusual hours and flap their wings much—when hens chaunt—when ducks and geese are unusually clamorous—when pigeons wash themselves—when peacocks squall loudly from trees—when the guinea-fowl makes an incessant grating noise—when sparrows chirp loudly, and congregate on the ground or in a hedge—when swallows fly low, and skim their wings on water, on account of the flies upon which they feed having descended so low—when the carrion-crow croaks solitarily—when water wild-fowl dip and wash vigorously—when moles throw up hills industriously—when toads creep out in numbers—when frogs croak—when bats squeak and enter houses—when singing-birds take shelter—when the robin approaches near the dwellings of man—when tame swans fly against the wind—when bees leave their hives with caution, and fly only short distances—when ants carry their eggs busily—

¹ Liebig's *Chem. Agric. Physio.*, 3d edition, 43-47.

when flies bite severely, and become troublesome in numbers—when earth-worms appear on the surface of the ground and crawl about—and when the larger sorts of snails appear.

A certain prognostic of rain may be obtained from the *aurora borealis*. When a bright aurora occurs in the autumn for the first time, a fall of rain two days after may be expected for three days in succession. The appearance of the aurora is at all times a strong indication of unsettled stormy cold weather for days.

Prevailing Winds.—The comparative prevalence of the E. and W. winds in Great Britain is shown in the following table:—

Years of Observation.	PLACES.	WIND.	
		Westerly.	Easterly.
10	London . . .	233.0	132.0
7	Lancaster . . .	216.0	149.0
51	Liverpool . . .	190.0	175.0
9	Dumfries . . .	272.5	137.5
10	Branxholm, near Hawick	232.0	133.0
7	Cambuslang . . .	214.0	151.0
8	Hawkhill, near Edinburgh	229.5	135.5
	Mean	220.3	144.7

Variable Winds.—The variations in the intensity and direction of the *wind* are the nearest indices to the change of weather that the agricultural student can study. In the temperate zone, and particularly in this island, flanked as it is with one great ocean, and not far removed from an extensive continent, the variations of the wind are so great, and apparently so capricious, as to baffle minute and correct inquiry; whereas in the tropics, the periodic winds correspond exactly with the uniform course of the seasons, and the limited range of the barometer—phenomena characteristic of that portion of the globe. It is the *variable* winds which stamp the nature of every climate; for although most apparent in their effects in the temperate regions, they nevertheless also exist in the tropics, as may be experienced along every coast and large island in the Indian Ocean. Their course, therefore, depends

on causes which act uniformly, notwithstanding their apparent irregularities. They may be all intimately connected with one another, and may probably succeed each other in a certain order, though that connection and that order have not hitherto been ascertained. When both have been discovered, then the course and intensity of the variable winds may be reduced to calculation as certainly as the regular winds are already.¹

Tides and Winds.—There being an atmospheric wave as well as a tidal, and as any elevation of the atmosphere cannot fail to produce a change in parts immediately below the point of disturbance, there seems no reason to doubt that an *analogy exists betwixt the tides and the winds, and also with rain.*

Prognostications of Wind.—The approach of high *wind* may be anticipated from the general prognostics: When cattle appear frisky, and toss their heads and jump—when sheep leap and play, boxing each other—when pigs squeal, and carry straw in their mouths—when a cat scratches a tree or a post—when geese attempt to fly, or distend and flap their wings—when pigeons clap their wings smartly behind their backs in flying—when crows mount in the air and perform somersets, making at the time a garrulous noise—when swallows fly on one side of trees, because the flies take the leeward side for safety against the wind—when magpies collect in small companies, and set up a chattering noise.

Storm Signals.—These are general indications of a *storm*: When the misel-thrush (*Turdus viscivorus*) sings loud and long, on which account it has received the name of the storm-cock—when sea-gulls come in flocks on land, or make a noise about the coast—when the porpoise (*Phocœna communis*) comes near the shore in numbers—when a great noise comes from the sea.

Foretelling Weather.—Every one is aware of the uncertainty of foretelling the state of the weather, but every one who has attempted to foretell it, and has not succeeded, is not aware of the

¹ Polehampton's *Gall. Nature and Art*, iv. 185.

nature of the many particulars which render his success doubtful. Fortunately for farmers and seamen, Admiral Fitzroy proved that forecasts of the

weather may be ventured on, and even depended upon, much beyond what could have been conjectured not many years ago.

SOILS.

The term *soil* does not convey the same meaning to all persons. The geologist does not recognise the term at all—except, perhaps, in common with the botanist and planter, as the mould which supports ordinary vegetation and trees; for “the term rock,” as Sir Henry de la Beche said, “is applied by geologists not only to the hard substances to which the name is commonly given, but also to those various sands, gravels, shales, marls, or clays, which form beds, strata, or masses.”¹ The common observer considers the ground he treads on as the soil. The farmer strictly confines his definition of a soil to the portion of the ground turned over by the plough.

The leading characters of all soils are derived from only two earths, *clay* and *sand*, the greater or less admixture of which stamps their peculiar character—for the properties of these earths are found to exist in calcareous and vegetable soils.

Clay Soil.—A pure *clay* soil has such distinctive external characters, that it may easily be recognised. When fully wetted, it feels greasy to the foot, which slips upon it. It has an unctuous feel in the hand, by which it can be kneaded into a smooth homogeneous mass, which retains the shape given to it. It glistens in the sunshine. It retains water upon its surface, and renders water very muddy when mixed with it, and the mud is long of settling to the bottom. It feels cold to the touch, and soils everything that touches it. It cuts like soft cheese with the spade. It parts with its moisture slowly. When dry, it cracks into numerous fissures, becomes hard to the foot, and collects into lumps, very difficult to be broken. It absorbs moisture readily,

and adheres to the tongue. When neither wet nor dry it is tough, and soon becomes hard with drought or soft with rain. On these accounts it is the most obdurate of all soils to manage, being, even in its best state, heavy to turn over with the plough, and difficult to pulverise with the other implements; and when wet, is in an unfit state to be wrought with any of the implements. A large number of horses is thus required to work a clay farm; and its workable state continues only for a short time, even in the best weather. But it is a powerful soil in its capability, bearing luxuriant crops, and producing them of an excellent quality. It generally occurs in deep masses, on a considerable extent of flat surface, exhibiting few undulations, along the margin of a large river or its estuary, and evidently being a deposition from deep water. It is a naturally fertile soil, containing little vegetable matter, and of a yellowish-grey colour.

Sandy Soil.—A pure *sandy* soil is also easily recognised. When wet it feels firm under foot, and then admits of being turned over by the plough with a pretty entire furrow. It feels harsh and grating to the touch, and will not compress into a ball with the hand. When dry it feels soft, and is so yielding that every object of weight sinks into it, and it is very apt to be blown away with the wind. Sandy soil generally occurs in deep masses, near the termination of the estuaries of large rivers, or along the sea-shore; and in some countries in the interior of Europe, and over a large proportion of Africa, it covers immense tracts of flat land, and has evidently been brought into its place by water.

Soil of Clay and Sand.—When clay is mixed with sand, its texture as a soil

¹ De la Beche's *Man. Geol.*, 35.

is very materially altered, and its productive powers are deteriorated. It is then called *till*. When such a clay is in a wet state, it still slips under the foot, and feels harsh rather than greasy. It does not easily ball in the hand. It retains water on its surface for a time. It renders water very muddy, and soils everything touching it. It has no lustre. When dry it feels hard; and when betwixt the state of wet and dry, is easily reduced to a fine tilth or mould. This kind of soil does not occur in deep masses, is rather shallow, in many instances is not far from the hard rock, nor is it naturally prolific. It occupies by far the larger portion of the surface of Scotland, much of the wheat being grown upon it, and may be characterised as a naturally poor soil, with but little vegetable matter, and of a yellowish-brown colour.

Loamy Soil.—When clay or sand is mixed with a considerable proportion of decomposed vegetable matter, naturally or artificially, the soil becomes a *loam*, the distinguishing character of which is derived from the predominating earth—clay loams and sandy loams. Loam, in modern phraseology, consists of any kind of earth containing a *sensible admixture of decomposed vegetable matter*,—a *sensible admixture* is mentioned, as there is no soil under cultivation, whether composed chiefly of clay or of sand, but contains some decomposed vegetable matter. Unless, therefore, the decomposed vegetable matter of the soil so preponderates as to greatly modify the usual properties of the constituent earths, the soil cannot in truth be called by any other name than a clayey or sandy soil; but when it does so prevail, a *clay loam* or a *sandy loam* is formed—a distinction well known to the farmer. Hence it is possible for husbandry to convert any earthy soil into a loam, as is clearly exemplified in the soil in the vicinity of large towns.

Clayey Loams.—A *clay loam* constitutes a useful and valuable soil. It yields the largest proportion of the finest wheat raised in this country, occupying a larger surface of the country than the carse clay. It forms a lump by the squeeze of the hand, but soon crumbles down again. It is easily wetted on the surface with rain, and then feels soft

and greasy; but the water is absorbed, and the surface soon becomes dry. It is easily wrought, and may be so any time after a day or two of dry weather. It becomes finely pulverised; is generally of some depth, forming an excellent soil for wheat, beans, swedes, and red clover; and is of a deep brown colour, often approaching to red.

All clay soils are better adapted to fibrous-rooted plants than to bulbs and tubers, such as wheat, the bean, red clover, and the oak, rather than turnips and potatoes. Its crops, bearing abundance of straw, require a deep hold of the soil. Clay soils are generally slow of bringing their crops to maturity, which in wet seasons they attain imperfectly; but in dry are usually strong, and of superior quantity and quality.

Gravelly Soil.—Sandy soils are divided into two varieties, which do not vary in kind but only in degree. Sand is a powder, consisting of small round particles of siliceous matter; but when these are of the size of a hazel-nut and larger—that is, gravel—they acquire the distinctive name of a *gravelly soil*, which, when mixed with a sensible proportion of vegetable matter, becomes gravelly loam. Gravelly deposits sometimes occupy a large extent of surface, and are of considerable depth. Such a soil never becomes wet, absorbing the rain as fast as it falls, and after rain feels somewhat firm under the foot. It can be easily wrought in any state of weather, and is not unpleasant to work, although the small stones with which it abounds render ploughing rather unsteady. This soil is admirably adapted to plants with bulbs and tubers; and no kind of soil affords so dry and comfortable a lair to sheep on turnips in winter, and on this account it is distinguished as "*turnip soil*."

Sandy Loams.—*Sandy* and *gravelly loams*, if not the most valuable, are the most useful of all soils. They become neither too wet nor too dry in ordinary seasons, and are capable of growing every species of crop, in every variety of season, to considerable perfection. On this account they are esteemed "*kindly soils*." They never occur in deep masses, nor do they extend over large tracts of land, being chiefly confined to the margins of

small rivers, forming haughs or holms, through which these rivers direct their course from amongst the mountains towards the larger rivers, or even to the sea.

Chalky Soils.—Besides these, there are soils which have for their basis another kind of earth—*lime*, of which the *chalky* soils of the south of England are examples. These differ in agricultural character according to the particular formation in which the chalk is situated. If the chalky soil is derived from flinty chalk, then its character is similar to that of a sandy soil; but if from the hard chalk formation, its character corresponds more nearly to that of clay.

Peaty Soils.—Writers on agriculture also enumerate a *peat* soil, derived from peat; but peat, as crude peat, does not promote vegetation, and when decomposed assumes the properties of *mould*, and should be regarded as such.

Any of the loams which have been long under cultivation, and enriched by putrescent manures, is converted into

mould, and forms a most valuable soil for every species of crop, as well in the field as in the garden.

Subsoil.—As the soil consists of that portion of the earth's surface which is turned over by the plough, so the ground immediately beneath the plough-furrow is the *subsoil*; and it may consist of the same earthy substance as the soil itself, or it may be of quite an opposite character, or it may consist of hard rock. The subsoil, whatever it may be composed of, exercising a sensible influence on the agriculture of the soil, is a subject of great interest to the farmer, and should be carefully studied by the agricultural student. An endeavour is made to illustrate the varieties by a figure of soils and subsoils. Let *a*, fig. 8, be the surface of the ground, the earthy mould derived from the growth and decay of natural plants; *b*, a dotted line, the depth of the plough-furrow. Now, the plough-sole may either just pass through the mould, *a*, when the mould will be the soil, and the earth below it, *b*, the

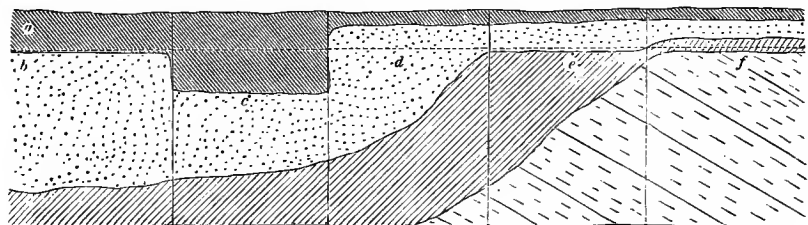


Fig. 8.—Sections of Soils and Subsoils.

subsoil; or it may not pass entirely through it, as at *c*, when the soil and subsoil will be both of mould; or it may pass through the earth below the mould, as at *d*, when the soil and subsoil will again be similar, while neither will be mould, but earth; or it may move along the surface of *e*, when the soil will be of one kind of earth, not entirely of mould, and the subsoil of another—of sand, gravel, or clay; or it may penetrate to *f*, when the soil will be of earth, a mixture of clay, sand, and mould, and the subsoil of hard rock. These different cases of soils and subsoils, each forming a distinct sectional division, may so occur in nature, though probably not all in the same locality.

Influence of Subsoil.—The subsoil

undoubtedly produces a sensible effect on the condition of the soil above it. If the soil is clay, it is impervious to water, and if the subsoil is clay also, it also is impervious to water. The immediate effect of this juxtaposition of retentiveness is to render both soil and subsoil continually wet, until evaporation dries first the soil and then the subsoil. A retentive subsoil, in like manner, renders even a porous soil above it wet. On the other hand, a gravelly subsoil, which is always porous, greatly assists to keep a retentive clay soil dry. When a porous soil rests upon a porous subsoil, scarcely any degree of humidity can injure either. Rock may be either a retentive or a porous subsoil, according to its structure—a massive

structure keeping the soil above it always wet; while a stratified one, with the stratification dipping downwards from the soil (as at *f*, fig. 8), will preserve even a retentive soil above it in a comparatively dry state.

Conditions of Soils.—These are the different *conditions of soils and subsoils*, considered practically. They have terms expressive of their state, which when spoken of the pupil should keep in remembrance.

Heavy Soil.—A soil is said to be *stiff* or *heavy* when it is difficult to be wrought with the ordinary implements of the farm; and all clay soils are so, and clay loams more or less so.

Light Soil.—On the other hand, soil is *light* or free when it is easy to work; and all sandy and gravelly soils and loams are so.

Dry and Wet Soils.—A soil is said to be *wet* when it is constantly wet; and to be *dry* when as constantly dry. All soils, especially clays, on retentive subsoils, are wet; and on porous subsoils, especially gravel and gravelly loams, dry.

Rich and Poor Soils.—Any soil that cannot bring to maturity a fair crop, without an inordinate quantity of manure, is considered *poor*; and any one that does so naturally, or yields a large return with a moderate quantity of manure, is said to be *rich*. As examples,—thin hard clays and ordinary sands are poor soils; and soft clays and deep loams are rich.

Deep and Thin Soils.—A soil is *deep* when it descends to a depth below the reach of the plough; and a soil is *thin* when the plough easily reaches beyond it; but good husbandry can, by deep digging, render a thin soil deep, and bad husbandry in shallow tillage may cause a deep soil to assume the character of a thin one. A deep soil conveys the idea of a good one, and a thin that of bad. Carse clays and sandy loams are instances of deep soils, and poor clays and poor gravel those of thin.

Hungry Soil.—A soil is said to be *hungry* when it requires frequent applications of manure to bear ordinary crops. A thin poor gravel is an instance of a hungry soil.

Grateful Soil.—A soil is *grateful*

when it returns a larger produce than might be expected from what was done for it. All loams, whether clayey, gravelly, or sandy—especially the last two—are grateful soils.

Kindly Soil.—A soil is *kindly* when every operation upon it can be done without doubt, and in the way and at the time desired. A sandy loam and a clay loam, when on porous subsoil, are examples of kindly soils.

Soil becoming Sick.—A soil becomes *sick* when the same crop is made to grow too frequently upon it; thus, soils become sick of growing red clover and turnips.

Sharp Soils.—A *sharp* soil is that which contains such a number of small gritty stones as to clear up the plough-irons quickly. Such a soil never fails to be porous, and is admirably adapted for turnips. A fine gravelly loam is an instance of a sharp soil. Some say that a sharp soil means a *ready* one—that is, quick or prepared to do anything required of it; but this opinion is not quite correct, because a sandy loam is a ready enough soil for any crop, and it cannot be called a sharp soil in any sense.

Deaf or Dead Soil.—A *deaf* soil is contrary to a sharp one—that is, it contains too much inert vegetable matter, in a soft spongy state, apt to be carried forward on the bosom of the plough. A deep black mould, whether derived from peat or plants, is often an example of a deaf soil.

Porous and Retentive Soil.—A *porous* or *open* soil and subsoil are those which allow water to pass through them freely and quickly, of which a gravelly loam and gravelly subsoil are eminent examples. A *retentive* or *close* soil and subsoil retain water on them; and a clay soil upon a clay subsoil is a double instance of retentiveness.

Hard and Soft Soils.—Some soils are always *hard* when dry, let them be ever so well wrought, as in the case of thin retentive clays. Other soils are *soft*, as fine sandy loams, which are very apt to become too soft when too often ploughed or too much shell-marled.

Fine and Coarse Soils.—Some soils are always *fine*, as is the case with deep easy sandy loams. Other soils are always *coarse* and *harsh*, as thin poor clays

and gravels. A fine clay becomes *smooth* when in a wet state. A thin clayey gravel is *rough* when dry.

Soil with Fine Skin.—A soil has a *fine skin* when it can be finished off with a beautifully granulated surface. Good culture will bring a fine skin on many soils, and rich sandy and clay loams are naturally so; but no art can give a fine skin to some soils, such as thin hard clay and rough gravel.

Black Soils.—The *colours* of soils and subsoils, though various, are limited in their range. *Black* soils are found on crude peat, and in deep deaf vegetable mould, the carbon of vegetable matter evidently giving origin to the colour. Soils of other colours may be made blacker by the addition of soot, charcoal, and of composts of peat. Oxide of manganese naturally gives a black colour to soils. Very black soils are deaf and inert.

White Soils.—*White* soil is met with in the chalky districts of the south of England. Many sandy soils forming tracts of country, as well as near the sea-shore, are of a yellow-white colour; and so are calcareous sands formed in a great measure of the comminuted shells of crustaceous animals. White soils assume a tinge of brown by the addition of vegetable matter in cultivation. Greyish-white stones and sand indicate the moory origin of the soil in which they occur. Some strong clays are light brownish yellow.

Blue Clay.—Fine clay, originating in the bottom of basins of still water, has frequently a *blue* colour, which changes to dark brown or brownish-black on cultivation and exposure to the air, and forms a useful soil for wheat, swedes, and mangel-wurzel.

Red Soils.—Soils are not unfrequently of a *red* colour, derived most probably from an oxide of iron; and this colour is a favourable indication of the good quality of the soil or subsoil, whether of a heavy or light texture. In East Lothian and the cider district of Herefordshire, examples of red soil may be found.

Brown Soils.—But the most common colour presented by soils is *brown*, and the tint most desired is the brown of the hazel-nut, and on that account is

named a hazel soil. This colour is most probably derived from oxide of iron existing in the soil, and is rendered darker by the addition of vegetable manure, used in cultivation, to hair and dark chestnut brown. Sharp, grateful, and kindly soils are always of a brown colour. Sand and gravel loams are usually of this colour.

Colour of Subsoils.—The *colour* of *subsoils* is less uniform than that of soils, owing, no doubt, to their exclusion from direct culture and air. Some subsoils are very particoloured, and the more so, and the brighter the colours they sport, are the more injurious to the soils resting upon them—such as light blue, green, bright red, bright yellow, and white. Dull red and chestnut brown subsoils are good; but the nearer they approach to hazel brown the better. Dull browns, reds, and yellowish greys are permanent colours, and are little altered by cultivation; but blues, greens, bright reds, and yellows, become darker and duller by exposure to the air, and admixture with manures and the surface soil.

Influence of Colour in Soils.—The colours of soil have a considerable influence in regulating the quantities of heat absorbed by soils from the sun's rays. The darker-coloured, such as black, brown, and dark reds, absorb more heat than greys and yellows; and all dark-coloured soils reflect least, whilst light-coloured most rays of light. According to Schübler, while the thermometer was 77° in the shade in August, sand of a natural colour indicated a temperature of 112½°, black sand, 123½°, and white sand 110°, exhibiting a difference of 13° in favour of the black colour. The highest temperature attained by the soil was observed by Schübler on 16th June 1828, in a fine day, calm, with the air from the west, at 153½° in the sun, that in the shade being 78°.

Colour has also an influence in *retaining heat* acquired by soils from the sun, dark-coloured radiating their heat more quickly in the absence of the sun's rays than light-coloured; and colour, together with dryness, has a greater influence in warming the soil than that of the various materials composing it. Thus sand will cool more slowly than

clay, and clay than a soil containing much humus. According to Schübler, a peat soil will cool as much in 1 hour 43 minutes as a pure clay in 2 hours 10 minutes, and as a sand in 3 hours 30 minutes. The practical effect of this difference is, that while the sand will retain its heat for three hours after the sun has gone down, and the clay two hours, the vegetable soil will only retain it for one hour; but then the vegetable soil will all the sooner begin to absorb the dew that falls, and in a dry season it may in consequence sustain its crops in a healthy state of vegetation, while those in the sandy soil may be languishing for want of moisture.

Temperature of Soils.—It is a fact well known to farmers, that the soil becomes much more heated when exposed to the rays of the sun in a perpendicular than in a sloping direction. "If the actual increase of temperature," says Schübler, "produced by the perpendicular rays of the sun beyond the temperature in the shade be between 45° and 63° , as is often the case in clear summer days, this increase would only be half as great if the same light spread itself in a more slanting direction, over a surface twice as large. Hence it is sufficiently explained why, even in our own climate, the heat so frequently increases on the slopes of mountains and rocks which have an inclination towards the south. When the sun is at an elevation of 60° above the horizon, as is more or less the case toward noon in the middle of summer, the sun's rays fall on the slopes of mountains, which are raised to an inclination of 30° to the horizon, at a right angle; but even in the latter months of summer the sun's rays frequently fall on them at a right angle, in cases where the slopes are yet sharper." Where the exposure and aspect of the soil are most favourably situated for absorbing the sun's rays, the light-coloured will derive more benefit than the dark in a less favourable position.

If we compare in the earths their power of retaining heat with their other physical properties, we shall find it to be nearly in proportion to their specific gravities. We may therefore conclude from this, with a tolerable degree of

probability, as to the greater or less power of retaining heat.

Heat in Soils.—Heat renders all sorts of soil dry by evaporating the moisture out of them; and so great an effect has heat on peat and strong clay in a course of dry weather, that they *shrink* one-fifth of their bulk. Thus, according to Schübler, in 100 parts the following soils shrank in these proportions:—

Siliceous sand . . .	no change.
Sandy clay . . .	6.0 parts.
Loamy clay . . .	8.9 "
Brick clay . . .	11.4 "
Grey pure clay . . .	18.3 "
Garden mould . . .	14.9 "
Arable soil . . .	12.0 "
Humus . . .	20.0 "

The consistency of a soil, and its tendency to shrink, exert a greater influence in deep than shallow soils.

Heat in Soils influenced by Moisture.—The influence of a damp or dry state of soils, on their acquisition of *warmth*, is also considerable. As long as they remain moist, the depression of temperature, arising from evaporation of water, amounts to $11\frac{1}{4}^{\circ}$ to $13\frac{1}{2}^{\circ}$ Fahrenheit; and in this state they exhibit but little difference in the power of acquiring heat, as they give off to the air, in this state of saturation with water, nearly equal quantities of vapour in the same time. When they have become a little dried, it is found that light-coloured earths, with great powers of containing water, acquire heat most slowly; while dark-coloured, with less power of containing water, become warm quicker and hotter.

Absorbing Power of Soils.—Excepting siliceous sand, all kinds of soil have the property of *absorbing moisture* from the atmosphere; and the absorption is greatest in clay soils, especially when they contain humus. Humus shows the greatest power of absorption. The absorption by all soils is greatest at first, and they absorb less the more gradually they become saturated with moisture, and attain that point in a few days. If exposed to the sunlight, a portion of the absorbed moisture becomes again vaporised, and this is again absorbed during the night. These daily periodic changes in respect to moisture

must have a beneficial effect on vegetation. Schübler has given the following table of the relative absorbing powers of soils:—

Kinds of earth.	1000 grains of earth on a surface of 50 square inches absorbed in			
	12 hours.	24 hours.	48 hours.	72 hours.
Siliceous sand	0	0	0	0
Sandy clay	21	26	28	28
Loamy clay	25	30	34	32
Brick clay	30	36	40	41
Grey pure clay	37	42	48	49
Garden mould	35	45	50	52
Arable soil	16	22	23	23
Humus	80	97	110	120

Soils' Capacity for containing Water.—Different soils have different capacities for containing *water to saturation*. Schübler gives this table of differences:—

	Per cubic foot. lb.
Siliceous sand	27.3
Sandy clay	38.8
Loamy clay	41.4
Brick clay	45.4
Pure grey clay	48.3
Garden mould	48.4
Arable soil	40.8
Humus	50.1

Sands have the smallest power of containing water, whether compared in weight or volume with other earths; and siliceous sand has the least power of all. These differ according to the different fineness of their grains; the power of the large-grained becomes diminished down to 20 per cent, while it amounts to 40 per cent when the particles are very fine. Humus has usually the greatest power of containing water to saturation of all ingredients of soil, and especially when the humic acid is still mixed with a large proportion of half-decomposed organic matters, as remains of wood, leaves, roots, &c. Where we meet with water-holding power exceeding 90, we may reckon on an abundant admixture of organic matter.

Retentive Power of Soils.—So, in like manner, different soils have different powers of *retaining the moisture* they have absorbed to saturation until they become dry, and this power increases

with the depth of soils. Schübler has given this table on the subject:—

Kinds of earth.	Water evaporated in 4 days.	Containing power of water of the earths.
	Grains.	Per cent.
Calcareous sand	146	29
Light garden mould	143	89
Very light turf soil	132	366
Black turf soil not so light	128	179
Arable soil	131	60
White fine clay	123	70
Grey fine clay	123	87

Hence the difference in degree of looseness or consistency of the ground has a considerable influence on drying deep soils. Garden mould, notwithstanding its great power of containing water, in which it stands near to pure clay (292), gave off to the air far more moisture, in the same time, than clay. Turf soils, though high in containing water, also became dry again at a quicker rate than clay. Fine grey clays, after 14 days, exhibited still a damp surface, while the surfaces of turf soils were perfectly dry many days earlier.

Soils absorbing Oxygen from the Air.—Another important physical property of soils is their power to *absorb oxygen* from the atmospheric air. Schübler's experiments on this subject afforded these results:—

Grains.	Cubic inches.
1000 Siliceous sand, in a wet state, absorbed	0.24
" Sandy clay	1.39
" Loamy clay	1.65
" Brick clay	2.04
" Grey pure clay	2.29
" Garden mould	2.60
" Arable soil	2.43
" Humus	3.04

From 15 cubic inches of atmospheric air containing 21 per cent of oxygen.

All earths lose, in drying, the property of absorbing oxygen from the air, but regain it in the same proportion as before on being moistened. If covered with water, the absorption takes place in the same manner. Water alone, however, in the same quantity, absorbs only a small portion per cent—a clear proof that it is the earths themselves which induce this process in a greater proportion.

Humus, of all the earths, exhibits the greatest degree of absorption of oxygen; the clays approach nearly to it, the sands the least. The included air standing over it becomes at last so poor in oxygen that lights would become extinguished and animals die in it. In this mode of absorption there is an essential difference between humus and the inorganic earths. Humus combines partly with the oxygen, in a strictly chemical sense, and assumes a state of higher oxygenation, in consequence of which there is formed also more carbonic acid.

The inorganic earths, on the other hand, absorb the oxygen without intimate combination.

In the case of earths which are frozen or covered with a surface of ice, no absorption of oxygen takes place, any more than in the case of dry earths.

In a moderately warm temperature, between 59° and 66° Fahrenheit, the earths absorb, in a given time, more oxygen than in a temperature only a few degrees above the freezing-point.

Physical Properties of Soils.—M. Schübler thus recapitulates the *physical properties* of soils: "The more an earth weighs, the greater also is its power of retaining heat; the darker its colour and the smaller its power of containing water, the more quickly and strongly will it be heated by the sun's rays; the greater its power of containing water, the more has it in general the power also of absorbing moisture when in a dry, and oxygen when in a damp state, from the atmosphere, and the slower it usually is to become dry, especially when endued with a high degree of consistency; lastly, the greater the power of containing water, and the greater the consistency of a soil, the colder and wetter, of course, will that soil be, as well as the stiffer to work, either in a wet or dry state."¹ The physical changes effected in soils by the atmosphere are:—

Pulverisation and expansion after frost.

Caking after rain.

Compression when filled with moisture.

Cracking in drought.

DISCRIMINATING SOILS BY THE PLANTS THEY PRODUCE.

There is another method by which the physical characters of soils and subsoils, such as have been explained, may be discriminated—namely, by the *plants which grow upon them*. This test, however, cannot be relied on so confidently as the chemical composition, or the external characters given above, for distinguishing soils.

Notwithstanding the difficulties attending the discrimination of soils by plants, it is an undoubted fact that plants do affect certain soils, as also certain conditions of the same soil. Such plants are limited in number, and may therefore be easily remembered. Only such as have come under our own observation need be enumerated—separating those which grow upon the soil, in a state of nature, from those which make their appearance after the land is in cultivation.

Weeds.—Every plant—other than that which it is intended to grow—found among cultivated corn, green crops, and sown grasses, is a *weed*.

On good *clay* soils, in a state of nature, in the low country, these herbaceous plants will be found—

<i>Spiraea Ulmaria</i> . . .	Queen of the meadow.
<i>Angelica sylvestris</i> . . .	Wild angelica.
<i>Ranunculus Lingua</i> . . .	Great spearwort.
<i>Rumex Acetosa</i> . . .	Common sorrel.

After such soils are in cultivation, these *weeds* appear, which have been sown either with corn, grass seeds, or carried by the wind, or amongst the dung—

<i>Rumex obtusifolius</i> . . .	Common broad-leaved dock.
<i>Senecio vulgaris</i> . . .	Groundsel.
<i>Lapsana communis</i> . . .	Nipple-wort.
<i>Agrostemma Githago</i> . . .	Corn-cockle or popple.
<i>Matricaria Chamomilla</i> . . .	Wild chamomile.
<i>Sonchus oleraceus</i> . . .	Common sow-thistle.

Thin clays, in their natural state in the low country, yield the following plants—

<i>Ranunculus acris</i> . . .	Bitter crowfoot, butter-cup.
<i>Aira cespitosa</i> . . .	Tufted hair-grass.
<i>Equisetum arvense</i> . . .	Corn horse-tail.
<i>Stachys palustris</i> . . .	Marsh woundwort.

Thin clays become clay loams under cultivation, and then yield these *weeds*—

<i>Tussilago Farfara</i> . . .	Common colt's-foot.
<i>Sinapis arvensis</i> . . .	Wild mustard, charlock.
<i>Polygonum Aviculare</i> . . .	Knot-grass.

¹ Jour. Roy. Agric. Soc. Eng., i. 177-212.

On deep strong clayey loam, on a porous subsoil, in a state of nature, in the low country, these plants are found—

<i>Silene inflata</i> . . .	Bladder campion.
<i>Linaria vulgaris</i> . . .	Toad-flax.
<i>Scabiosa arvensis</i> . . .	Field scabious.
<i>Centaurea Scabiosa</i> . . .	Great knapweed.
<i>Polygonum amphibium</i> . . .	Redshank.
<i>Dactylis glomerata</i> . . .	Rough cock's-foot grass.

On thin strong clayey loam, on a porous subsoil, in a state of nature, in the low country, these plants are found—

<i>Ononis arvensis</i> . . .	Common rest-barrow.
<i>Trifolium arvense</i> . . .	Hare's-foot trefoil.
<i>— procumbens</i> . . .	Hop trefoil.

After cultivation, both deep and thin clay loams, on a porous subsoil, in the low country, yield these weeds—

<i>Anagallis arvensis</i> . . .	Scarlet pimpernel.
<i>Veronica hederifolia</i> . . .	Ivy-leaved speedwell.
<i>Sinapis nigra</i> . . .	Black mustard.
<i>Vicia hirsuta</i> . . .	Hairy tare, or fetter.

Plants peculiar to sandy soils, in a state of nature, in the low country are—

<i>Lotus corniculatus</i> . . .	Bird's-foot trefoil.
<i>Campanula rotundifolia</i> . . .	Common bluebell.
<i>Euphrasia officinalis</i> . . .	Eye-bright.
<i>Anthoxanthum odoratum</i> . . .	Sweet-scented vernal grass.

After cultivation, these weeds appear—

<i>Spergula arvensis</i> . . .	Common spurry.
<i>Lamium purpureum</i> . . .	Purple dead-nettle.
<i>Fumaria officinalis</i> . . .	Common fumitory.
<i>Capsella bursa-pastoris</i> . . .	Shepherd's-purse.
<i>Scleranthus annuus</i> . . .	Common knawel.
<i>Gnaphalium germanicum</i> . . .	Common cudweed.
<i>Triticum repens</i> . . .	Common couch-grass.

Upon sandy loam on clay subsoil, in a state of nature, in the low country, are these plants—

<i>Juncus effusus</i> . . .	Common or soft rush.
<i>Achillea Ptarmica</i> . . .	Sneezewort.
<i>Potentilla anserina</i> . . .	Goose-tongue or silver-weed.
<i>Artemisia vulgaris</i> . . .	Mugwort.

After cultivation, these weeds appear—

<i>Raphanus raphanistrum</i> . . .	Wild radish or "runch."
<i>Rumex Acetosella</i> . . .	Sheep's sorrel.
<i>Chrysanthemum segetum</i> . . .	Corn marigold.
<i>Juncus bufonius</i> . . .	Toad-rush.

Sandy loam, upon a porous subsoil, in a state of nature, in the low country, yields these plants—

<i>Cytisus scoparius</i> . . .	Common broom.
<i>Centaurea nigra</i> . . .	Black knapweed.
<i>Galium verum</i> . . .	Yellow bed-straw.
<i>Senecio Jacobææ</i> . . .	Common ragweed.

When cultivated, the soil yields these weeds—

<i>Mentha arvensis</i> . . .	Common corn-mint.
<i>Centaurea Cyanus</i> . . .	Corn blue-bottle.
<i>Sherardia arvensis</i> . . .	Field madder.
<i>Lithospermum arvense</i> . . .	Corn groomwell.
<i>Alchemilla arvensis</i> . . .	Parsley-pier.
<i>Avena elatior</i> . . .	Tall oat-grass.
<i>Cnicus arvensis</i> . . .	Corn-thistle.

Alluvial deposits, in a state of nature, in the low country, yield a vegetation indicative of wet clay soil and subsoil—

<i>Arundo Phragmites</i> . . .	Common reed.
<i>Juncus conglomeratus</i> . . .	Round-headed rush.
<i>Agrostis alba</i> . . .	Marsh bent-grass.
<i>Glyceria aquatica</i> . . .	Reed meadow-grass.
<i>— fluitans</i> . . .	Floating meadow-grass.

These plants disappear on cultivation, except the common reed, which keeps possession of the soil for an indefinite time amidst the best cultivation. Where such soil is indifferently cultivated, the corn-thistle, *Cnicus arvensis*, is a very troublesome weed.

Besides these soils, there are others in the low country which cannot be rendered arable, but form the sites of numerous plants, which find their way into the adjoining arable soils. From the sea-beach, gravel-pits, and sandy downs, plants stray by the assistance of the wind upon any kind of arable soil in their respective neighbourhoods.

On gravel, as found in the *débris* of mountains, occasioned by the disintegration of indurated rocks, the vegetation is different from that of the beaches, and is the same as the alpine plants of the district. In gravel in the low country these plants are found—

<i>Polygonum Aviculare</i> . . .	Knot-grass.
<i>Rumex Acetosella</i> . . .	Sheep's sorrel.
<i>Agrostis vulgaris</i> . . .	Common bent-grass.
<i>Aira caryophyllæ</i> . . .	Silver hair-grass.
<i>Festuca durtuscula</i> . . .	Hard fescue-grass.
<i>Arenaria serpyllifolia</i> . . .	Thyme-leaved sandwort.
<i>Hieracium murorum</i> . . .	Wall hawkweed.
<i>Papaver dubium</i> . . .	Long smooth-headed poppy.
<i>— Rhæas</i> . . .	Common scarlet poppy.
<i>Polygonum Convolvulus</i> . . .	Climbing buckwheat.
<i>Cheopodium urticum</i> . . .	Upright goose-foot.
<i>Lolium perenne</i> . . .	Perennial ryegrass.
<i>Bromus mollis</i> . . .	Soft brome-grass.

Gravel on the sides of rivers producing these plants, indicates a wet subsoil—

<i>Juncus bufonius</i> . . .	Toad-rush.
<i>— acutiflorus</i> . . .	Sharp-flowered rush.
<i>Littorella lacustris</i> . . .	Plantain shore-weed.

Drifting sands, links, or downs, have this peculiar vegetation—

<i>Elymus arenarius</i> . . .	Sea lyme-grass.
<i>Triticum junceum</i> . . .	Sand wheat-grass.
<i>Festuca duriuscula</i> . . .	Hard fescue-grass.
<i>Carex arenaria</i> . . .	Sand carex.
<i>Galium verum</i> . . .	Yellow bed-straw.

The vegetation of *moory ground* only a little elevated, varies according to the wetness or dryness of the subsoil. Wet moors are characterised by these plants—

<i>Salix repens</i> . . .	Dwarf silky willow.
<i>Pinguicula vulgaris</i> . . .	Butterwort.
<i>Carex pitulifera</i> . . .	Round-fruited carex.
<i>Juncus squarrosus</i> . . .	Moss-rush.
<i>Parnassia palustris</i> . . .	Grass of Parnassus.

On dry moors, containing a proportion of peat-earth, and resting on a porous subsoil, these plants are found—

<i>Genista anglica</i> . . .	Needle green-weed.
<i>Nardus stricta</i> . . .	Mat-grass.
<i>Viola lutea</i> . . .	Yellow mountain-violet.
<i>Potentilla tormentilla</i> . . .	Common tormentil.
<i>Gnaphalium dioicum</i> . . .	Mountain cudweed.

Marshes in the interior of the country produce these plants—

<i>Lychnis Flos-cuculi</i> . . .	Ragged robbin.
<i>Menyanthes trifoliata</i> . . .	Fringed buck-bean.
<i>Caltha palustris</i> . . .	Marsh marigold.
<i>Veronica Beccabunga</i> . . .	Brook-lime.
<i>Comarum palustre</i> . . .	Marsh cinquefoil.
<i>Galium uliginosum</i> . . .	Marsh bed-straw.

After marshy ground has been cultivated, these *weeds* retain a strong hold—

<i>Tussilago Farfara</i> . . .	Common colt's-foot.
<i>Petasites vulgaris</i> . . .	Common butter-bur.
<i>Galium Aparine</i> . . .	Goose-grass.

On *peat* or *moss* the vegetation differs as it is wet or dry. On dry spots these plants are found—

<i>Erica tetralix</i> . . .	Cross-leaved heath.
<i>Calluna vulgaris</i> . . .	Common ling.
<i>Agrostis canina</i> . . .	Dog bent-grass.

In wet hollows in peat these plants establish themselves—

<i>Eriophorum polystachion</i> . . .	Cotton-grass or sedge.
<i>Vaccinium Oxyccocos</i> . . .	Cranberry.

Cultivated peat is infested with these *weeds*—

<i>Bromus mollis</i> . . .	Soft brome-grass.
<i>Myosotis arvensis</i> . . .	Field scorpion-grass.
<i>Avena fatua</i> . . .	Wild oats.
<i>Galium Aparine</i> . . .	Goose-grass.

On *mountain pastures* plants are numerous. At moderate heights these prevail—

<i>Calluna vulgaris</i> . . .	Common ling.
<i>Dryas octopetala</i> . . .	Mountain avens.
<i>Salix reticulata</i> . . .	Reticulated willow.
<i>Gnaphalium alpinum</i> . . .	Mountain cudweed.
<i>Rubus Chamæmorus</i> . . .	Cloud-berry.
<i>Arbutus Uva-ursi</i> . . .	Common bear-berry. ¹

In very elevated mountain pastures these plants are found on peaty soil—

<i>Calluna vulgaris</i> . . .	Common ling.
<i>Empetrum nigrum</i> . . .	Crowberry.
<i>Erica tetralix</i> . . .	Cross-leaved heath.
<i>Lycopodium clavatum</i> } . . .	Club-moss.
<i>alpinum</i> } . . .	
<i>Juncus squarrosus</i> . . .	Moss-rush.
<i>Equisetum palustre</i> . . .	Paddock-pipe.
<i>Scirpus cæspitosus</i> . . .	Deer-hair.
<i>Narthecium ossifragum</i> . . .	Bog asphodel.
<i>Melica carulea</i> } . . .	{ Fly-bent, rot-grass, or
<i>Seteria carulea</i> } . . .	{ blue moor-grass.
<i>Nardus stricta</i> . . .	Wire-bent or mat-grass.

In wet mossy places these thrive—

<i>Juncus effusus</i> . . .	Soft rush.
<i>Holcus lanatus</i> . . .	Yorkshire fog.
<i>Carex cæspitosa</i> . . .	Risp.
<i>Juncus acutiflorus</i> . . .	Sprat.
<i>Carex panicea</i> . . .	Fry.
<i>Scabiosa succisa</i> . . .	Devil's-bit scabious.
<i>Hypnum palustre</i> . . .	Marsh-fog. ²

Professor Macgillivray truly remarked, that "no soil that we have examined has been found to produce plants peculiar to itself, excepting *sand* and *peat*; and these two soils, so different from each other in their mechanical and chemical nature, also form a striking contrast in respect to the plants growing upon them, each being characterised by a vegetation differing in aspect and qualities from each other, and scarcely agreeing in any one circumstance." The existence of peat is invariably indicated by *Calluna vulgaris*, common ling,—*Erica cinerea*, fine-leaved heath,—and *Erica tetralix*, cross-leaved heath; and loose sand is as invariably covered with *Psamma arenaria*, sand-reed, most frequently accompanied by *Triticum junceum*, sand wheat-grass, and *Galium verum*, yellow bed-straw.

In as far, then, as the arable soils are concerned, the information imparted by their *weeds* possesses greater interest to the farmer than their natural vegetation; and they give a truer account of the state of the soils at the time than of their nature, although this even is not overlooked. For example, *clayey* soils are indicated by the existence of the *grasses*, and of these the genera of *Poa*, *Agrostis*, and *Festuca* prevail.

Gravelly soils are indicated by *Aira caryophyllea*, silvery hair-grass; *Aira præcox*, early hair-grass; and *Rumex Acetosella*, sheep's sorrel. When intermixed with a little clay, the grasses also appear.

¹ *Trans. High. Agric. Soc.*, vii. 123.
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² *Ibid.*, vii. 281.

Good *vegetable* soil is indicated by *Trifolia*, *Vicia*, and *Lathyrus pratensis*. *Thymus Serpyllum*, wild thyme, indicates a thin vegetable mould; and ragweed, *Senecio Jacobææ*, one of depth. Where ragweed prevails, sheep are absent, as they fondly eat down its young leaves.

Purge-flax, *Linum catharticum*; autumn hawkbit, *Leontodon autumnalis*; and mouse-eared hawk-weed, *Hieracium pilosella*, indicate a dry soil;—the *Galium verum*, yellow bed-straw, one very dry.

Yellow iris, *Iris pseud-acorus*; the sharp-flowered rush, *Juncus acutiflorus*; lady's smock or cuckoo-flower, *Cardamine pratensis*; and ragged robin, *Lychnis Flos-cuculi*; the purple dead-nettle, *Lamium purpureum*; and smooth naked horse-tail, *Equisetum limosum*, assure us of a supply of moisture below.

The broom, *Cytisus scoparius*, indicates a pernicious, and the whin, furze, or gorse, *Ulex europæus*, a favourable sub-soil.

The common nettle, *Urtica dioica*; common dock, *Rumex obtusifolius*; mugwort, *Artemisia vulgaris*; annual poa, *Poa annua*; field poa, *Poa pratensis*; and common tansy, *Tanacetum vulgare*, grow near the dwellings of man; while white clover, *Trifolium repens*; red clover, *Trifolium pratense*; annual poa, *Poa annua*; hoary plantain, *Plantago media*; ribwort or ribgrass, *Plantago lanceolata*; purple meadow-vetch, *Vicia Cracca*; and common daisy, *Bellis perennis*, are found in the pasture around his house.

Common chickweed, *Stellaria media*; and common fumitory, *Fumaria officinalis*, indicate a rich condition of soil.

The great ox-eye, *Chrysanthemum Leucanthemum*, points out a soil in a state of poverty; and its poverty from want of manure is indicated by the parsley-pest, *Alchemilla arvensis*.

Wild mustard or charlock, *Sinapis arvensis*, tells of manure having been derived from towns.

The common corn-thistle, *Cnicus arvensis*, is a tell-tale that the land is not well farmed.

Wherever there is the least admixture of peat, the *Erica* or *Calluna* and spotted-bearded orchis, *Orchis maculata*, are sure to be there.

General View of the Relation of Plants to Soils.—Taking a more extended view of the indications of the condition of soils by plants, the observations of Dr Singer are graphic: "*Green* mountains, like those of Cheviot and Ettric Forest, abounding in grass without heath, indicate a strong soil, which is rendered productive, though frequently steep and elevated, by a retentive sub-soil. This quality, and the frequent mists and showers that visit rather elevated sheep-walks, render them productive in strong grasses (*Agrostis*). . . . *Dark* mountains, clothed with a mixture of heath and grass, indicate a drier soil on a less retentive bottom. Such are many of the Highland mountains, and such also are some of those which appear occasionally among the green mountains of the southern pastoral district, in which the light soil is incumbent commonly on gravel or porous rock. On these dark-coloured mountains, a green and *grassy* part often appears where there is no heath, and the subsoil is retentive; and if the upper edge of such a spot appears well defined, this is occasioned by the regular approach of a stratum of clay or other substance impervious to water towards the surface, and the green hue disappears below, when the subsoil again becomes open. . . . On any of the mountains, whether dark or green, when the fern or bracken, *Pteris aquilina*, appears in quantities, it indicates a deep soil and a dry subsoil."¹

A stunted growth of heath indicates a part having been bared by the paringspade; and when vegetation becomes of a brown colour in summer, the subjacent rock is only a little way under the surface.

Viewing the connection of plants to the soil on the great scale, one cannot but be forcibly impressed with the conviction that "the grand principle of vegetation is simple in its design; but view it in detail, and its complication astonishes and bewilders." And yet, as Professor Macgillivray justly observed, "it is the same sun that calls forth, and, thus elicited, gives vigour to the vegetation, the same earth that supports it, the

¹ *Trans. High. Agric. Soc.*, vii. 264.

same moisture that swells its vessels, the same air that furnishes the medium in which it lives; but amid all these systems of general, how multiple the variations of particular constituent causes, and how infinitely diversified the results!"

Agricultural Botany.—The relation of the study of plants to agriculture is this: "It is a fact familiarly known to all, in addition to those circumstances by which we can perceive the special functions of any one organ to be modified, there are many by which the entire economy of the plant is materially and simultaneously affected. On this fact the practice of agriculture is founded, and the various processes adopted by the practical farmer are only so many modes by which he hopes to influence and promote the growth of the whole plant, and the discharge of the functions of all its parts. Though the manures in the soil act immediately through the roots, they stimulate the growth of the entire plant; and though the application of a top-dressing to a crop of young corn or grass may be supposed first to affect the leaf, yet the beneficial result of the experiment depends upon the influence

which the application may exercise on any part of the vegetable tissue."¹

Distribution of Plants.—A knowledge of the geographical distribution of plants is a subject of interest to the farmer, as it may be useful by affording him the means of judging whether new plants, recommended for cultivation in this country, will be suitable to the soil of his own farm situate in a certain latitude and elevation above the sea.

"It is the influence of temperature which is the chief cause of the distribution of plants, and on this account the face of the globe has been divided into eight zones, called the isothermal zones, each of which is distinguished by a peculiar vegetation."

"As the physiognomy of the vegetable kingdom is characterised by certain plants in the different latitudinal zones from the equator to the poles, so also, in a perpendicular direction, in the mountain regions which correspond with the zones. Proceeding with the vegetation of the equatorial zone, we follow the series of vegetable regions in ascending lines, one after the other, and may compare them with the different zones as follows:—

1.	The region of palms and bananas—equatorial zone—equator to lat. 15°—from max. temp. to 78°.	lat. 15° to lat. 25°—mean temp. from 78° to 73°.
2.	" " trees, ferns, and figs—tropical zone	" 25° " 34° " " 73° " 62°.
3.	" " myrtles and laurels—sub-tropical zone	" 34° " 45° " " 62° " 53°.
4.	" " evergreens—warm temperate zone	" 45° " 58° " " 53° " 42°.
5.	" " European trees—cold temperate zone	" 58° " 67° " " 42° " 39°.
6.	" " pines—sub-arctic zone	" 67° " 72° " " 39° " 28°.
7.	" " rhododendrons—arctic zone	" 72° " 90° " " 28° " 1°."
8.	" " alpine plants—polar zone	

which *directly* exerts any influence upon vegetation.

STRUCTURE AND COMPOSITION OF SOILS.

It is time to take a closer view of soils, their structure and composition. The structure is mechanical, the composition chemical. Their *mechanical structure* is thus described by Dr Henry Madden: "Soil, considered scientifically, may be described to be essentially a mixture of an impalpable powder with a greater or smaller quantity of visible particles of all sizes and shapes. Careful examination will prove to us, that although the visible particles have several *indirect* effects, of so great importance that they are absolutely necessary to soil, still the impalpable powder is the only portion

Inorganic and Organic Matter in Soils.—This impalpable powder consists of two distinct classes of substances—viz., *inorganic* or *mineral* matters, and *organic*, *animal*, and *vegetable* substances, in all the various stages of decomposition. The greater the proportion of the impalpable matter, the greater, *ceteris paribus*, will be the fertility of the soil.

Stones afford renewed Supplies of Mineral Matter.—"The *stones* which we meet with in soil have in general the same composition as the soil itself, and hence, by gradually crumbling down under the action of air and moisture,

¹ Johnston's *Lec. Agric. Chem.*, 2d ed., 159.

² Johnston's *Phys. Atl.*—"Bot. Geog."

they are continually adding new impalpable matter to the soil, and as a large quantity of this impalpable mineral matter is annually removed by the crops, it will at once be perceived that this constant addition must be of great value to the soil. This, therefore, is one important function performed by the stones of the soil—viz., their affording a continually renewed supply of impalpable mineral matter.”

Capillary Action of Soils.—On one important character of the mechanical property of soil—its capillary power and mode of action—Professor Johnston observed: “When warm weather comes, and the surface soil dries rapidly, then by capillary action the water rises from beneath, bringing with it the soluble substances that exist in the subsoil through which it ascends, for water is never pure. Successive portions of the water evaporate from the surface, leaving their saline matter behind them. And as the ascent and evaporation go on as long as the dry weather continues, the saline matter accumulates about the roots of plants, so as to put within their reach an ample supply of any soluble substance which is really not defective in the soil. I believe that in sandy soils, and generally in all light soils, of which the particles are very fine, this capillary action is of great importance, and is intimately connected with their power of producing remunerating crops. They absorb the falling rains with great rapidity, and these carry down the soluble matters as they descend, so that when the soil becomes soaked, and the water begins to flow over its surface, the saline matter, being already deep, is in little danger of being washed away. On the return of dry weather, the water reascends from beneath, and again diffuses the soluble ingredients through the upper soil.”¹

Chemical Composition of Soils.—“Hitherto,” Dr Madden continues, “I have pointed out merely the mechanical relations of the various constituents of soil, with but little reference to their *chemical* constitution: this branch of the subject, although by far the most important and interesting, is nevertheless

so difficult and complex that I cannot hope for the practical farmer doing much more than making himself familiar with the *names* of the various chemical ingredients, learning their relative value as respects the fertility of the soil, and acquiring a knowledge of the quantities of each requisite to be applied to particular crops; for as to his attempting to prove their existence in his own soil by analysis, I fear that it is far too difficult a subject for him to grapple with, unless regularly educated as an analytical chemist.

Twelve Substances in Soils.—“Soil, to be useful to the British agriculturist, must contain no less than 12 different chemical substances—viz., silica, alumina, oxide of iron, oxide of manganese, lime, magnesia, potash, soda, phosphoric acid, sulphuric acid, chlorine, and organic matter. I shall confine my observations solely to their relative importance to plants, and their amount in the soil.

Silica in Soils.—“*Silica* is the pure matter of sand, and also constitutes on an average about 69 per cent of the various clays, so that in soil it generally amounts to from 75 to 95 per cent. In its uncombined state, it has no *direct* influence upon plants, beyond its mechanical action, in supporting the roots, &c.; but as it possesses the properties of an acid, it unites with various alkaline matters in the soil, and produces compounds which are required in greater or less quantity by every plant. The chief of these are the *silicates of potash and soda*, by which expression is meant the compounds of silica, or, more properly, silicic acid with the alkalies potash and soda.

Alumina in Soils.—“*Alumina* exists pure in soil. It is the characteristic ingredient of clay, although it exists in that compound to the extent of only 30 or 40 per cent. It exerts no *direct chemical* influence on vegetation, and is scarcely ever found in the ashes of plants. Its chief value in soil, therefore, is owing to its effects in rendering soil more retentive of moisture. Its amount varies from $\frac{1}{2}$ per cent to 13 per cent.

Oxides of Iron in Soils.—“There are two *oxides of iron* found in soils—

¹ Johnston's *Lec. Agric. Chem.*, 2d ed., 535.

namely, the protoxide and peroxide. The protoxide is frequently very injurious to vegetation—so much so, that $\frac{1}{2}$ per cent of a soluble salt of this oxide is sufficient to render soil almost barren. The peroxide, however, is often found in small quantities in the ashes of plants. The two oxides together constitute from $\frac{1}{2}$ to 10 per cent of soil. The blue, yellow, red, and brown colours of soil, are more or less dependent upon the presence of iron.

Oxide of Manganese in Soils.—"The oxide of manganese exists in nearly all soils, and is occasionally found in plants. It does not, however, appear to exert any important influence, either mechanically or chemically. Its amount varies from a mere trace to about $1\frac{1}{2}$ per cent. It assists in giving the black colour to soil.

"These four substances constitute by far the greatest bulk of every soil, except the chalky and peaty varieties, but, nevertheless, *chemically speaking*, are of trifling importance to plants; whereas the remaining eight are so absolutely essential that no soil can be cultivated with any success unless provided with them, either naturally or artificially. And yet, when it is considered that scarcely any of them constitute 1 per cent of the soil, their value will no doubt excite surprise. The sole cause of their utility lies in the fact, that they constitute the

Ashes of the Plants ;

and as no plant can, by possibility, thrive without its inorganic constituents (*its ashes*), hence no soil can be fertile which does not contain the ingredients of which these are made up. The very small percentage of these ingredients in any soil necessitates a minute analysis of every soil before it can be ascertained whether or not it contains any, or what proportion, of these ingredients. But the reason for such minuteness in analysis becomes obvious when we consider the immense weights which have to be dealt with in practical agriculture; for example, every imperial acre of soil, considered as only 8 inches deep, will weigh 1884 tons, so that 0.002 per cent—that is, only a two-thousandth per cent—the amount of *sulphuric acid* in a barren soil amounts to 80.64 lb. in the imperial acre !

Potash and Soda in Soils.—"Potash and soda exist in variable quantities in many of the more abundant minerals, and hence it follows that their proportion in soil will vary according to the mineral which produced it. For the sake of reference, I have subjoined the following table, which shows the amount per cent of alkalies in some of these minerals, and likewise a rough calculation of the whole amount per imperial acre, *on the supposition of a soil composed solely of these rocks, and of a depth of 10 inches*; and the amount is abundant beyond conjecture :—

Name of Mineral.	Amount per cent of Alkali.	Name of Alkali.	Amount per Imperial Acre in a soil 10 inches deep.	
			Tons cwt. qr. lb.	Tons cwt. qr. lb.
Felspar . . .	17.75	Potash . . .	422 18 2 8	
Clinkstone . .	3.31 to 6.62	Potash and soda	71 17 2 0 to	143 15 0 0
Clay-slate . .	2.75 " 3.31	Potash . . .	35 18 3 0 "	71 17 2 0
Basalt . . .	5.75 " 10.	Potash and soda	17 0 0 7 "	25 7 3 7

"One acquainted with chemistry will naturally ask the question, How is it that these alkalies have not been long ago washed away by the rain, since they are both so very soluble in water? The reason of their not having been dissolved is the following—and it may in justice be taken as an example of those wise provisions of nature whereby what is

useful is never wasted, and yet is at all times ready to be abundantly supplied. These alkalies exist in combination with the various other ingredients of the rock in which they occur, and in this way have such a powerful attraction for these ingredients, that they are capable of completely resisting the solvent action of water as long as the integrity of the

mass is retained. When, however, it is reduced to a perfectly impalpable powder, this attraction is diminished to a considerable extent, and then the alkali is much more easily dissolved. Now this is the case in soil, and consequently, while the stony portions of soil contain a vast supply of these valuable ingredients in a condition in which water can do them no injury, the impalpable powder is supplied with them in a soluble state, and hence in a condition available to the wants of vegetation.

"In the rocks which we have mentioned, the alkalies are always associated with clay, and it is to this substance that they have the greatest attraction; it follows, therefore, that the more clay a soil contains, the more alkalies will it have, but at the same time it will yield them less easily to water, and through its medium to plants."

Analysis of Soil.—It may be useful to give the following *minute analysis of a soil*, by Dr Anderson, of a good arable light sandy loam, well fitted for the growth of turnips in Dumbartonshire.

<i>Soluble in water.</i>	Organic matter	5.53
	Peroxide of iron	0.37
	Lime	0.36
	Magnesia	0.49
	Potash	1.25
	Chloride of sodium	2.91
	Phosphoric acid	0.72
	Sulphuric acid	4.43
	Silicic acid	8.02
		<hr/>
		24.08
	Peroxide of iron	427.02
	Alumina	260.15
	Lime	33.77
	Magnesia	27.71
	Potash	221.05
	Soda	3.48
	Chloride of sodium	20.66
	Phosphoric acid	37.77
	Sulphuric acid	5.94
	Silicic acid	52.68
	Organic matter	576.61
	Insoluble silicate	7,988.62
	Moisture	323.46
		<hr/>
		10,000.00

In a chemical point of view, this arable soil, analysed previous to liming and manuring, was a good one, and contained a suitable proportion of all the necessary elements of plants, and was particularly rich in potash.

What Plants withdraw from the

Soil.—"On comparing the constituents of such a soil as the above with the mineral ingredients obtained by incineration from the ashes of plants, it is found that plants withdraw from the soil chiefly its alkaline, mineral acid, and earthy ingredients; and if all these were not essential to the very existence of the plants, they would not, of course, be taken up by them; and as the plants constituting our cultivated crops withdraw those ingredients in a varied amount, it follows that, unless the soils we cultivate contain them in ample amount and variety, it will be impossible for the plants placed upon them to arrive at a perfect state of development of all their parts; for, chemically speaking, and rationally speaking too, soils cannot be expected to produce crops abundantly unless they contain a sufficient supply of every ingredient which all the crops we wish to raise require from them."¹

As examples of the *quantities of mineral ingredients taken from the soil under culture* by some of the cultivated plants, the following amounts of percentage are given:—

By grain crops—

100 lb. of	Grain.	Husk.	Straw.
Wheat	1.2 to 2.0	—	3.5 to 18.5
Barley	2.3 to 3.8	—	5.2 to 8.5
Oats	2.6 to 3.9	5 to 8	4.1 to 9.2
Rye	1.0 to 2.4	5 to 8	2.4 to 5.6
Rice	0.9 to 0.7	14 to 25	—
Indian corn	1.3	—	2.3 to 6.5
Buckwheat	2.13	—	—
Field-beans	2.1 to 4.0?	—	3.1 to 7.0
Field-pease	2.5 to 3.0	Pod 7.1	4.3 to 6.2
Vetches	2.4	—	—
Linseed	3.8 to 4.63	—	—
Flax-seed	4.5	—	1.28
Hemp-seed	5.6	—	1.78
Mustard-seed	4.2 to 4.3	—	—

By root and leaf crops—

100 lb. of	Root or tuber.		Leaves.	
	Undried.	Dried.	Undried.	Dried.
Potato	0.8 to 1.1	3.2 to 4.6	1.8 to 2.5	18 to 25
Turnip	0.6 to 0.8	6.0 to 8.0	1.5 to 2.9	14 to 20
Beet	—	6.3	—	—
Carrot	0.7	5.1	—	16.42
Parsnip	0.8	4.3	—	15.76
Mangel-wurzel	1.1	7.0	—	7.55
Cabbage	—	—	—	18 to 26

By grasses—

100 lb. of	Green.	Dry.
Lucerne	2.6	9.5
Red clover	1.6	7.5
White clover	1.7	9.1
Rye-grass	1.7	6.0
Knot-grass	—	2.3
Holcus lanatus	—	5.6 to 6.8
Poa pratensis	—	6.2
Scirpus	—	2.3

¹ Johnston's *Lee. Agric. Chem.*, 2d ed., 528.

By trees—

100 lb. of	Wood.	Seed.	Leaves, dried.
Larch . . .	0.33	5.0	6.0
Scotch fir . .	0.14 to 0.19	4.98	2.0 to 3.0
Pitch pine . .	0.25	4.47	3.15
Beech . . .	0.14 to 0.60	—	4.2 to 6.7
Willow . . .	0.45	—	8.2
Birch . . .	0.34	—	5.0
Elm . . .	1.88	—	11.8
Ash . . .	0.4 to 0.6	—	—
Oak . . .	0.21	—	4.5
Poplar . . .	1.97	—	9.2
Common furze .	0.82	flower, 3.1	—
Hop . . .	5.0	10.90	16.3

Inorganic Matter in Plants.—The discovery of the constant existence of *inorganic matter* in plants, which could have been discovered by chemistry alone, has a very important influence in regulating the practice of cultivating our plants. "It establishes a clear relation between the kind and quality of the crop, and the nature and chemical composition of the soil in which it grows; it demonstrates what soils ought to contain, and therefore how they are to be improved; it explains the effect of some manures in permanently fertilising and of some crops in permanently impoverishing the soil; it illustrates the action of mineral substances upon the plant, and shows how it may be, and really is, in a certain measure, *fed* by the dead earth;—over nearly all the operations of agriculture, indeed, it throws a new and unexpected light."¹

Origin of Soils.—It is argued by many practical men that the *origin of soil* is not so easily explained as is attempted by geological writers; and the difficulty of explanation may be assumed from the fact of geologists having paid little attention to the loose materials composing the *surface* of the globe. The deposits of clay, sand, and gravel, bear a variable relation to one another, as well as to the indurated rocks upon which they rest, like that by the indurated rocks to themselves, and therefore have not been deposited by the operation of any law of superposition, but simply that of gravity; and it is the want of order in the position which baffles the ability of the geologist to ascribe their origin correctly.

Diluvium or Subaqueous Deposits.—The incoherent rocks, when complete in all their members, consist of three

parts. The oldest or lowest part is not unfrequently termed *diluvium*; but this is an objectionable term, inasmuch as it conveys the idea of its having been formed by the Noachian deluge. *Diluvium*, therefore, should be termed *subaqueous deposits*, and may consist of clay, or gravel, or sand, in deep masses and of large extent. It may, in fact, be transported materials, which, if they had been allowed to remain in their original site, might have formed indurated aluminous and siliceous rocks. When such subaqueous deposits are exposed to atmospherical influences, an arable soil is easily formed upon them.

Alluvial Deposits.—True *alluvial* deposits may raise themselves by accumulation above their depositing waters, and art can assist the natural process by the erection of embankments against the waters of rivers and lakes, and by forming large ditches for carrying the waters away, as has been done in several places in the rivers and lakes of our country. Atmospherical influences soon raise an arable soil on alluvium.

Upper Mould.—The third member of soils is the upper *mould*, which is directly derived from vegetation, and can only come into existence after either of the other deposits has been placed in a situation favourable for the support of plants—that is, in the atmosphere. Mould, being the production of vegetation, always exists on the surface; but when either the subaqueous deposit or the alluvium is wanting, it is formed upon the indurated rock itself, but still by the atmosphere.

Notwithstanding the possibility of the formation of mould upon the surface of hard rocks by means of atmospheric influences, by far the largest proportion of agricultural soil is based upon incoherent and not indurated rocks.

Chemical Analysis of Soils Essential.—On viewing, then, the chemical composition of soils of known *natural fertility*, a standard will be afforded us by which we may, perhaps, be enabled to render other soils equally fertile by artificial means; but all our exertions may soon find a limit in this direction, inasmuch as without a certain amount of impalpable matter soils cannot possibly be fertile—and how can we produce

¹ Johnston's *Lec. Agric. Chem.*, 2d ed., 307.

this impalpable matter? Yet, while the existence of this material proves the soil to be *mechanically* well suited for cultivation, *chemical* analysis alone can *prove* its absolute value to the farmer. The subject of soils is thus full of interest in every respect—mechanically and chemically—to the agricultural student.

THE FERTILITY OF SOIL.

The fertility of the soil is the basis of all agricultural operations. Recent scientific and practical research has substantially increased our knowledge regarding this important subject, and the substance of what is known concerning it is embraced in the following treatise written specially for this edition by Mr R. Warington, F.C.S., who has had the benefit of being associated with Sir John Bennet Lawes and Dr Gilbert in the experimental work at Rothamsted:—

By the fertility of soil we understand its capability of producing crops. A soil producing small crops we speak of as deficient in fertility, while another yielding a large average produce we speak of as decidedly fertile. It is evident, however, to every one acquainted with agriculture, that the production of large or small crops depends greatly on circumstances quite unconnected with the nature of the soil. It depends, for instance, greatly on the climate of the district, or on the character of the season. The same soil in Sweden and in the south of France would yield very different amounts of produce. The same soil on the north and south sides of a Scotch hill will have a very different value. Or, to give one more familiar illustration, a change from the east to the west coast of Great Britain will entirely alter the productiveness of a soil for many crops.

The fertility of land is thus a very complex idea, and may depend on circumstances quite unconnected with the character of the soil. This fact must always be borne in mind. In the present short article we shall speak only of those elements of fertility which belong to the soil itself; these require the co-operation of a suitable climate and season

before they can determine actual fertility—that is to say, the production of crops.

The limited influence of the character of the soil on the fertility of land is easily understood if we have any acquaintance with the facts of agricultural chemistry. A wheat crop, weighing at harvest 5000 lb., contains in the corn and straw only 172 lb. of incombustible constituents and 48 lb. of nitrogen, both of them derived from the soil; the whole of the rest of the crop has been derived from the air and rain. For the wheat plant to assimilate to itself the carbon of the atmosphere, and to form starch, fibre, and albuminoids, it is necessary that the energy of sunlight should be received by the plant; the vigour of the plant, in fact, mainly depends on the supply of light and heat during the months of active growth. The amount of produce, thus, in most cases, depends more on the character of the season than on the composition or condition of the soil.

Physical Condition of the Soil.

Fertility is dependent, to a considerable extent, on the physical condition of the soil. The particles of a soil must be neither too coarse nor too fine. A gravel can never be fertile, although the stones composing it may possibly contain an abundance of plant-food. A pure clay would be equally unsuitable as a soil. For a soil to be really fertile it must be porous, and freely allow the movement of water and air within it; but the particles of the soil must be fine, and exposing therefore a large surface; they must also be sufficiently close together for the soil to retain, as in a sponge, a considerable amount of water. A favourable mechanical condition is frequently confined to the surface soil, but in very fertile soils a deep tilth will always be found. The physical condition of a soil is fortunately a point on which the farmer's practical skill can have great influence; he can, to a considerable extent, consolidate it or pulverise it at pleasure. Who does not know the amazing difference in the growth of a crop of barley, or turnips, according to the kind of tilth which the farmer obtained at the

time of sowing! Any lumps in a soil are clearly useless to the plant. Roots do not penetrate them; they neither furnish plant-food nor moisture. In a finely pulverised soil delicate roots spread with freedom, and every particle of soil is in a condition to yield to the roots the plant-food which it may contain.

There are a few points relating to the physical condition of soils which should be thoroughly understood by every farmer. The cementing ingredients in a soil are clay and humus. A sandy soil is made firmer, and its power of retaining water increased either by claying, or by applications of farmyard manure, or by the cultivation of grass or clovers, or by any treatment in which the vegetable matter in the soil is increased. Clays, on the other hand, are made more open and pulverulent by applications of chalk or lime, the effect of which is often quite surprising. An increase in the amount of humus will act in the same direction; and frost is also a most powerful disintegrating agent.

Relation of Soils to Water.

Some facts concerning the relation of soils to water should also be remembered. The ingredient of soils which has the greatest power of retaining water is humus; next to this stands clay. In a time of drought the soil loses least water when the surface is in a rough open condition, as under these circumstances the subsoil water cannot reach the surface by capillary attraction. Sometimes, however, as when sowing turnips in very dry weather, it is necessary to make use of any water remaining beneath the surface. To effect this the farmer must obtain a fine tilth, and finally consolidate the land by rolling: capillary attraction will thus be established, and probably enough moisture brought to the surface to germinate the seed.

In spring time, and generally in cold seasons, the warmth of the soil will have a great influence on its fertility. The warmth of a soil will be less in proportion to the amount of water which it contains. One of the great benefits of draining is to increase the temperature

of cold soils, and thus determine an earlier growth in spring.

Plant-Food.

The fertility of soil depends in great measure on the amount and condition of the plant-food which it contains. The soil furnishes the plant with all its incombustible constituents, and also with nitrogen. The ash of plants always contains six substances, which, described by their most familiar names, are—potash, lime, magnesia, iron, phosphoric acid, and sulphuric acid. These six ash constituents, and nitrogen, are all absolutely essential for plant-growth, and the absence of any one of them would deprive a soil of fertility. Besides the six substances just mentioned, the ash of plants contains soda, silica, and chlorine; these are often present in the plant in large quantity, but they are far less important to plant-life than the six first mentioned.

Of the seven essential elements of plant-food which are derived from the soil, four—lime, magnesia, iron, and sulphuric acid—are usually present in the soil in sufficient quantity. The attention of the agriculturist has, therefore, chiefly to be directed to the remaining three—nitrogen, phosphoric acid, and potash. The various degrees of fertility possessed by different soils depend, to a large extent, on the amounts of these three substances present in the soil, and on their state or condition, as suitable or otherwise, for assimilation by crops.

Sources of Fertility in Soil.

The phosphoric acid, potash, and other ash constituents of plants which are found in soils, are derived from the rocks from which the soil has been formed. The nitrogen of the soil has, on the contrary, been originally derived from the atmosphere. The origin of soil is to be traced to the gradual disintegration of rocks—the work of frost, of simple chemical agents, as water and carbonic acid, and the action of vegetation. The first vegetation would be of the scantiest description, and consist of extremely simple organisms; these would derive the small amount of nitrogen they would require from the ammonia and nitric

acid of the rain, and the ammonia of the air. The decay of these organisms would furnish the beginning of a vegetable soil, containing nitrogen and carbon. Gradually the disintegration of the rock, and the formation of a soil containing nitrogen, would reach the stage at which the herbage of a pasture or forest-trees would find a suitable feeding-ground. The soil might then remain in a condition of natural vegetation till broken up by man, and devoted by him to arable culture.

Many soils have not been formed in the places where we now find them, but have been brought to their present position by the washing of higher rocks by rain, or by the transporting power of rivers and floods. In this manner soils may be produced which contain carbon and nitrogen (the remains of vegetable

matter) throughout a great depth. The most fertile soils have usually been formed by the transportation and accumulation of soil which had already attained great fertility; the deep rich soils of river-valleys have clearly such a history.

Distribution of Plant-Food in Soils.

As the nitrogenous matter of soils is derived from the remains of previous vegetation, it naturally follows that it is chiefly found at the surface. Frequently the subsoil is sand or clay, containing very little nitrogen, while the top 6 or 9 inches are of an altogether different texture, dark in colour, and containing a considerable amount of nitrogen and carbon. In an arable soil, and in an old pasture soil, at Rothamsted, there were found at different depths—

	ARABLE SOIL.		OLD PASTURE SOIL.			
	Nitrogen.		Nitrogen.		Carbon.	
	In 10,000 lb.	Per acre.	In 10,000 lb.	Per acre.	In 10,000 lb.	Per acre.
	lb.	lb.	lb.	lb.	lb.	lb.
First 9 inches . . .	13.8	3507	24.7	5,336	337.7	73,079
9 to 18 " . . .	7.2	1679	7.2	1,916	76.4	20,223
18 to 27 " . . .	5.6	1272	4.4	1,329	37.3	11,346
27 to 36 " . . .	4.0	886	4.3	1,290	28.9	8,772
36 to 45 " . . .	3.3	772	3.8	1,231	23.1	7,464
45 to 54 " . . .	3.1	773	3.6	1,208	21.3	7,110
Total, 54 inches		8889		12,310		127,994

The concentration of both nitrogen and carbon in the first 9 inches is here very apparent.

The distribution of the important ash constituents in a soil is somewhat different. When a soil has been unmanured the phosphoric acid generally shows accumulation at the surface, but to a less extent than the nitrogen. Potash shows still less accumulation at the surface, and is sometimes more abundant in the subsoil. In a soil which has been well manured, the tendency to accumulation at the surface is naturally increased. Lime and magnesia are generally more abundant in the subsoil than at the surface.

Nitrogen, Phosphoric Acid, and Potash in Soils.

The proportion of nitrogen, phosphoric acid, or potash in a soil is generally very small. Thus the arable soil above mentioned, though of fair fertility, contained in the first 9 inches barely 14 lb. of nitrogen per 10,000 lb. of soil; and soils may be of very fair fertility which contain only 15 lb. of potash and 10 lb. of phosphoric acid per 10,000 lb. of soil. These quantities, however, become really considerable when we remember what they amount to *per acre*. Nine inches of soil when dry will weigh somewhere about 3,000,000

lb.¹ A soil, therefore, of the description just assumed, would contain in 9 inches, 4200 lb. of nitrogen, 4500 lb. of potash, and 3000 lb. of phosphoric acid on an acre. In soils of renowned fertility, the quantities of plant-food will be much more considerable. Thus C. Schmidt found in 10,000 lb. of the black earth of South Russia—

	Nitrogen.	Phosphoric Acid.	Potash.	Lime.
	lb.	lb.	lb.	lb.
First 7 inches	31	15	220	162
At 28 "	17	14	220	413
At 105 "	5	11	214	557

The proportion of nitrogen and potash is here very exceptionally high; the richness of the soil in these constituents, also, extends to a considerable depth. Deep soils with such a composition have an almost inexhaustible store of fertility.

The quantities of nitrogen, phosphoric acid, and other elements of plant-food contained in a soil, indicate, however, very imperfectly, its degree of fertility. Not only the quantity but also the *condition* of these elements has to be taken into account. An acre of soil may contain near the surface several thousand pounds of nitrogen and several thousand pounds of phosphoric acid; and yet the application of 50 lb. of nitrogen or nitrate of soda might double the wheat crop, and 50 lb. of phosphoric acid as superphosphate might double the turnip crop. Such facts would plainly show that, however large might be the quantity of nitrogen or phosphoric acid in the soil, the crops did not actually find enough *available for their use* without the aid of manure.

Humus.

We have seen that the nitrogenous matter found in the surface-soil is a residue from the decay of a previous vegetation. The nitrogen in this vegetable matter is in combination with a large amount of carbon; and in its original condition it is unfit to serve as food for crops. This nitrogenous vegetable matter is attacked in the soil by a number of agents—insects, worms, fungi,

and bacteria—which, in various ways, effect the oxidation of the carbon, which is given off as carbonic acid gas, while the nitrogen remains in the soil in simpler combinations.

The black, nitrogenous, humic matter of soils is a substance admirably fitted to serve as a store of nitrogen within the soil. Only slowly acted on by water, it is not liable to be removed by excessive drainage; while by the natural processes of oxidation and hydration within the soil, a portion of the nitrogen is yearly converted into substances fitted to serve as plant-food. The most important result of the oxidation of humus is the production of nitrates. This work is accomplished by a minute vegetable organism, a bacterium.

Production of Nitrates in Soils.

As upon the production of nitrates the fertility of a soil greatly depends, we must for a moment glance at the conditions which are requisite for this operation to occur. The production of nitrates is favoured by aerating the soil, by ploughing, stirring, and cultivation of all kinds. It is increased when the soil becomes wet, provided that there is free drainage. It is greatly increased by a rise of temperature, and is far more active in summer than in winter. Nitrification will not take place in a sour soil, as a peat-bog. To such a soil chalk or a moderate dose of lime must be added before nitrification can occur.

A bare fallow affords the greatest opportunity for the accumulation of nitrates in the soil. The results of analyses of soil and of drainage-water have shown that not less than 80 lb. of nitrogen, per acre, are ordinarily converted into nitrates during a season of fallow (about fifteen months) on the farm-land at Rothamsted.

Solubility of Phosphates and Potash in Soils.

We have seen that only a very small part of the nitrogen in a soil is immediately available to a crop. The same may be said both of the phosphoric acid and potash which soils contain. Neither of the last-named substances occur in soils in a readily soluble form. If soluble phosphates or potash salts are ap-

¹ The true soil of the fields referred to in the preceding table weighed less than this, owing to the great bulk of stones present.

plied to a fertile soil, the potash and phosphoric acid are removed from solution by the soil. This fact is of great importance, as these valuable substances are thus scarcely at all removed from the soil by subsequent drainage. Potash and phosphates enter the plants chiefly through the solvent action of the feebly acid root-sap. The quantity of phosphoric acid and potash in a soil which is soluble in a weak acid may be very small. Thus Schmidt found in the Russian soil already referred to, that out of 220 lb. of potash in the surface-soil, less than 5 lb. were soluble in a cold one per cent acid, while 35 lb. were dissolved by hot acid of ten times the strength. In the same way, out of 15 lb. of phosphoric acid, 5 lb. were soluble in cold one per cent acid, and 13 lb. in hot ten per cent acid. The smallest of the quantities extracted by the chemist's acid would be much larger than a crop would be able to take up. We have then always to bear in mind that only a small proportion of the phosphoric acid and potash present in a soil is immediately available as plant-food.

It follows from what has been said that chemical analysis is not a certain guide in discriminating the value of soils; for while the chemist can state with certainty the total amount of nitrogen, phosphoric acid, potash, lime, &c., present, he can give very little information as to the amount annually available to a crop.

Accumulation and Exhaustion of Fertility.

Having now some elementary notions respecting the capital of fertility or store of plant-food which soils contain, we must next consider the manner in which practical agriculture influences this capital.

In the natural life of a prairie or a forest, there is no exhaustion of the fertility of the soil; all the incombustible constituents of the plants and animals dwelling on the land are returned again to the soil after their death; the greater part of their nitrogen is also returned to the soil. The early history of a prairie or forest soil is one of accumulation of nitrogen, the annual gain from the atmosphere somewhat exceeding the annual

loss from the soil. By-and-by a stage will be reached at which the amount of nitrogen in the surface-soil, and in the vegetable and animal life upon it, has become so considerable that the annual loss of nitrogen is on an average equal to the annual supply from the atmosphere. An equilibrium will then be established, which will continue till man steps in and disturbs it. There will be also under the conditions of natural vegetation an accumulation in the surface-soil of some of the ash constituents of plants, since these are taken from the subsoil by the deeper roots, and returned to the surface on the decay of the plants, or in the manure or dead bodies of the animals pasturing there.

With human agriculture two distinct sources of soil-exhaustion commence. There is, first, the destruction of the accumulated nitrogenous matter of the soil by oxidation, which commences as soon as the soil is broken up by the plough; secondly, the general exhaustion, affecting all the elements of plant-food, which is brought about by the removal from the land of the crops and animals reared on it.

The effect which the ploughing up of pasture and the continuous growth in its place of arable crops has on the nitrogenous matter of the soil is well seen in the following analyses of soil, quoted by Sir J. B. Lawes in 1883, showing the amount of nitrogen in various arable soils, and in pastures of different age, at Rothamsted:—

<i>Nitrogen per 10,000 lb. in first nine inches of soil.</i>	
	lb.
Very old pasture	24.7
Pasture laid down in 1838	19.5
Pasture laid down in 1863	17.4
Pasture laid down in 1872	15.1
Ordinary arable land	12.4
Arable soil, wheat grown continuously 38 years without nitrogenous manure	10.0
Arable soil, roots grown continuously 27 years without nitrogenous manure	9.3

When we recollect that much of the arable land at Rothamsted was probably originally pasture, the destruction of nitrogenous matter by the arable culture of centuries becomes very evident. The slow accumulation of nitrogen which takes place during the making of a modern pasture is naturally the con-

verse of the destruction of nitrogenous matter which takes place when ancient pasture is devoted to arable culture.

It is most important, if we are to have an intelligent acquaintance with the laws which determine the fertility of soil, that we should clearly understand the circumstances which determine the exhaustion or accumulation of nitrogen in the soil. In a bare fallow we have the conditions most favourable to the destruction of the nitrogenous vegetable matter which the soil contains; the nitrogen and carbon of this vegetable matter are oxidised in the manner already described, carbonic acid and nitrates being produced, and these nitrates are readily *washed out of the soil by rain*. The season in which the chief loss of nitrates in the drainage-water occurs is during the autumn and winter. In climates in which the soil is frozen during the winter months, the loss of nitrates from the soil will be considerably diminished.

When a crop is grown on arable land, the nitrates formed in the soil are taken up by the crop during its period of active growth. A wheat crop may take up all the nitrates in an arable soil between April and July, but fails to protect the soil from loss during the remainder of the year. If, on the other hand, the land is laid down with grass-seeds, the loss of nitrogen as nitrates is reduced to a minimum; the production of nitrates in the soil is diminished as the land is left unploughed, and the grass is always ready to take up and convert into vegetable matter any nitrates that may be present.

But a growing crop does something more than prevent the loss of nitrates in the drainage-water. Every crop leaves a residue of nitrogenous vegetable matter in the soil, consisting of roots, leaves, stubble, &c., and this residue is a fresh addition to the nitrogenous capital of the soil. If the quantity of nitrogen in a soil is stationary, neither increasing nor diminishing, the average annual additions to the soil, in crop residues and manure, equal the average losses which the soil sustains. In nature everything tends to come to an equilibrium. If the system of cropping is bad and manuring scanty, the

nitrogen in the soil will gradually fall till the annual oxidation of nitrogenous matter is equal to the annual receipt. If the treatment is changed to one of high farming, the amount of nitrogen in the soil will rise, and with this the amount of nitrogenous matter annually oxidised, till at length again oxidation equals the annual receipt.

Leguminous Crops enrich the Soil with Nitrogen.

Different crops are of very different value as restorers of soil nitrogen. Foremost in this respect stand leguminous crops. Leguminous crops, as peas, beans, clovers, vetches, sainfoin, and lucerne, contain far more nitrogen than any other kind of crop grown by the farmer. To grow a crop of peas, and plough the whole into the land as manure, is a plan much used for renovating the soil in parts of the United States. The leguminous fodder crops, and especially those with deep roots, as red clover and lucerne, leave, however, so large a residue of root and leaf on the land, that the crop may be cut for hay and removed, and the surface-soil still left greatly enriched with nitrogen. On land which will grow leguminous crops, the farmer should have no difficulty in maintaining the nitrogenous richness of the surface-soil.

Nitrogenous Manures which enrich the Soil.

The manures which tend to increase the nitrogenous capital of the soil are those which contain nitrogen united with carbon, as farmyard manure, seaweed, oilcakes, &c. Salts like nitrate of soda or sulphate of ammonia benefit the crop and not the land; or rather, they benefit the land only through the crop, as the larger crops grown by their use leave of course a larger residue of roots, &c., in the soil. The experiments at Rothamsted afford several examples of the great enrichment in nitrogen of the surface-soil from long-repeated applications of farmyard manure or oilcake; they also show that the nitrogen of such manuring stored in the soil is but slowly transformed into a state suitable for plant-food, and that its effect is consequently spread over many years.

Oxidation in different Soils.

Before leaving the subject of the conservation of the nitrogen of the soil, we must remark that different soils will differ greatly in their rate of oxidation, and will demand, therefore, a different treatment. In a light soil, admitting a free access of air, and rapid drainage, the effect of manure will be far less enduring than on a heavier soil, and great skill will be needed to maintain such land in a fertile condition. On the other hand, upon heavy soils the effect of farmyard manure will be felt over many years; on such land oxidation may be so slow that bones may almost be without effect.

Farmers have long ago recognised the distinctive treatment proper to light and heavy soils. On light, free-draining soil, the farmer will rely on green-crop sheep feeding, and organic manures, and he will use artificial manures sparingly. He should endeavour to prevent loss of nitrates by keeping his land always occupied by some growing crop. Catch-crops of rye or mustard which can be fed off, or ploughed in immediately before sowing the main cereal crops, are very advisable. On heavy land organic manures are of less immediate value, and soluble artificial manures become of more importance. The farmer endeavours to keep the land from becoming too solid, and avoids sheep treading in winter. He will act wisely, however, by following the advice already given, and keeping the land as far as possible always under a crop. It should be borne in mind that although autumn ploughing is excellent for improving the physical condition of clay soils, it is at the same time frequently the cause of much loss of nitrogen to the soil. The aeration caused by ploughing, and the absence of crop through the winter months, are indeed the special conditions favourable to a loss of nitrates by drainage. When ploughing can be delayed till spring there is less loss of nitrogen in winter, and the aeration of the soil by the spring ploughing comes at the time when nitrate is needed by a young crop.

Exhaustion by removal of Crops and Stock.

We must next consider very briefly the exhaustion of fertility which is due

to the removal of crops or animal produce from the land. The principal constituents of farm crops of average bulk are shown in the table on next page.

It is frequently supposed that cereal crops are among those most exhausting to the soil. A study of the table shows that this is not really the case. The grain from fairly good crops of wheat, barley, or oats, removes from an acre of land only about 35 lb. of nitrogen, 9 lb. of potash, and 14 lb. of phosphoric acid—quantities smaller (with one exception) than those contained by any other crop mentioned in the table. The apparently exhausting character of cereal crops is doubtless due to the small residues which they leave in the soil, and to the loss of nitrogen as nitrates which the soil frequently suffers from autumn and winter rains after the crop has been removed from the land. The straw of cereal crops usually contains a rather considerable amount of potash; the sale of straw from land naturally poor in potash is therefore unadvisable, unless manure containing potash is also purchased for the farm. Poverty in potash is, however, not a common fault of soils.

A crop of grass hay removes generally a greater quantity of valuable constituents from the soil than a cereal crop, and this is particularly the case in respect of potash. The exhaustion of potash is of greater importance, as the short roots of grass limit its power of taking potash from the subsoil. Potash manures are often of great service on meadows mown for hay.

Root crops, if removed from the land, are by far the most exhausting to the soil of any crops grown by the farmer. The amount of nitrogen they contain is very considerable, and the quantity of potash extremely large. As the growth of roots extends much later into the autumn than is the case with cereal crops, they are able to make use of nitrates formed in the soil long after the cereals have been removed. Root crops are thus economical so far as their demand for nitrogenous manure is concerned.

The leguminous crops remove very large quantities of nitrogen and potash from the soil; the nitrogenous residue

of roots, leaves, and stubble left in the soil is, however, so considerable, that in practice they rank as agents for enriching the surface-soil with nitrogen.

The exhaustion of fertility by any crop depends of course on whether it is removed from the farm. The figures in

the table given below plainly show that the sale of cereal grain removes a far smaller quantity of the elements of plant-food than the sale of hay or roots. The sale of straw will remove a considerable amount of potash, but will not else be productive of exhaustion to the soil.

THE WEIGHT AND AVERAGE COMPOSITION OF ORDINARY CROPS IN POUNDS PER ACRE.

	Weight of Crop.		Total pure Ash.	Nitrogen.	Sulphur.	Potash.	Soda.	Lime.	Magnesia.	Phosphoric Acid.	Chlorine.	Silica.
	At Harvest.	Dry.										
Wheat, grain, 30 bushels	1b. 1,800	1b. 1,530	1b. 30	1b. 33	1b. 2.7	1b. 9.3	1b. 0.6	1b. 1.0	1b. 3.6	1b. 14.2	1b. 0.1	1b. 0.6
" straw . . .	3,158	2,653	142	15	5.1	19.5	2.0	8.2	3.5	6.9	2.4	96.3
Total crop .	4,958	4,183	172	48	7.8	28.8	2.6	9.2	7.1	21.1	2.5	96.9
Barley, grain, 40 bushels	2,080	1,747	46	35	2.9	9.8	1.1	1.2	4.0	16.0	0.5	11.8
" straw . . .	2,447	2,080	111	13	3.2	25.9	3.9	8.0	2.9	4.7	3.6	56.8
Total crop .	4,527	3,827	157	48	6.1	35.7	5.0	9.2	6.9	20.7	4.1	68.6
Oats, grain, 45 bushels	1,890	1,625	51	38	3.2	9.1	0.8	1.8	3.6	13.0	0.5	19.9
" straw . . .	2,835	2,353	140	17	4.8	37.0	4.6	9.8	5.1	6.4	6.1	65.4
Total crop .	4,725	3,978	191	55	8.0	46.1	5.4	11.6	8.7	19.4	6.6	85.3
Meadow-hay, 1½ ton .	3,360	2,822	203	49	5.7	50.9	9.2	32.1	14.4	12.3	14.6	56.9
Red clover hay, 2 tons .	4,480	3,763	258	102	9.4	83.4	5.1	90.1	28.2	24.9	9.8	7.0
Beans, grain, 30 bushels	1,920	1,613	58	77	4.4	24.3	0.6	2.9	4.2	22.8	1.1	0.4
" straw . . .	2,240	1,848	99	22	4.9	42.8	1.7	26.3	5.7	6.3	4.3	6.9
Total crop .	4,160	3,461	157	99	9.3	67.1	2.3	29.2	9.9	29.1	5.4	7.3
Turnips, root, 17 tons .	38,080	3,126	218	63	15.2	108.6	17.0	25.5	5.7	22.4	10.9	2.6
" leaf . . .	11,424	1,531	146	49	5.7	40.2	7.5	48.5	3.8	10.7	11.2	5.1
Total crop	49,504	4,657	364	112	20.9	148.8	24.5	74.0	9.5	33.1	22.1	7.7
Swedes, root, 14 tons .	31,360	3,349	163	74	14.6	63.3	22.8	19.7	6.8	16.9	6.8	3.1
" leaf . . .	4,704	706	75	28	3.2	16.4	9.2	22.7	2.4	4.8	8.3	3.6
Total crop .	36,064	4,055	238	102	17.8	79.7	32.0	42.4	9.2	21.7	15.1	6.7
Mangels, root, 22 tons .	49,280	5,628	426	96	4.9	222.8	69.4	15.9	18.3	36.4	42.5	8.7
" leaf . . .	18,233	1,654	254	51	9.1	77.9	49.3	27.0	24.2	16.5	40.6	9.2
Total crop .	67,513	7,282	680	147	14.0	300.7	118.7	42.9	42.5	52.9	83.1	17.9
Potatoes, 6 tons	13,440	3,360	127	47	2.7	76.5	3.8	3.4	6.3	21.5	4.4	2.6

When the sales from the farm are confined to corn and meat, the annual loss of phosphoric acid from the farm is but small. In a four-course rotation with average crops this loss would be generally covered by the use of only 1½ cwt. of superphosphate per acre for the root crop. The loss of potash would, in the case assumed, be still less, and on a clay soil, containing considerable amounts of potash in the subsoil, might be safely neglected. Potash can

be applied as potash salts, but is more usually restored to the land by the consumption of purchased food.

The annual loss of nitrogen by the sale of corn, and during the consumption of hay and root crops by stock, is much more considerable than the loss of phosphoric acid or potash. The amount of nitrogen retained by an animal from its food, and sold as meat, is but small, but the loss of nitrogen from the manure may be very great. The smallest loss of nitrogen

will probably occur when the hay or root crop is consumed on the land during showery weather; on a dry soil there is sure to be loss of ammonia. In feeding roots to sheep, it is a good plan to let the plough follow the sheepfold as soon as possible.

When food is consumed at the home-stead, and farmyard manure is made, there must be a good supply of litter. In Germany considerable use is made of powdered gypsum or kainit for preventing loss of ammonia in stables. One pound of either per horse per day, sprinkled on the litter, is said to be a sufficient quantity. Farmyard manure must be protected from heavy rain. But it should, on the other hand, not be allowed to become dry. A failure in these conditions will entail more or less loss of nitrogen.

As a set-off to the losses of nitrogen in farm practice, we must remember that the atmosphere supplies some quantity every year. The amount of ammonia, nitric acid, and organic nitrogen in the rain does not apparently exceed 4 lb. to 5 lb. per acre per annum, but there is, doubtless, a still larger amount directly absorbed from the atmosphere by soil and crop. What the total supply from the air may amount to we cannot say. It is clearly not enough to prevent the exhaustion of land suffered to lie fallow, or from which cereal or root crops are regularly removed without the employment of nitrogenous manure; but it is apparently sufficient to maintain the nitrogen of the soil undiminished in the case of permanent pasture, and in the case of certain rotations on poor heavy land, when the amount of nitrogen removed is limited by the consumption of straw and green crops on the farm.

We must not leave the subject of the exhaustion of land by crops without pointing out that the farmer has the power, by varying his rotation, to alter at will the amount of this exhaustion. Thus the conversion of a four-course rotation into a five-course, by keeping the land in grass and clover seeds for two years, would have a distinct effect in increasing the amount of nitrogen in the soil.

The amounts of nitrogen, phosphoric acid, potash, and some other elements

of plant-food, which are removed from the farm by the sale of animal produce, are shown in the following table:—

ASH CONSTITUENTS AND NITROGEN IN
1000 LB. OF VARIOUS ANIMALS AND
THEIR PRODUCE.

	Nitro- gen.	Phos- phoric acid.	Potash.	Lime.	Mag- nesia.
	lb.	lb.	lb.	lb.	lb.
Fat calf . .	24.64	15.35	2.06	16.46	0.79
Half-fat ox .	27.45	18.39	2.05	21.11	0.85
Fat ox . .	23.26	15.51	1.76	17.92	0.61
Fat lamb . .	19.71	11.26	1.66	12.87	0.52
Store sheep .	23.77	11.88	1.74	13.21	0.56
Fat sheep . .	19.76	10.40	1.48	11.84	0.48
Store pig . .	22.08	10.66	1.96	10.79	0.53
Fat pig . .	17.65	6.54	1.38	6.36	0.32
Wool, unwashed	73.00	1.00	40.00	1.00	0.70
Milk	5.92	2.00	1.70	1.70	0.20

It will be noticed that sheep, for the same weight, contain less phosphoric acid than oxen. A pig removes less of all the valuable constituents than an ox or sheep. A fat animal contains, for its weight, less nitrogen and phosphates than a lean one. The milk of one cow (600 gallons) will, if sold, remove in a year 36 lb. of nitrogen, 12 lb. of phosphoric acid, and 10 lb. of potash.

Restoration of Fertility by Manuring.

Having thus briefly considered the influences of cropping on the fertility of soil, and the losses of fertility arising from the sale of crops and of animal produce, we must, in the next place, speak still more briefly of the restoration of fertility by manuring.

The general manuring effected by the application to the land of the manure resulting from the consumption of crops by stock will, of course, only partially replace the loss of fertility by the soil; the sale of corn and animal produce, and the waste of nitrogen in the preparation of manure, and by winter drainage from the soil, will still remain as annual sources of loss. On heavy land in poor condition, the losses of nitrogen by sales, by drainage from the soil, and in the preparation of manure, may be so moderate, that the whole may be covered, or nearly covered, by the atmospheric supply; but on fertile soil, where good crops are produced, the quantity of nitrogen sold, the loss in dealing with a large bulk of manure,

and the loss by drainage from a soil rich in nitrogen, will amount to a total far in excess of the supply from the air, and demanding, therefore, the use of additional manure if high fertility is to be maintained.

We need not now discuss the theories of manuring long ago propounded by Liebig. Facts have taught both the farmer and chemist that it is needless to attempt the restoration of *all* the elements removed by the crop from the soil, since with some of these the soil is abundantly provided. Neither must manuring be confined to the substances contained in the ash of crops. The supply of nitrogen to the soil is indeed frequently more necessary than the supply of ash constituents if we desire to restore a lost fertility.

Phosphatic Manure.

The secret of economical manuring is to apply the manure required on the farm to that crop which most stands in need of it, and in no greater quantity than will produce a profitable result. Thus the farmer will apply the phosphates which his land requires to the turnip crop, because this crop will show the largest return for phosphate. He will also, if he wishes to avoid waste, ascertain, *by trial on his own land*, what is the largest quantity of superphosphate that will give a paying result. It will frequently be found that any quantity exceeding 3 cwt. per imperial acre, drilled with the seed, produces no profitable result. In such a case, to use more than this is clearly waste.

Nitrate of Soda.

Nitrate of soda is a manure of the greatest value to a farmer, more especially for cereal crops and mangels. When the nitrates naturally formed in the soil have been in great part washed out by winter rains, a small spring dressing of nitrate of soda restores at once the lost fertility. If a considerable dressing of nitrate is to be employed, it should generally be accompanied by a dose of phosphate. Any amount of nitrate in the soil which is in *excess* of the other ingredients of plant-food is of no advantage to the crop. Sulphate of ammonia acts more slowly than nitrate

of soda. The ammonia is converted into nitric acid in the soil. The relative permanency of the different nitrogenous manures, and their influence on the nitrogenous contents of the soil, have been already noticed (p. 62).

Potash.

Potash manures can now be purchased at a moderate price. On certain soils they produce a great effect on pasture, grass-seeds, potatoes, and roots. Potash salts are therefore worth a careful trial by every farmer.

Retention of Manures.

On soils containing clay, applications of potash have a permanent value, the manure unused by the crop remaining in the soil available for other crops. Phosphates are also firmly retained by a fertile soil. The phosphate of lime applied in the manure changes, however, in the soil to phosphate of iron, and becomes less valuable as plant-food. Fresh applications of phosphatic manure are thus continually demanded for the turnip crop.

The power of retaining phosphoric acid, potash, and ammonia, differs with different soils; a high retentive power is requisite for economic manuring and the accumulation of fertility. A soil having a high retentive power will, other things being equal, be naturally more fertile than one having less power of retention. The ingredients of the soil which retain potash and ammonia are clay, humus, and oxide of iron; oxide of iron and clay retain phosphoric acid. Phosphoric acid is more firmly held than potash or ammonia, and occurs only in minute quantity in drainage-waters.

Manurial Value of Foods.

A common mode of increasing the fertility of land is by the use of manure obtained by the consumption of purchased food. The value of such manure depends—1. On the composition of the food; 2. On the character of the animal consuming it; 3. On the treatment of the manure before it reaches the land.

A food rich in nitrogen, phosphates, and potash, will give a far more valuable manure than a food poor in these constituents. Indeed, as a rule, the

richer is the diet in these constituents, the smaller will be the proportion of them retained by the animal. The following table shows the quantity of nitrogen, potash, and phosphoric acid contained in 1000 lb. of ordinary cattle-foods:—

MANURIAL CONSTITUENTS IN 1000 LB.
OF ORDINARY FOODS.

	Dry matter.	Nitro- gen.	Potash.	Phos- phoric acid.
	lb.	lb.	lb.	lb.
Cotton-cake (decorticated) . . .	918	70.4	16.3	31.5
Rape-cake . . .	887	50.5	13.0	20.0
Linseed-cake . . .	883	43.2	12.5	16.2
Cotton-cake (undecorticated) . . .	878	33.3	20.0	22.7
Linseed . . .	882	32.8	10.0	13.5
Palm-kernel meal (English) . . .	930	25.0	5.5	12.2
Beans . . .	855	40.8	12.9	12.1
Peas . . .	857	35.8	10.1	8.4
Malt-dust . . .	905	37.9	20.7	18.1
Bran . . .	860	23.2	15.5	27.2
Oats . . .	870	20.6	4.9	6.9
Wheat . . .	877	18.7	5.3	8.1
Barley . . .	860	17.0	4.7	7.8
Maize . . .	890	16.6	3.8	5.9
Clover-hay . . .	840	19.7	18.6	5.6
Meadow-hay . . .	857	15.5	16.0	4.3
Bean-straw . . .	840	10.1	19.4	2.9
Wheat-straw . . .	857	4.8	6.3	2.2
Barley-straw . . .	857	5.6	10.7	1.9
Oat-straw . . .	857	6.4	16.3	2.8
Potatoes . . .	250	3.4	5.8	1.6
Mangels . . .	115	1.9	4.6	0.7
Swedes . . .	107	2.4	2.0	0.6
Carrots . . .	150	2.2	3.0	1.1
Turnips . . .	80	1.6	2.9	0.8

These figures show that oilcakes, beans and peas, malt-dust and bran, are the most valuable foods for the production of rich manure. Hay and straw are characterised by containing a considerable amount of potash. The cereal grains and roots contain nearly the same quantity of nitrogen in their *dry substance*, the roots supplying the most potash. The poorest manure is that yielded by wheat-straw.

The proportion of nitrogen, &c., which passes into the manure depends, of course, on the amount retained by the animal. The same food supplied to different animals will yield manure of very different values. A ton of corn consumed by a milking cow or fattening pig will produce manure of much less value than if given to a working horse. When, as in the latter case,

there is no increase of animal produce during feeding, the quantity of nitrogen, phosphates, and potash in the manure will be practically the same as in the food consumed.

Lastly, the value of the manure will much depend on the manner in which it is preserved. This part of the subject has been already noticed on p. 64.

Lime.

We have not spoken of lime as a manure, because it is not generally, like other manures, intended to serve as a plant-food. An application of chalk or lime often greatly increases the fertility of a soil; but it does this chiefly by improving its physical and chemical condition. Lime especially acts by attacking the nitrogenous organic matter of the soil, and rendering it more available as plant-food. Lime is invaluable in reclaiming peat.

Valuation of Unexhausted Manures.

Before concluding our brief summary of the chief points which determine the fertility of soil, some reference will probably be expected to the difficult question of the valuation of unexhausted improvements. Under certain circumstances an outgoing tenant can now claim compensation for past expenditure which has resulted in an increase of the fertility of the land. In considering any such claim, it should always be recollected that the only real proof of increased fertility is the fact that better crops can be grown than formerly. If this fact cannot be established, it is hard to see how any claim can be sustained. The amount of increase in the crops, and the length of time that the additional fertility of the land will probably endure, are thus points which would, if they could be fixed, determine the unexhausted value of past improvements. Such estimates are, however, attended with much uncertainty. In cases, therefore, in which the outgoer has a clear claim, either against the landlord or the incoming tenant, it is more usual to estimate what proportion of the value of each item of acknowledged improvement is unexhausted at the time of leaving. The value of such operations as draining or liming depends so greatly on the

nature of the soil, that the experience already gained in carrying out these operations on similar land will be the chief, if not the only, guide in assessing a fair charge for these items of claim.

With regard to unexhausted manures something more may be said. We have already pointed out that while nitrate of soda and salts of ammonia give their effect entirely in the first year, applications of nitrogenous organic manures, as farmyard manure, sea-weed, fish, bones, or oilcakes, give only a portion of their effect in the first season of their application, and their employment may therefore become a subject of claim against the landlord or incoming tenant. The use of purchased phosphates or potash salts may also possibly become a subject of claim, as any surplus of phosphates or potash remaining in the soil is more or less available for future crops.

As nitrogenous manures are the most costly, and, on the whole, of most importance in increasing the fertility of the land, their valuation has naturally received the greatest attention. Nitrogenous organic manure is generally obtained by the consumption of food by stock. The consumption of purchased foods on the farm thus becomes a frequent subject of claim. The claim has frequently but erroneously been based on the price given for the cake or corn consumed; it is obvious, however, that the price of the food has no necessary connection with its manure value. A ton of wheat and of cotton-cake may be similar in price, but the latter contains nearly four times as much nitrogen as the former, and will yield a manure nearly four times as valuable.

Sir J. B. Lawes in 1860 published a table showing the estimated value of the manure obtained by the consumption of one ton of various articles of food. In 1885, Messrs Lawes and Gilbert returned to the subject, and published in the *Journal of the Royal Agricultural Society* (vol. xxi. p. 590) a table showing the estimated value of the manure from one ton of food, not only when freshly prepared, but during a series of eight years after the application of the manure to the soil. The amount of nitrogen, phosphoric acid, and potash in the manure is reckoned by subtracting from the amount

in the food that which is stored up in the animal. The foods are assumed to be consumed by *fattening* animals; and it must be recollected that if the same foods were supplied to a growing animal, or to one producing milk, a larger proportion of the nitrogen, phosphoric acid, and potash would be retained by the animal, and therefore lost to the manure. The quantities of nitrogen, phosphoric acid, and potash estimated as present in the manure are first reckoned at the money value which these substances have in active artificial manures. This value is, however, clearly in excess of the true value of animal manure,—*firstly*, because the animal manure is sure to contain less than the estimated quantity of nitrogen, the manure being, in its preparation, exposed to several sources of loss; *secondly*, because the constituents of the manure, especially the nitrogen, are not in the immediately available condition which they possess in artificial manures, and have thus not an equal money value. Messrs Lawes and Gilbert, therefore, in the case of cake, corn, and roots, take one-half of the calculated full manure value, and in the case of hay and straw, one-third of the full value, as the highest figure to be used for the purpose of valuation.

This highest valuation would be awarded if the foods had been consumed in the last year, and the manure had not yet produced a crop. From this highest valuation $\frac{1}{3}$ would be deducted if another year had elapsed, or $\frac{1}{5}$ in the case of hay and straw; and the valuation of each succeeding year would, always according to the character of the food, be $\frac{1}{3}$ or $\frac{1}{5}$ less than that of the year preceding.

To give an example: The full calculated value of the manure from 1 ton of linseed-cake is £3, 18s. 6d. One-half of this, or £1, 19s. 3d., is taken as the fair value of the manure, if made last year, and has not yet grown a crop. The residual value of the same manure the second year is £1, 6s. 2d.; the third year, 17s. 6d.; the fourth year, 11s. 8d., and so on. In making this estimate of the gradual diminution in the value of the manure, it is assumed that the land to which it is applied is heavy land. On a sandy soil, and espe-

cially on a calcareous soil, the value of the manure will more rapidly disappear.

Causes of Infertility.

In conclusion, we must refer to some special conditions which render certain soils infertile. A soil may be "sour" from the presence of an excess of vegetable matter and water; the cure is lime and draining. A soil or subsoil sometimes contains ferrous salts, either natural

to the formation, as in lias clays, or produced by the causes mentioned as yielding "sour" soils; the cure is lime and thorough ploughing. A soil reclaimed from the sea is charged with salts; these are best removed by throwing the land into ridges and draining. When the salts are alkaline, as is the case with large districts in California and India, repeated dressings of gypsum must accompany ridging and draining.

AGRICULTURAL EDUCATION.

In preceding pages reference has been made to the principal subjects of a scientific nature upon which a young farmer should endeavour to inform himself. The aim has been, rather to point out in what way these have a bearing on farm life, and to advise the farm-pupil to study them, than to enter into details regarding any particular one, leaving him to find these in books devoted to their special subjects. It must not, of course, be supposed that those mentioned are the only subjects which ought to be studied by those who desire to become successful farmers; but they are of greatest importance, and others not mentioned might almost be looked on as special departments of these general headings.

Besides these scientific matters, however, there are a large number of others—not exactly scientific in the proper sense of the term—which are equally important, such as book-keeping and commercial knowledge, agricultural law, forestry, &c.,—so that there is a wide range of subjects before the agricultural student.

But a beginner must not be disheartened by a too formidable array. The matter, indeed, will not be found so very difficult by any one who attacks it with the determination of doing earnest work.

Agricultural Curriculum.

Usually two winter sessions at a college, or at most two full years, are sufficient to enable a student to acquire sufficient information to pass the various

agricultural examinations, and look on himself as "duly qualified" to "practise as a farmer," as we shall show immediately. For those who cannot afford the time or the money to attend college classes, there are a superabundance of books treating on each subject which might be studied in leisure hours, or during the long winter evenings, with the greatest benefit. There are not wanting men who have raised themselves to the highest position as authorities on agricultural science who have done it all by private study, without attending any classes, and scarcely even a lecture.

Nevertheless, attendance at classes where these subjects are taught is by far the best plan for the great majority of young men. The hard manual labour of the farm and the open-air life are not conducive to mental exertion, and one who has been at the plough-tail all day does not feel inclined to tackle chemistry or mechanics in the evening.

Practice and Science.

Farming is made up of two parts—practice and science. The practice can be learned only by actual continuous work on a farm, attending to all the minute details of labour and management. The science of agriculture is best learned away from the manual labour altogether. Both of them are necessary nowadays, the one being an essential complement of the other, to ensure agriculture being a successful whole; and both of them will be found equally use-

ful by a young man when he comes to manage land for himself.

Importance of Agricultural Education.

It is perfectly certain that in the future—whatever it may have been in the past—the educated farmer will take the lead. The merely practical man, whose mind can hold only a few ideas, will give place to one who, while thoroughly well versed in every practical detail of work and management, is at the same time a man of education and scientific skill.

The period of “depression” which has befallen agriculture in common with other businesses, has had the effect of making the rank and file of tenant-farmers more willing to attend to anything which promises to help them to farm with better results, and thus of late there has been a greater inclination to hear what science has got to say on the matter, and to put it into practice. The various agricultural colleges and science-classes scattered up and down the country are becoming better attended as time goes on, and sooner or later the “leaven” will affect the whole mass, and we may then expect to see agriculture take the position it is entitled to hold.

TEACHING INSTITUTIONS.

Mention has been made of colleges and classes where the theory and practice of agriculture are taught. It will be useful if a short statement regarding the leading institutions is given, and the curriculum laid down for a farm-pupil. Before doing so, however, it may just be mentioned that some of them are more suited for the education of landowners and land-agents than for ordinary tenant-farmers. This is not because the information given is not of the proper kind—for all the classes are well chosen—but because it is necessary to charge fees which are prohibitory to ordinary occupiers, and also because the ordinary farmer's son will learn the practical work far better and cheaper at home on his father's farm than on any other.

It has already been pointed out that a young man ought to learn the practice first by regular manual labour on a farm, and *afterwards* study the sciences

appertaining thereto, so that a college “with a farm attached” is quite an unnecessary institution for the great majority of farmers' sons.

But for those, however, who have not been bred on the farm, and whose means are ample enough, there is no doubt that two or three years at such an institution is the best possible arrangement—ininitely better than paying £100 to £150 per annum to learn farming from some “practical” man who, perhaps, has little or no teaching abilities.

For farmers' sons, attendance at lectures during the winter only, with a return home during the summer, is most to be recommended, both on the score of economy and suitability.

Royal Agricultural College, Cirencester.

The Royal Agricultural College, Cirencester, is the oldest and best known of the various institutions for teaching both the practice and science of agriculture. The complete course extends over two years, there being three terms in each, and students can graduate at the end of that time with the diploma of membership. Shorter periods of study can be undertaken, if desired, and students may be either boarders in the college or reside outside.

The subjects taught are Practical Agriculture and Dairy-Farming; Chemistry; Geology, Botany, and Zoology; Mensuration, Physics, and Mechanics; Land-Surveying and Estate Engineering; Veterinary Surgery; Book-keeping; Agricultural Law; Building and Construction; Estate Management and Forestry; and Drawing. There is a large farm of 500 acres attached to the college buildings, which is worked after the manner of the best-managed farms of the Cotswold district. To this the students have access, and they are expected to make themselves practically acquainted with all the work which is going on. Cotswold sheep and Berkshire pigs form the principal live stock—both being well known in the show-yard.

Instruction in dairy-work is one of the lately introduced features, and there is a veterinary hospital for the practical treatment of animals. There is also a botanic garden, and the building con-

tains class-rooms, laboratories, museum, library, and all appliances for teaching.

The fees charged are £135 per annum or £45 per term for in-students, and £75 per annum, or £25 per term for out-students.

Edinburgh University.

Edinburgh University has had a Chair of Agriculture for well on to a century, and though the most of the sciences bearing on farming have been taught from other chairs, yet these have always had more of a medical or general than an agricultural bearing.

Degree in Agriculture.—In 1886 a degree of Bachelor of Science in Agriculture was instituted on the same standing as the B.Sc. degree in other departments, and open to all those who had attended certain qualifying classes. The subjects prescribed are eight in number, which can be taken in two periods of four each. These are Agriculture (Elementary Principles), Chemistry, Botany, and Engineering for the first part; with Zoology as an alternative for Botany; and Agriculture (the whole subject), Agricultural Chemistry, Geology, and Veterinary Science for the final.

As with all other medical and science degrees, however, there is a preliminary examination in general education, comprising some seven different subjects, and such as a youth coming up from a public school or academy is expected to be acquainted with. Students must have attended classes for three years, or for two years, with at least one year on a farm, one of the years being spent at Edinburgh University. Certain extramural classes are recognised as qualifying for graduation, especially those of Agricultural Chemistry and Veterinary Science, which are not as yet taught within the University.

It is notable that this is the only degree in Agricultural Science which is granted at a university in Britain—perhaps, we may say, in the world. And it is very appropriate that the university of the capital city of a country so long famous for good farming should be the first to recognise the importance of the subject in this way, and accept it as of equal standing with every other profession taught within its walls.

The cost of taking this degree will vary with the individual student, and may be kept down within a very moderate limit. In Scottish universities all the students reside in their own private lodgings, and consequently the outlay for each winter session of six months will depend on the style of living adopted. The class fees are usually about three or four guineas each, with extra fees for matriculation, examination, &c.; but altogether the cost of education and living need not exceed £40 per session, unless the student is personally extravagant. The whole course for the degree might be gone through by a farmer's son for less than £100.

College of Agriculture, Downton.

The College of Agriculture, Downton, Salisbury, Wilts was established in 1880 for the purpose of giving a practical and scientific course of instruction in agriculture. The farm—which extends to 600 acres—is in the occupation of the college, and its management is part of the work of the college authorities. It is farmed in a manner similar to the land in the neighbourhood, the soil being a good light loam, with the fields rising up to the Downs. The principal stock is the famous breed of Hampshire Down sheep; but the dairy, and a herd of Berkshire pigs, are notable features of the farm.

The subjects taught are,—Practical Agriculture; Dairy and Pastoral Farming; Estate Management, Land Agency, and Forestry; Mensuration, Trigonometry, Land-Surveying, Building, Construction, and Drawing; Book-keeping and Commercial Knowledge; Physics and Mechanics; Chemistry and Chemical Analysis; Geology and Mineralogy; Botany and Vegetable Physiology; Zoology and Entomology; Anatomy and Physiology; and Veterinary Surgery. The course occupies two full years, and is sufficient to qualify students for the examinations of the Royal Agricultural Society, the Highland and Agricultural Society of Scotland, the Royal Agricultural Society of Ireland, and the Surveyor's Institute.

There are three terms in the year, and the fees are £135 per annum

for in-students and £72 for out-students.

Lectures at Oxford.

The University of Oxford has long had an endowment for a Chair of Rural Economy, but up till quite recently it was united with the Chair of Botany. Since 1884, however, the two have been separate, and now the students of that university have the privilege of attending a class on Agriculture. The lectures are given in Magdalen College, and twelve is the minimum number per annum—four in each term. The professor is appointed for three years only, and cannot hold the post for more than six years altogether. As the course is so short, the subjects of agriculture must be treated very generally, or else only a very small department taken up.

There is also a lectureship in "Agricultural Science" attached to Balliol College, Oxford, intended especially for the Indian Civil Service Probationers. Both are open to students who take an interest in farming, and as these are mostly of the landlord or land-agent class, they can gain a certain amount of information which will be of use to them later in life, though of course not a thorough or exhaustive knowledge of the subjects.

Aberdeen University.

In the University of Aberdeen there is the Fordyce lectureship on Agriculture, the chemical, botanical, and geological aspects of the matter being most largely dealt with. The lectures, not less than twelve in number, are given at intervals, and are free and open to any one, whether regular students of the University or not.

Glasgow Technical College.

In the Glasgow and West of Scotland Technical College there is a course of 100 lectures on Agriculture delivered during the winter six months, and arrangements have now been made for a special class of Agricultural Chemistry. Farming students can attend the ordinary classes on Botany, Geology, Engineering, Drawing, &c., in common with those of other professions. The full course occupies three winters, and is

intended to cover the ground taken up by the diploma of the Highland and Agricultural Society, and qualifies students for the same, while the fees charged are very moderate, varying with the number of classes attended. Students have, of course, special advantages in seeing so much good practice going on, as the district of Clydesdale, which is at hand, is one of the best farmed localities in the United Kingdom.

Normal School, London.

The Normal School of Science and the Royal School of Mines (affiliated), London, some few years ago established a lectureship of Agriculture, which later on was made a professorship, where students could attend a course of about thirty to forty lectures. The other classes in the same institution, which were attended by young men intending to become mining engineers, geologists, &c., were utilised for making a complete course, as far as they had any connection with agriculture. Three years are required to complete attendance at all the prescribed classes, and at the end of that time a student can graduate with the degree of "Associate."

The subjects taught are—Chemistry; Physics and Astronomy; Mathematics and Drawing; Biology; Geology and Mineralogy; and during the third year Mechanics, Principles of Agriculture, and Agricultural Chemistry, in the special department of "Agriculture." The fees for the first two years amount to about £75, and for the remainder of the course for the associateship they vary from £30 to about £40.

Institute of Agriculture.

The Institute of Agriculture, South Kensington, has been established for the purposes of advancing technical instruction upon various sections of agricultural practice, as a preparation for learning the business of farming, and especially for bringing these advantages within the reach of any and every person desiring to avoid much expense. Short courses of lectures on specific subjects are instituted from time to time, and gentlemen noted as authorities are asked to conduct a course on

their own special department. The full series amounts to about 280 lectures at the rate of two daily, by about twenty of the most eminent authorities—the fees amounting to a total of £14.

The lectures are principally intended for teachers and students under the Science and Art Department, and they are varied to suit the demand for instruction.

The subject of the "Principles of Agriculture," which forms No. XXIV. of those under the superintendence of the Science and Art Department just mentioned, is perhaps the one which is best known and most widely taught in country districts. Wherever a sufficient number of students can be got together, a committee formed of men of local standing are at liberty to appoint a teacher to deliver one lecture per week—twenty-eight in all—during the winter six months. The students are expected to attend the examination in May, and the teacher is paid by Government grant according to the success of the students. The lecturer must possess certain qualifying certificates, or be otherwise approved by the Department. There are some 300 or 400 of these classes in the British Islands, and over 12,000 students—the number varying from year to year. There can be no doubt that for beginners, or for those who can attend local centres only, one of these classes would be very suitable and useful.

Agricultural College, Aspatria.

The Agricultural College, Aspatria, was established in 1874, for the purpose of affording pupils as much insight into agricultural science and practice as possible before they left school. The pupils first receive a good general education up to the age of fifteen, and then they proceed to the study of various sciences bearing on farming, such as Chemistry, Agricultural Chemistry, Physics, Botany, Animal Physiology, Geology, Entomology, Forestry, and Veterinary Science. The older youths work a portion of each day on one or other of nine distinct farms, under the personal supervision of the principal and practical farmers. The instruction qualifies the pupils for the Junior Examinations of the Royal

Agricultural Society of England, the Bursary Examinations of the Highland and Agricultural Society, and for the Certificates of the Science and Art Department. The institution has been largely assisted by the landowners and farmers of Cumberland.

There are three terms in the year. In-pupils pay from 15 to 17 guineas per term, and out-pupils £3, 5s.

Dairy Schools.

Dairy schools recently established in Cheshire and Derbyshire are doing excellent work, and the British Dairy Farmers' Association have matured a scheme for founding a school or college near Aylesbury for teaching improved dairying.

AGRICULTURAL TEACHING IN IRELAND.

Ireland has long enjoyed exceptional advantages in respect to facilities for imparting agricultural education. Substantial Government grants have been given to Ireland for this purpose; and although the Irish National Agricultural Schools have not, as a whole, been so successful as could have been desired, there is no doubt that the country has derived great benefit from the movement for the promotion of technical and scientific training in agriculture. The Albert Institution at Glasnevin, near Dublin, with its admirably conducted model farm attached, is a well-equipped agricultural college, in the curriculum of which all the usual subjects, including a special course in dairying, are embraced.

Then the Munster Dairy School near Cork, supported by Government grant and local effort, is at present the most complete and most efficient institution of the kind in the United Kingdom.

GENERAL TEACHING FACILITIES.

It will thus be seen that there are considerable facilities for scientific teaching in relation to agriculture in the British Islands. Upon the whole, too, this teaching has been of a high character, and it has not been unreasonably expensive.

State Aid to Agricultural Education.—It is a noteworthy fact that

Continental countries and the United States do far more to encourage scientific education in farming, in the way of Government grants and equipping State-aided colleges, than is done here in Britain. On the other hand, it is generally recognised that British farmers are the best in the world. It has thus often been pertinently asked what good science does when, notwithstanding the existence of a college in every province abroad, British agriculture is so decidedly in advance of that in foreign countries? The answer to this is, that there the science has only just now reached down to the great mass of the farming community—often of the peasant-proprietor class—and is only of late being taken advantage of, so that in the immediate future there is likely to be greater results than ever before attained.

The fact, however, that Continental and other farm-produce of all kinds can be sold in our own markets at less than would be its cost of production in this country, while the quality is often superior, goes far to prove that there is something in their knowledge of the sub-

ject, and that it is not all the result of cheap labour or a better climate.

All that our Government has hitherto done to help in the matter in Great Britain has been to give an annual grant to the Chairs of Agriculture at Edinburgh and in the Normal School of Science, while, of course, the Science and Art Department work is carried on mostly by State aid.

At last, however, a step in advance has been taken. It was announced early this year (1888) that the Government had decided to establish an Agricultural Department, with a Minister of Agriculture at its head, and that a grant of £5000 would be given in aid of agricultural education in England and Scotland. Various schemes are on foot for the utilisation of this grant; the one which has received most favour being that of aiding institutions already in working order. To this end the money has been divided in various proportions among those institutions which have satisfied the Government authorities. It is to be hoped that the beginning thus made, tardy though it be, may develop into an extensive and useful organisation.

THE PLAN OF THE WORK.

Two modes of describing *farm business* may be adduced. One, to arrange the particulars of business under different heads, and describe similar operations under the same head, as is done in systematic works on agriculture. The other, to describe the operations as they *actually occur, singly, and in succession*, on the farm, as is to be done in this book; and this is the natural method. Both methods describe the general farm operations, and may be consulted for any particular operation. But the relative position any work stands in regard to, and influences any other, can be shown only by the natural method, and it does so at a glance. As one piece of farm work terminates, another commences, and at different periods of the year, the natural method only can clearly indicate the period in which any work commences,

is continued, or terminates, and can give the details of it minutely.

The Agricultural Year.—The agricultural year, like the common, is conveniently divided under the four seasons, and the entire farm business is also conveniently divided into *four parts*, each bearing the name of the season that influences the operations performed in it. It is by such an arrangement only that every operation, whether requiring longer or shorter time for completion, can be intelligibly described, as it takes its turn in the field. The work that occupies only a short time to finish, in any of the seasons, may be described in a single narrative. Very few of the operations, however, are completed in one of the seasons, some extending over the whole four, and most into two or three. Any work that extends over

most of the seasons can nevertheless be described with accuracy; for although it may occupy a long time to reach its completion, every season imposes its part on the work, and terminates it so far; so that cessations of labour are thus not mere conveniences, but necessary and temporary finishings of work which would be wrongly prosecuted but in its own proper season. In this way the extended works are advanced, in progressive steps, from season to season, until their completion; while the shorter ones are concurrently brought onwards and completed in *their* proper season.

These preliminary remarks, it is to

be hoped, may enable the agricultural student and farmer to follow the details of farming as they usually occur. The mixed husbandry system is that which is most fully dealt with, but an endeavour is made to acquaint the reader with the corresponding operations in the other modes of farming adopted in localities peculiar to themselves.

Narrating the operations in the order they are performed, the work begins with WINTER—the beginning, also, of the agricultural year—and proceeds in the natural order through the seasons of SPRING, SUMMER, and AUTUMN, until the winter season and another year are again reached.

PRACTICE.

WINTER.

THE WEATHER, AND FIELD OPERATIONS IN WINTER.

Work in the Steading.—The subjects which court attention in winter are of the most interesting description to the farmer. He directs his attention mainly to work conducted in the steading, where the cattle and horses are collected, and this with the preparation of the grain for market affords pleasant employment within doors. The progress of live stock towards maturity is always a prominent object of the farmer's solicitude, and especially so in winter, when they are comfortably housed in the farm-steading, plentifully supplied with wholesome food, and so arranged in various classes, according to age and sex, as to be easily inspected at any time.

Field Work.—The labours of the field in winter are confined to a few great operations. These are chiefly ploughing the soil in preparation for future crops, and supplying food to live stock. The commencement of the ploughing for the year consists in turning over the ground which had borne a part of the grain crops, and which now bears their *stubble*—which is just the portion of the straw of the previous crops left uncut.

Water-channels in Ploughed Land.—The stubble land ploughed in the early part of winter, in each field in succession, is protected from injury from stagnant rain-water, by cutting channels with the spade through hollow places, permitting the rain to run quickly off into

the ditches, and leaving the soil in a dry state until spring.

Ploughing Lea.—Towards the latter part of winter, the grass land, or *lea*, intended to bear a crop in spring, is ploughed; the oldest grass land being earliest ploughed, that its toughness may have time to be softened before spring, by exposure to the atmosphere. The latest ploughed is the youngest grass.

Best Season for Draining.—When the soil is naturally damp underneath, winter is selected for removing the water by draining. It is questioned by some farmers whether winter is the best season for draining, as the usually rainy and otherwise unsettled state of the weather renders the carriage of the requisite materials on the land too laborious. By others it is maintained that, as the quantity of water to be drained from the soil determines both the number and size of the drains, these are best ascertained in winter; and as the fields are then entirely free of crop, that season is the most convenient for draining. Truth may not absolutely acquiesce in either of these reasons, but, as a rule, draining may be successfully pursued at all seasons.

Planting Hedges.—Where fields are unenclosed, and are to be fenced with a quick thorn-hedge, winter is the season for performing the work. Hard frost, a fall of snow, or heavy rain, may put a stop to the work for a time, but in all other states of the weather it may be proceeded with in safety.

Water-meadows.—When water-mea-

dows exist on a farm, winter is the season for carrying on the irrigation with water, that the fostered grass may be ready to be mown in the early part of the ensuing summer. It is a fact worth bearing in mind that *winter* irrigation produces more wholesome herbage for stock than summer irrigation. On the other hand, summer is the most proper season for forming water-meadows.

Stock in Houses.—Almost the entire live stock of an arable farm are dependent on man for food in winter. The stock, thus concentrated before their owner, excite greater interest than at any other season. He classifies them in the farmstead by their age and sex, their nature and condition, and marks the progress of all towards the destination of each. He provides them with a comfortable bed and sufficient clean food at appointed hours.

Feeding Stock.—The feeding of stock is so large and important a branch of farm business in winter, that it regulates the time for prosecuting several other operations. It determines the quantity of turnips that should be carried from the field in a given time, and causes the prudent farmer to take advantage of dry fresh days to store up a reserve for use in any storm that may ensue. All the cattle in the farmstead in winter are placed under the care of the *cattle-man*.

Threshing Grain.—The necessities of stock-feeding also determine the quantity of straw that should be provided from time to time; and upon this, again, depends largely the supply of grain that may be sent to market at any time. For although it is in the farmer's power to thresh as many stacks as he pleases at one time, and he may be tempted to do so when prices are high; yet, as new threshed straw is better than old, both as litter and fodder, its threshing depends mainly on the wants of the stock; and as its use as litter is greater in winter, when wet weather prevails, the quantity then used is most considerable, and so must be the grain sent to market.

Sheep on Turnips.—The feeding of sheep on turnips, in the field, is practised in winter. When put on turnips early in winter, sheep consuming only a proportion of the crop, a favourable oppor-

tunity occurs for storing the remaining portion for cattle in case of bad weather. The proportion of turnips used by cattle and sheep determines the quantity that should be taken from the field.

Attention to Ewes.—Ewes roaming at large over pastures require attention in winter in frost and snow, when they should be supplied with clover-hay, or with turnips when hay is scarce. The *shepherd* has the charge of the sheep flock.

Marketing Grain.—The preparation of grain for sale is an important branch of winter farm business, and should be strictly superintended. A considerable proportion of the labour of horses and men is occupied in carrying grain to the market town or railway station—a species of work which used to jade farm-horses very much in bad weather, but railways have materially shortened the journeys of horses in winter.

Carting Manure.—In hard frost, when the plough is laid to rest, or the ground covered with snow, and as soon as

“By frequent hoof and wheel, the roads
A beaten path afford,”

farmyard manure is carried from the courts, and placed in large heaps on convenient spots near or on the fields which are to be manured in the ensuing spring. This work is continued as long as there is manure to carry away, or the weather proves severe.

Implements used in Winter.—Of the implements of husbandry, only a few are used in winter;—the plough is constantly so when the weather will permit; the threshing-machine enjoys no sinecure; and the cart finds frequent and periodic employment. The others are laid by for the winter.

Winter Marketing.—The winter is the season for visiting the market town regularly, where the surplus produce of the farm is disposed of—where articles are purchased or bespoke for the use of the farm, when the busy season shall arrive—where intermixture with the world affords the farmer an insight into the conduct of men.

Winter Recreation.—*Field-sports* have their full sway in winter, when the fields, bared of crop and stock, sus-

tain little injury by being traversed. Although farmers bestow but a small portion of their time on field-sports—and many have no inclination for them at all—they might harmlessly enjoy these recreations at times. When duly qualified, why should not farmers join in a run with fox-hounds?—or take a cast over the fields with a pointer?—or shout a see-ho to greyhounds? Either sport forms a pleasing contrast to the week's business, gives a fillip to the mind and a stimulus to the circulation. These sports are pursued only in fresh weather, and when the ground is not heavy with wet. Should frost and snow prevent their pursuit, curling and skating afford healthful exercise both to body and mind.

Winter Hospitality.—Winter is the season for country people reciprocating the kindnesses of hospitality, and participating in the amusements of society. The farmer delights to send the best produce of his poultry-yard as Christmas presents to his friends in town, and in return to be invited into town to partake of its amusements. But there is no want of hospitality nearer home. Country people maintain intercourse with each other; while the annual county ball in the market-town, or an occasional one for charity, affords a seasonable treat; and the winter is often wound up by a meeting given by the Hunt to those who had shared in the sport during the hunting season.

Domestic Enjoyment.—Winter is the season of *domestic enjoyment*. The fatigues of the long summer day leave little leisure, and less inclination, to tax the mind with study; but the long winter evening, after a day of bracing exercise, affords a favourable opportunity for conversation, quiet reading, or music. In short, there is no class more capable of enjoying a winter's evening in a rational manner, than the family of the country gentleman or of the farmer.

Repose of Nature.—Viewing winter in a higher and more serious light—in the repose of nature, as emblematical of the mortality of man—in the exquisite pleasures which man in winter, as a being of sensibility, enjoys over the lower creation—and in the eminence in which man, in the temperate regions,

stands, with respect to the development of his mental faculties, above his fellow-creatures in the tropics;—in all these respects, winter is hailed by the dweller in the country as the purifier of the mental as well as of the physical atmosphere.

Weather in Winter.—The *weather* in winter, being very precarious, is a subject of intense interest, and puts the farmer's skill to anticipate its changes severely to the test. Seeing that every operation of the farm is to some extent dependent on weather, a familiar acquaintance with local prognostics which indicate a change for better or worse becomes a duty. In actual rain, snow, or hard frost, few outdoor occupations can be executed; but if the farmer have wisely "discerned the face of the sky," he may arrange his operations to continue for a length of time, if the storm is to endure—or be left in safety, should the strife of the elements quickly cease. Certain atmospherical phenomena only occurring in winter should be noticed here—aurora borealis, halos, frost, ice, snow.

Aurora Borealis.—The only electrical excitation witnessed in winter is the *aurora borealis*. It consists of two varieties,—one a luminous quiet light in the northern horizon, gleaming most frequently behind a dense stratum of cloud; the other, vivid coruscations of white light, of sufficient transparency to allow a sight of the fixed stars. The coruscations are sometimes coloured yellow, green, red, and of a dusky hue: they are generally short, and confined to the proximity of the northern horizon; but occasionally they reach the zenith, and even extend to the opposite horizon, their direction being from N.W. to S.E.

The *prognostics* connected with the appearance of aurora in winter are these: When exhibiting itself in a gleam in the north, it is indicative of change; when it coruscates a little, the weather is decidedly changeable; and when the coruscations reach the zenith, and beyond, they augur cold stormy wind and rain. It has been long alleged that the aurora has the effect of producing a certain direction of wind. Mr Winn stated that in the south of England it was constantly followed by

a S.W. wind and rain, and that the gale always began from 3 to 24 hours after the phenomenon; and that the intensity of the storm, and the time it appears, may perhaps depend on the intensity of the aurora.¹ Coloured aurora is usually indicative of a change from good to bad.

Thunderstorms in Winter.—*Thunderstorms* are of rare occurrence in winter, owing, probably, to the generally humid state of the atmosphere carrying off the superfluous electricity silently, and not allowing it to accumulate in any one place. Sometimes, however, they do occur, and are generally violent and dangerous; at times setting fire to dwellings, rending trees, and destroying elevated buildings. Such storms are almost always succeeded by intense frost and a heavy fall of snow in the line of their march. Flashes of white lightning near the horizon are sometimes seen in clear fresh nights, when stars are numerous and twinkling, and falling stars plentiful, and they all indicate a coming storm.

Halos.—A *halo* is an extensive luminous ring, including a circular area, in the centre of which the sun or moon appears, and is seen only in winter. It is formed by the intervention of a cloud between the spectator and the sun or moon. This cloud is generally the denser kind of *cirro-stratus*, the refraction and reflection of the rays of the sun or moon at definite angles through and upon which cause the luminous phenomenon. The breadth of the ring of a halo is caused by a number of rays being refracted at somewhat different angles, otherwise the breadth of the ring would equal only the breadth of one ray. Mr Forster has demonstrated mathematically the angle of refraction, which is equal to the angle subtended by the semidiameter of the halo. Halos may be double and triple; and there is one which Mr Forster denominates a *discoïd* halo, which constitutes the boundary of a large corona, and is generally of less diameter than usual, and often coloured with the tints of the rainbow.² Halos are usually pretty correct circles, though they have been observed of an oval

shape; and are generally colourless, and sometimes display faint colours of the rainbow. They are most frequently seen around the moon, and acquire the appellation of *lunar* or *solar* halos, as they happen to accompany the particular luminary.

The *corona* or *brough* occurs when the sun or moon is seen through a thin *cirro-stratus* cloud, the portion of the cloud more immediately around the sun or moon appearing much lighter than the rest. Coronæ are double, triple, and even quadruple, according to the state of the intervening vapours. They are caused by a similar refractive power in vapour as the halo, and are generally faintly coloured at their edges. Their diameter seldom exceeds 10°. A halo frequently encircles the moon, when a small corona is more immediately around the moon's disc.

Weather Prognostics in Winter.—*Prognostics* indicated by appearances in the sky in winter may be noticed: Sharp horns of a new moon, and a clear moon at any time, are characteristics of coming frost.

In frost, the *stars* appear small, clear, and twinkling, and not very numerous; when few in number in fresh weather, it is certain that much vapour exists in the upper portion of the atmosphere; but if very numerous, having a lively twinkle, rain is indicated—the transparent vapour, in the act of subsiding into clouds, causing the twinkling.

Falling stars occur pretty frequently in winter, appearing in greatest number when stars are numerous, and are indicative of deposition of vapour, accompanied with wind from the point towards which they fall.

Dull sun, moon, and stars—occasioned by thin *cirro-stratus*, almost invisible—are indicative of change to rain in fresh, and to snow in frosty, weather.

Coronæ always indicate fall of vapour, whether in rain, snow, or hail, according to the warmer or colder state of the air at the time. *Coloured* coronæ and halos are sure indications of approaching fall of rain in fresh, and snow in frosty, weather.

Clouds in Winter.—The most common cloud in winter is the *cirro-stratus*, whether in the state of a shrouding veil,

¹ *Field Natur.*, i. 108.

² Forster's *Atmos. Phen.*, 101-107.

more or less dense, across the whole sky for days, or in heavy banked clouds in the horizon before and after sunset. Whenever this cloud is present, there must be a large amount of vapour in the air, coming nearer to the ground as the power that suspends it is by any means weakened. Rain mostly falls direct from the cirro-stratus; but ere snow falls in any quantity, the cirro-stratus descends to the horizon into cumulo-stratus, from whence it stretches over the zenith in a dense bluish-black cloud. Cirri in winter are a sure indication of a change of wind in twenty-four or more hours from the quarter to which their turned-up ends point; but if their ends do not turn up, rain may be expected in twelve hours. Rain follows sooner than wind. It may be taken as an established fact, that if Noah's ark does not extend over the zenith, rain or wind will be experienced only at the place where it does span over the zenith.

Winter Rain.—The character of *winter rain* has more of cold and discomfort than of quantity. When frost suddenly gives way in the morning about sunrise, rain may be looked for during the day. If it do not fall, a heavy cloudiness will continue all day, unless the wind change, when the sky may clear up. If a few drops of rain fall before mid-day after the frost has gone, and then ceases, a fair and most likely a fine day will ensue, with a pleasant breeze from the N. or W., or even E. When the moon shines brightly on very wet ground, the shadows of objects become very black; which is a sign of continuance of rain, and unsettled state of the wind. Rain often falls with a rising barometer, which is usually followed by fine healthy weather, attended with feelings that indicate a strong positive state of electricity. "We have," says Mr Forster, "usually a warm and agreeable sensation of the atmosphere with such rain, which is strikingly contrasted to the cold and raw sensation occasioned by the fall of thick wet mists or rain, which happens when, even with a N. or E. wind, the barometer and thermometer sink together, and when the air has previously been found to be either negatively or non-electrified; and the cause of this is most probably oc-

casioned by a supervening current of colder or supersaturated air; and the rise of the thermometer, which accompanies the fall of the barometer in this case, may be owing to the increase of temperature produced by the condensation of the vapour in the case of rain."

Winter Winds.—"Gusts of *wind*, in some high windy weather, seem to fluctuate in a manner somewhat analogous to the undulatory motion of waves. This fact may easily be seen by a pendulous anemometer. When the wind is accompanied by the rain, the periods of the gusts may be counted by the intervals of the more or less violent impulses of the water on the windows opposed to the wind, or the leaves of any tree twined across them."¹

Utility of Rain.—Rain is useful in husbandry by consolidating light soils, and dissolving and carrying down solutions of manure *into* the soil—when sheep are feeding on turnips, for example—and placing them beyond the reach of evaporation; but its chief utility in winter is supplying threshing machinery, or irrigation, with abundance of water.

Cold and Frost.—*Frost* has been represented to exist only in the absence of heat; but, more than this, it also implies an absence of moisture. Sir Richard Phillips defines *cold* to be "the mere absence of the motion of the atoms called heat, or the abstraction of it by evaporation of atoms, so as to convey away the motion, or by the juxtaposition of bodies susceptible of motion. Cold and heat are mere relations of fixity and motion in the atoms of bodies."²

Frost, it is supposed, originates in the upper portions of the atmosphere, by expansion of the air carrying off existing heat, and making it susceptible of acquiring more. What the cause of the expansion may be, when no visible change has taken place in the meantime in the ordinary action of the solar rays, may not be obvious to a spectator on the ground; but it is known, from the experiments of Lenz, that electricity is as capable of producing cold as heat, to the

¹ Forster's *Atmos. Phen.*, 247 and 342.

² Phillips's *Facts*, 395.

degree of freezing water rapidly.¹ The poles of cold and the magnetic poles probably coincide.²

The most intense frosts in this country never penetrate more than one foot into the ground, on account of the excessive dryness occasioned by the frost itself withdrawing the moisture. Frost cannot penetrate through a thick covering of snow, or below a sheet of ice, or through a covering of grass on pasture, or the fine tilth on ploughed land, all which act as non-conductors against its descent.

Beneficial influence of Frost.—

Frost is always present in winter, though seasons do occur in which very little exists. It is a useful assistant to the farmer in pulverising the ground, and rendering the upper portion of the ploughed soil congenial to the vegetation of seeds. It acts in a mechanical manner on the soil, by freezing the moisture in it into ice, which, on expanding at the moment of its formation, disintegrates the indurated clods into fine tilth. Frost always produces a powerful evaporation of the pulverised soil, and renders it very dry on the surface; by the affinity of the soil for moisture putting its capillary power into action, the moisture from the lower part of the arable soil, or even from the subsoil, is drawn up to the surface and evaporated, and the whole soil is thus rendered dry. Hence, after a frosty winter, it is possible to have the ground in so fine and dry a state as to permit the sowing of spring wheat and beans, in the finest order, early in spring. Frost, being favourable to the exhibition of electricity, may also prove useful to husbandry, by stimulating its influence, not only in the soil but on vegetation.

Snow.—Rain falls at all seasons, but snow only in winter, or late in autumn, and early in spring. Snow is just frozen rain, so that whenever symptoms of rain occur, snow may be expected if the temperature of the air is sufficiently low to freeze vapour. Vapour is supposed to be frozen into snow at the moment it is collapsing into drops to form rain, for clouds of snow cannot float about the

atmosphere any more than clouds of rain.

"If flakes of snow," observes Kaemtz, "are received on objects of a dark colour, and at a temperature below the freezing-point, a great regularity is observed in their forms: this has for a long time struck attentive observers. The crystals of ice are never so regular as when snow falls without being driven by the wind; but temperature, moisture, the agitation of the air, and other circumstances, have a great influence over the forms of the crystals. Notwithstanding their variety, they may be all associated under a single law. We see that isolated crystals unite under angles of 30, 60, and 120 degrees. Flakes which fall at the same time have generally the same form; but if there is an interval between two consecutive falls of snow, the forms of the second are observed to differ from those of the first, although always alike among themselves."³

Forms of Snow.—The forms of snow have been arranged by Scoresby into 5 orders: 1. The *lamellar*, which is again divided into the *stelliform*, *regular hexagons*, *aggregation of hexagons*, and *combination of hexagons* with radii, or spines and projecting angles. 2. The *lamellar* or *spherical nucleus* with spinous ramifications in different places. 3. Fine *spiculae* or 6-sided prisms. 4. *Pyramids* with six faces. 5. *Spiculae*, having one or both *extremities* affixed to the *centre* of a *lamellar* crystal. There are numerous varieties of forms of each class.⁴

All the forms of crystals of snow afford most interesting objects for the microscope, and when perfect no objects in nature are more beautiful and delicately formed. The lamellated crystals fall in calm weather, and in heavy flakes, and are evidently precipitated from a low elevation. The spiculae of 6-sided prisms occurring in heavy drifts of snow, accompanied with wind and intense cold, are formed at a considerable elevation, and are so fine as to pass through the minutest chinks in houses, and so hard and firm that they may be poured like sand from hand to hand, with a jingling

¹ Bird's *Nat. Phil.*, 232.

² Kaemtz's *Meteo.*, 462.

³ Kaemtz's *Meteo.*, 127.

⁴ Scoresby's *Pol. Reg.*

sound, and without the risk of being melted. In this country spiculæ are most frequently accompanied by one of the varieties of the lamellar crystals, which meet their fall at a lower elevation; but in mountainous countries, and especially above the line of perpetual snow, they constitute the greatest bulk of the snow, ready to be blown about with the wind, and lifted up in dense clouds, and precipitated suddenly upon the unwary traveller like sand-drift of the torrid zone. These spiculæ feel sharp when driven against the face, as is experienced on Mont Blanc.

Professor Leslie supposes that, all other things being equal, a flake of snow, taken at 9 times more expanded than rain, descends 3 times as slow.

From the moment snow alights on the ground it begins to undergo certain changes, which usually end in a more solid crystallisation than it originally possessed. The adhesive property of snow arises from its needly crystalline texture, aided by a degree of attendant moisture which afterwards freezes in the mass. Sometimes, when a strong wind sweeps over a surface of snow, portions of it are raised by its power, and, passing on with the breeze under a diminished temperature, become crystallised, and by attrition assume globular forms.

Snow keeps Land warm.—During the descent of snow the *thermometer sometimes rises*, and the *barometer usually falls*. Snow has the effect of retaining the temperature of the ground at what it was when snow fell. It is this property which maintains the warmer temperature of the ground, and sustains the life of plants during the severe rigours of winter in the arctic regions, where the snow falls suddenly after the warmth of summer; and it is the same property which supplies water to rivers in winter, from under the perpetual snows of the alpine mountains. "While air, above snow, may be 70° below the freezing-point, the ground below the snow is only at 32°."¹ Hence the fine healthy green colour of young wheat and grass after the snow has melted in spring.

Snow-water and Rain.—In melting,

27 inches of snow give 3 inches of water. Rain and snow-water are the *softest* natural waters for domestic purposes, and are also the purest that can be obtained from natural sources, provided they are caught before reaching the ground. Nevertheless, they are impregnated with oxygen, nitrogen, and carbonic acid, especially with oxygen; and rain-water and dew contain nearly as much air as they can absorb.² Liebig considers that ammonia is the probable cause of the great softness of rain and snow-water.

Falls of Snow.—A heavy fall of snow generally commences in the evening, continues throughout the next day, and at intervals in succeeding days. Snow-showers may fall heavily for the time; and when they fall, and the sky clears up quickly, another shower may follow. In such a case, the air always feels cold. In moonlight, masses of cumulo-strati may be seen to shower down snow at times, and then roll across the face of the moon with the most beautiful fleecy and rounded forms imaginable. The forms of flakes of snow are pretty correct indications of the amount of fall to be; as, when large and broad, and falling slowly, there will not be much, and the probability is that thaw will soon follow; but when they fall thick and fast, and of medium size, there may be some inches before it fairs, and may lie some time. When flakes are spicular and fall very thick and fast, a heavy fall may be expected, accompanied with a firm breeze of wind, varying from N.E. to S.E. Neither frost nor snow will last long if either come when the ground is in a wet state from rain.

Uses and Drawbacks of Snow.—Snow renders important services to husbandry. If it fall shortly after a confirmed frost, it acts as a protective covering against its further cooling effects on soil, and in this way protects the young wheat and clover from destruction by intense frosts. On the other hand, frost and rain and snow may all retard the operations of the fields in winter very materially, by rendering ploughing and the cartage of turnips impracticable. Heavy snow-

¹ Phillips's *Facts*, 440.
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² Reid's *Chem. Nat.*, 192.

storms are also very detrimental to the interests of sheep farmers.

Hoar - frost. — *Hoar - frost* is not always frozen dew, for dew is sometimes frozen in spring into globules of ice which do not at all resemble hoar-frost, which is beautifully and as regularly crystallised as snow. The formation of hoar-frost is always attended with a considerable degree of cold, because it is preceded by great radiation of heat and vapour from the earth, and the phenomenon is the more perfect the warmer the day and clearer the night. In the country, hoar-frost is of most frequent occurrence in autumn and winter, in such places as have little snow or continued frost; and this arises chiefly from great radiation of heat and vapour at those seasons, occasioned by a suspension of vegetable action admitting of little absorption of moisture for vegetable purposes.

Dr Farquharson, Alford, Aberdeenshire, observed that the mean temperature of the day and night at which injurious hoar-frosts may occur may be, relatively to the freezing-point, very high. Thus, on the nights of the 29th and 31st August 1840, leaves of potatoes were injured, while the lowest temperatures of those nights, as indicated by self-registering thermometers, were as high as 41° and 39° respectively.

Hoar-frost takes place only during calm. A slight steady breeze will quickly melt away frosty rime.

The air is always unclouded at the time of hoar-frost. So incompatible is hoar-frost with a clouded state of the atmosphere, that on many occasions when white frosty rime has been formed in the earlier part of the night, the passage of a close cloud at a later part has melted it off before sunrise.

Hoar-frosts most frequently happen with the mercury in the barometer at a high point and rising, and with the hygrometer at comparative dryness for the temperature and season; but there are striking exceptions to these rules.

In general, low and flat lands in the bottoms of valleys, and grounds that are land-locked hollows, suffer most from hoar-frost, while all sloping lands and open uplands escape injury. But it is not their relative elevation above

the sea, independently of the freedom of their exposure, that is the source of safety to the uplands; for if they are enclosed by higher lands, without any wide open descent from them on one side or another, they suffer more than similar lands of lesser altitude.

A very slight inclination of the surface of the ground is generally quite protective of the crops from injury by hoar-frost, while flat and hollow places suffer at the time great injury. But a similar slope downward in the bottom of a narrow descending hollow does not save the crop, although that on either side of the banks higher up may be safe.

An impediment of no great height on the surface of the slope, such as a stone-wall fence, causes damage immediately above it, extending upwards proportionally to the height of the impediment. A still loftier impediment, as a tall wood or belt of trees, across the descent, or at the bottom of sloping land, causes damage more severely.

Rivers have a bad repute as the cause of hoar-frosts in their neighbourhood; but the general opinion regarding their evil influence is erroneous: the protective effect of *running* water, such as rivulets or waterfalls from mill-sluiques, on patches of potatoes, when others in like low situations are blackened by frost, is an illustration which can be referred to.

The severity of the injury by hoar-frost is much influenced by the wetness of the soil at the place; and this is exemplified in potatoes growing on haugh-lands by the sides of rivers. These lands are generally dry, but bars of clay sometimes intersect them, over which the land is comparatively damp. Hoar-frost will affect the crop growing upon these bars of clay, while that on the dry soil will escape injury; and the explanation of this is quite easy. The temperature of the damp land is lower than that of the dry, and on a diminution of the temperature during frost, it sooner gets down to the freezing-point, as it has less to diminish before reaching it.¹ Young potato-plants are exceedingly susceptible of being blackened by hoar-frost.

¹ *Trans. High. Soc.*, xiv. 250.

Frost-smoke.—Clear calm air, admitting much sunshine at the middle of the day, is very bracing, healthy, and agreeable; but in the evening of such a day the sun usually sets in red, and a heavy dew falls, which is frozen into *rime*, incrusting every twig of trees and shrubs into the semblance of white coral. When the cold is intense, the dew is frozen before it reaches the objects on which it is deposited, and it then appears like smoke or mist, and is called "*frost-smoke*," which, when deposited on the naked branches of trees and shrubs, converts them into a semblance of the most beautiful filigree-work of silver. This mist may last some days, during the day as well as night, and then new depositions of incrustated dew take place on the trees and walls every night, until they seem overloaded with it. The smallest puff of winter wind dispels the enchanting scene.

Winter-fog.—Winter-fog, as long as it hovers about the plains, is indicative of dry weather; but when it betakes itself to the hills, a thaw may be expected soon to follow; and nothing can be more true than "He that would have a bad day, may go out in a fog after frost;" for no state of the air can be more disagreeable to the feelings than a raw rotten fog after frost, with the wind from the S.E.

Hail.—*Hail*, consisting of soft, snowy, round, spongy masses, frequently falls in winter after snow, and may lie for some time unmelted.

Ice.—Though a solid, *ice* is not a compact substance, but contains large interstices filled with air, or substances that have floated on the surface of the water. Ice is a confused mass like the inside of the rolls of brimstone, but in the progress of crystallisation on the margin of water, needles are seen to shoot out in angles of 30°, 60°, and 120°. It is quickly formed in shallow, but takes a long time to form in deep water; and it cannot become very thick in the lower latitudes of the globe, from want of time and intensity in the frost. By 11 years' observations at the observatory at Paris, there were only 58 days of frost throughout the year, which is too short and too desultory

a period to freeze *deep* water in that latitude.

Process of Freezing.—The process of the freezing of water into ice is like a freak of nature. The water *contracts in bulk* by the frost, until it reaches the temperature of 39°.39, when it is in its state of greatest density and least bulk, and then sinks in layer after layer. After this the water resists frost in calm air, until it reaches 28°, *without decreasing further in bulk*, and it remains floating on the warmer water below it, which continues at 39°.39. So placed, and at 28°, whenever agitated it freezes, and suddenly starts up to 32°, and then in the form of ice as suddenly *expands* one-ninth more in bulk than at its ordinary temperature, and of course more in bulk than in its most condensed state of 39°.39. After water has undergone all these mutations, it retains its expanded state as ice until that is melted.

So great is the force of water on being suddenly expanded into ice, that, according to the experiments of the Florentine Academy, every cubic inch of it exerts a power of 27,000 lb.

Sea-Water Freezing.—*Sea-water* freezes at once on the surface, and that below the ice retains the temperature it had when the ice was formed. Frost in the polar regions becomes suddenly intense, and the polar sea becomes as suddenly covered with ice, without regard to the temperature of the water below. The ice of the polar sea, like the snow upon the polar land, thus becomes a protective mantle against the intense cold of the atmosphere, which is sometimes as great as 70° below zero. In this way sea animals, as well as land plants, in those regions are protected at once, and securely, against the effects of the intensest cold.

Evaporation from Ice.—*Ice evaporates moisture as largely as water*, which property preserves it from being easily melted by any unusual occurrence of a high temperature of the air, because the rapid evaporation, occasioned by the small increase of heat, superinduces a great counteracting coldness on the surface of the ice.

Cooling Power of Ice.—The *great cooling powers of ice* may be witnessed

by the simple experiment of mixing 1 lb. of water at 32° with 1 lb. at 172° —the mean temperature of the mixture will be as high as 120° ; whereas 1 lb. of ice at 32° , on being put into 1 lb. of water at 172° , will reduce the mixture to the temperature of ice—namely, 32° . This perhaps unexpected result arises from more heat being required to break up the crystallisation of ice than to heat water.

Relation of Wind to Rain and Snow.—The true character of all the phenomena of rain and snow is much modified by the *direction of the wind*. In winter, it may be generally stated as a fact, that when the wind blows from the N.W. to S.E. by the N. and E., cold and frost may be looked for as certain, and if there are symptoms of a deposition from the air, snow will fall; but if the wind blows from the S.E. to N.W. by the S. and W., fresh weather and rain will ensue. Heavy falls of snow occur, however, with the wind direct from the S.; but they are always accompanied with cold. In this case, the wind veers suddenly from the N. or N.E. to the S., which causes the lower stratum of vapour to expand by the introduction of warm air, and the heavy cold vapour above then suddenly descends in quantity.

Any wind that blows for a considerable length of time, such as two or three days, lowers the temperature of the air considerably. When any wind blows a good way overhead, it will be fair weather for some time, or until a change of the wind take place; but when it blows very near the ground, and is raw, chilly, and thin to the feelings, rain will follow in fresh weather, and thaw in frost. Mostly all winds begin to blow in the upper portion of the atmosphere; and whether they will descend to the earth or not depends on the quantity, first, of the cirri, and then of the cirri-strati, in the air. Very frequently different currents of air, at different elevations, may be seen in winter at the same time by means of the motions of the clouds. These motions may be in the same or in contrary directions. When this is observed, it may be relied upon that the uppermost current will ultimately prevail. It is char-

acteristic of winds in winter to shift much about—sometimes to all points of the compass in the course of 24 hours, and seldom remaining more than three days in one quarter. Winter winds are heavy, overpowering, stormy.

Sky-tints.—A difference in the blue tint of the *sky* in winter indicates a fall of different states of moisture: if of a deep blue, in fresh weather, rain will fall; of a yellowish or greenish colour near the horizon in frost, snow will certainly come; and on a clear watery blue opening in the clouds occurring in fresh weather near the horizon in the S., a heavy rain may be expected.

PREPARING AND COMMENCING WINTER OPERATIONS.

The Agricultural Year.—Attention will now be directed to the *practice* of farming. The agricultural year commences immediately after the completion of harvest, and of the sowing of autumn wheat; and as these operations may be finished sooner or later, according to the lateness or earliness of the season, so the agricultural year may commence sooner or later in different years. It seldom, however, commences before the middle of October, which it does when the harvest has been early. It may be postponed until towards the end of November when the harvest is very late.

Mixed Husbandry.—To preserve consistency in practice, it is necessary to adopt some regular method of good farming, and as *mixed* husbandry is the most comprehensive as well as the most general, it has been chosen. It is eminently adapted for the purpose of learning farming, since it embraces the raising of grain, as on heavy carse clays; of root and forage crops, as on farms in the neighbourhood of large towns; the rearing of stock, as in pastoral farming; the making of cheese and butter, as in dairy farming; and the feeding of cattle and sheep on grass in summer, and on turnips and other food in winter, as in common farming.

As large farms afford greater scope for managing the arrangements of labour than small, and as the mixed husbandry

is suited to a large farm, we shall suppose we occupy a farm of 500 imperial acres.

The seasons usually permitting the finishing of harvest before the grass

fails, the winter operations begin with ploughing. In an early winter, however, the ploughing is sometimes postponed, that turnips may be brought to the live stock housed in the steading.

PLOUGHS AND PLOUGHING.

THE PLOUGH, SWING-TREES, AND PLOUGH-HARNESS.

The *plough* serves the same purpose to the farmer as the spade to the gardener, both being used to *turn over* the soil. The object of both in doing so is to bring the soil into a state fit for the reception of the seed.

Digging and Ploughing.—The operation of the plough upon the soil is to imitate the effect of the *spade* upon it; but the plough being too large and heavy to be wielded by hand, it is not under man's control, as is the spade. The ploughman is obliged to call in the aid of horses to wield it, and through their means, in combination with harness, he can command its motions effectively. Turning over the soil with so very simple an implement as the spade seems an easy operation; but the act of digging is neither simple nor easy, requiring every muscle of the body to be put in action, so that any implement to imitate that action perfectly would be obliged to have a very complicated structure. This would be the case even were the machine fixed to a spot; but it is a difficult problem in practical mechanics to construct a light, strong, durable, and easily moved implement, which shall attain a complex result by a simple action. The modern plough is an implement possessing these properties to a certain extent, and is the most convenient implement as yet designed for the purpose.

Construction of the Common Plough.—The common plough used in this kingdom is made either wholly of iron, or partly of wood and partly of iron. Formerly it was universally made of wood and iron, but now almost as universally of iron alone. It is now made so, because iron withstands the changes

of weather better than wood—a desirable property in any implement that must necessarily be much exposed to weather—and because, when old, iron is worth something, whereas ash timber is now scarce, dear, and worthless when decayed,—another advantage being, that iron implements are not so clumsy as those made of wood. An ordinary two-horse wooden plough with iron mountings weighs 14 stones imperial, and an iron one for the same work 15 to 20 stones.

Varieties of Ploughs.—Two varieties of ploughs, Small's and Wilkie's, were originally used in Scotland, and from these nearly all the forms now in use have been derived. The varieties to be found throughout the country are almost innumerable, most implement-makers having several patterns of their own.

Ordinary Scotch Plough.—Fig. 9 is the *furrow-side* elevation of the ordinary Scotch iron swing-plough. The ploughman holds and guides the implement by the *stilt*s. The *bridle* or “muzzle” with the hook, is that part by which the horses are attached to the beam. The *coulter* is the cutting instrument that severs the slice of earth or furrow from the firm land. The *sock* or share severs the slice below from the subsoil. The *mould-board* receives the slice from the sock, turns it gradually over, and deposits it continuously at an angle. The coulter has a sharp cutting edge in front, and is slightly inclined that it may cut the cleaner.

Fig. 10 is the *land-side* elevation of the same plough. The *land-side plate* presents a straight broad surface to the firm land, and prevents the earth falling within the body of the plough. The sole-shoe supports the plough, and slides upon the firm subsoil below. The attachment of the sock is with the lower

end of the head of the plough, which is concealed in the figure, and which is fixed to the beam by its upper end.

The ear of the mould-board prevents the earth falling into the bosom of the plough on that side.

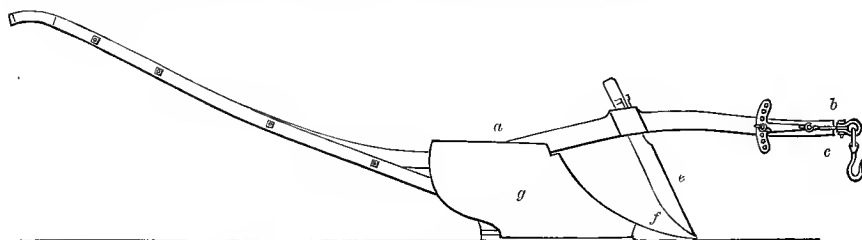


Fig. 9.—Furrow-side elevation of a Scotch swing-plough.

a b Beam.
c Bridle, with its hook.

a d Stilts or handles.
e Coulters.

f Sock or share.
g Mould-Board.

Fig. 11 is a plan of the same plough. The lines of the body of the plough on the land side are in one plane from the

bridle to the end of the great stilt. The head of the coulters is fastened in a socket in the beam by means of iron

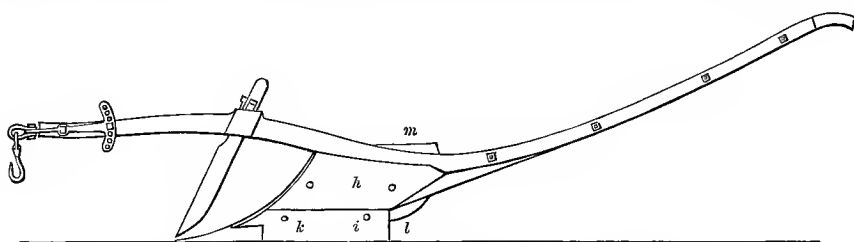


Fig. 10.—Land-side elevation of a Scotch swing-plough.

h Land-side plate.
i Sole-shoe.

k Onset of the sock.
l Heel.

m Ear of mould-board.

wedges. The rake of the coulters varies from 55° to 65° . In the mould-board the upper edge is straight, and the

breast is formed on the lines of a screw, or a plate twisted about itself, the fore part of which is truncated. The sock is

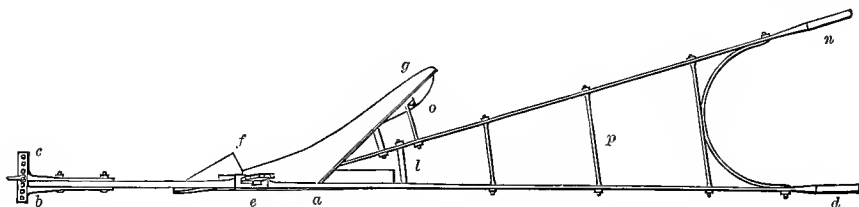


Fig. 11.—Plan of a Scotch swing-plough.

b d Straight line of body.
a b Beam.
c Bridle.
a d Great stilt.

a n Little stilt.
e Head of coulters.
f Feather of sock.
g Ear of mould-board.

l Heel.
o Bolts fastening the mould-board to the little stilt.
p Stays to support the stilts.

pointed, with a feather having a breadth of at least two-thirds the breadth of the furrow, and its cutting edge lying about

as low as the plane of the sole. The neck of the sock is prolonged backward, joining and coinciding with the curve of the

mould-board at its truncated end. This plough cuts a furrow-slice of 10 inches in breadth by 7 inches in depth, leaving the sole open level and clean. This width and depth are pretty near the standard size of furrow for two-horse ploughing on ordinary soils, and these proportions are the best adapted for the ends in view where a greater or lesser furrow-slice is desired.

Modern Scotch Plough. — The general differences between the modern Scotch and English ploughs are that an English plough has usually two wheels and chill-metal shares, while the Scotch

has no wheel, or at most only one, and has wrought-iron shares. Less skill is required to hold a plough with two wheels; but in skilled hands the plough is, perhaps, more useful and more controllable without wheels. The main reason, no doubt, why Scotch farmers have adhered so largely to the use of the wrought-iron shares, is that their soil is of a very variable and stony nature, for which the chill-metal shares are not quite so suitable. They cannot be so easily adapted to stony and unequal soil as the wrought-iron shares, which can be altered by any country blacksmith

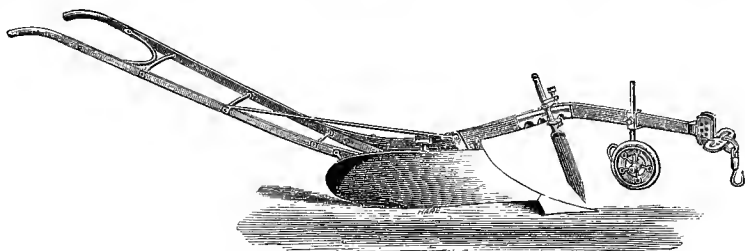


Fig. 12.—Sellar's modern Scotch plough. (Side view.)

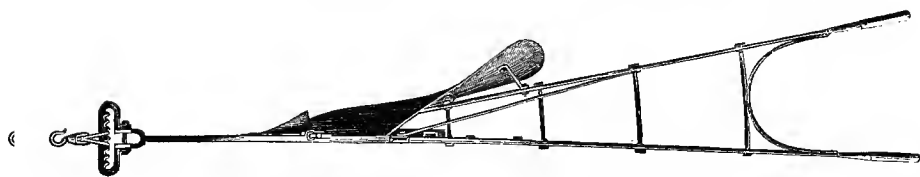


Fig. 13.—Sellar's modern Scotch plough. (Vertical view.)

to suit stony or clayey land, and to cut a rectangular or high-cut furrow of any shape as desired.

Figs. 12 and 13 represent the side and

vertical views of Sellar's modern Scotch plough.

English Wheel-plough. — Fig. 14 gives a furrow-side view of Ransome's



Fig. 14.—Ransome's "Newcastle" plough.

wheel-plough, one of the most improved of modern English forms. It is fitted with two wheels of unequal size on the

front part of the beam, one of which is intended to run on the top of the ground, and the other at the bottom of the furrow.

By means of these the width and depth of the furrow-slice are regulated, so that the plough is kept steadily at the one place, and thus the draught is made easier for the horses, and less skill and exertion are needed on the part of the ploughman. It is also fitted with a skim coulter, the object of which is to pare off a little piece of the edge of the furrow-slice, so that the grass or surface-rubbish may be completely buried when the soil is turned over. The mould-board is removable, so that a long or

short one can be used according to the kind of work desired. In wheel-ploughs the stilts are shorter and the beams longer than is the case with the swing-plough; and as the wheels really do the guiding part of the work, the handles could be dispensed with altogether, as is actually done in the case of the "gang-ploughs" of America.

Chilled Ploughs.—In recent years there has been introduced into this country a modification of these latter ploughs—viz., the American chilled-steel plough.

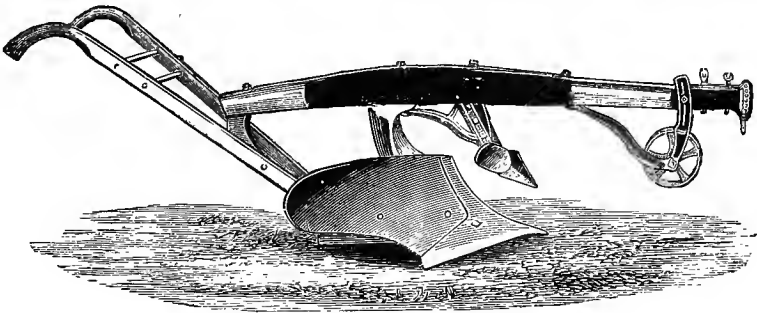


Fig. 15.—*Oliver's chilled plough.*

Fig. 15 represents Oliver's chilled plough, one of the best of the kind. This differs completely in appearance from those in common use in Britain in being very short and dumpy, though the beam is about the usual length. The principal point of difference lies, however, in the fact that the wearing parts are made of chilled steel, which takes on an exceedingly fine polish, thus

reducing the friction of the draught some 25 to 30 per cent less than that of common ploughs, which have their breasts of ordinary steel or cast-iron only. The short wide-set mould-board has the effect of pulverising the furrow-slice as the plough goes along; and as it takes a great width in proportion to the depth, a large acreage can be quickly gone over. This sort of ploughing,

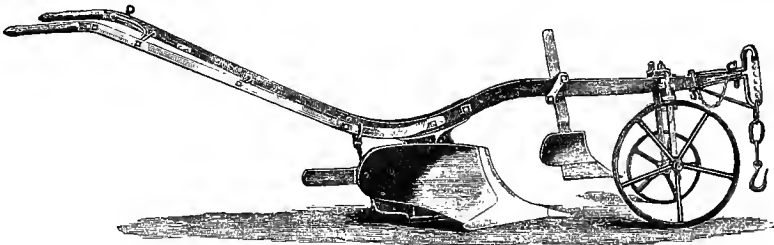


Fig. 16.—*Ransome's chilled plough.*

however, is suitable only for the moderate and lighter class of soils, and is not so well adapted for those of a heavy nature; the reason for which will be apparent when the principles of me-

chanics on which the plough works are explained.

Chilled ploughs are now made by several British firms, and the demand for them is very large and still increasing.

In figs. 16 and 17 are represented two of the best British chilled ploughs, made respectively by Ransome, Sims, & Jefferies, of Ipswich, and J. & F. Howard of Bedford.

MECHANICS OF THE PLOUGH.

The ordinary swing-plough, looked at

as a machine, is a combination of some four of the "mechanical powers." The stilts with the body form a lever of the "first" or "second" kinds according to the way in which they are used. The share and front part of the wrest form an "inclined plane," up which slides the furrow-slice for a certain distance. The whole body of the implement forms

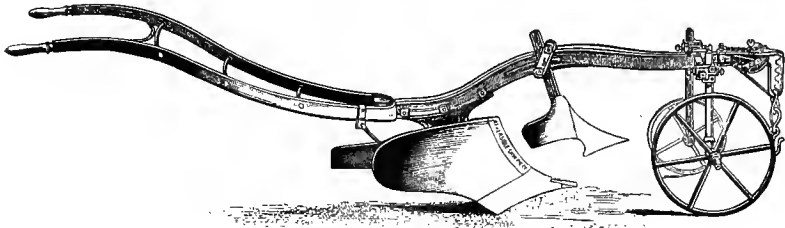


Fig. 17.—Howard's chilled plough.

a "wedge," as does also the coulter of itself; and the wrest or mould-board is to some extent a "screw."

Length of Stilts and Leverage.—In the case of the lever, every one knows from experience that the longer the "arm" or end at which the power or force is applied in proportion to the length of the other end, so much the more effective will be the "purchase" or ability to move a weight—as in the case of a labourer moving a stone with a crowbar. Applying this to the plough, we find that whether the heel of the sole-plate is used as a fulcrum (1st kind) in pressing down the handles, or the point of the share (2d kind) in lifting them up, the longer the stilts are the more power shall we have to do so—*i.e.*, to guide the implement easily. On the other hand, the length is limited by the necessity for easy manipulation of horses at the land ends, so that a medium of 6 or 7 feet is usually adopted between *a* and *d*, fig. 11. There are ploughs in practical use, however, with stilts 10 feet long.

Length of Beam.—On the other hand, the beam, *a b*, fig. 9, ought to be as short as possible. The horses are yoked to the end of it, and any unsteadiness on their part is communicated to the plough and must be counteracted by the ploughman, so that the less leverage power the animals have the

more easily will the plough be held. The actual length is regulated by the "line of draught," which will be explained further on.

Body of Plough and Length of Wrest.—The body of the plough—including the coulter and share, as well as the wrest, cheek-plates, and sole-plate—is a combination of the inclined plane, wedge, and screw—the two latter of these being in their mechanical principles simply modifications of the first—so that we may study their various actions as parts of one whole. It may be necessary to explain that the power exerted and work done in connection with an inclined plane varies according to the perpendicular height of the plane and the horizontal length. In other words, if we have two inclined planes of equal height, but the one double the length of the other, then a body will be pushed up the longer one with one-half the exertion required for the shorter—neglecting friction,—but the time occupied will be double. The wedge is simply two inclined planes put base to base, and the same reasoning is true of it—that is, the thinner the wedge or more gradual the slope, the more easily it is driven. Applying this to the plough, we find that the coulter, share, wrest, cheek-plates, and sole-shoe, all form more or less continuous parts of a large wedge or moving inclined

plane. The weight or body to be moved is represented by the furrow-slice, both as regards its actual weight and its tenacity or toughness; and from what has been already said it will be seen that the wrest should be as long as possible, as it will thus be equivalent to a gradual incline. It also follows that a short wrest stuck out at a greater angle will use up more of the power of the horses, just as a steep brae would do. On the other hand, if the wrest and body were too long it would make the implement unwieldy, and limit the leverage power of the handles, so that experience has taught that a medium of 30 to 36 inches is best, though ploughs with wrests about four feet long are in use.

Friction of the Earth.—The friction of the earth on the parts is a point of importance, and requires separate consideration. The law of friction is that it varies as the weight or pressure, and that it is independent of extent of surface, but roughness or smoothness of surface influence it very much. Applying this to our plough, it shows that the mere extent of surface sliding in contact with the soil has little effect; but, as already shown, a short wide wrest gives greater resistance to passage through the soil, and it follows that the friction on such will be greater than on a long-bodied tool. As regards the smoothness, the metal must take on as fine a polish as possible, and work clear or cleanly, as if earth lodges on the face of the breast, or the metal is rough, the friction will be immensely increased. Short mould-boards, of course, will break up and pulverise the furrow-slice more, and for this reason are often employed—independently of their greater difficulty of draught—especially on the lighter class of soils; but they are not so well suited for heavy lands, as none but the longer breasts will work satisfactorily there.

Wheels on Ploughs.—Wheels are put on ploughs for two reasons—viz., to keep the plough steadily at the one width and depth, and also to lessen the friction. In fig. 14 the front end of the beam is elongated a little, so as to allow of fitting on two wheels, whereby the former purpose is attained. There is

nothing that tires out horses so quickly as jerky irregular work, a trouble that is obviated by these wheels, or even by the use of one alone running on the surface. More is necessary, however, for lessening the friction. The sole-plate and cheek have to bear about one-half of the total weight or friction on the whole plough body, and if we substitute wheels for these we can diminish it greatly. For this purpose the wheels must be placed either in a line with the body of the tool, or else behind it, as exemplified by the “gang” or wheel ploughs in common use in America—in which case the front wheels are sometimes dispensed with altogether. The friction at the axle of a wheel is, of course, very much less than that of the two large sliding surfaces.

Yoking Horses to a Plough.—In the yoking of the horses, again, certain mechanical principles come into play. The “centre of resistance” of the plough—that is, the point round which it would naturally balance itself when moving in work—is not a fixed point, but is about the heel of the share, and in the middle of the body. The horses really pull from this part; but as it is impossible to yoke them directly to it, the beam comes into use for this purpose, and the line of draught from the shoulder-hook of the haims to this point must pass through the bridle of the beam, else the plough will not move properly at the depth required. Again, the plough moves forward in a horizontal direction, while the horses are pulling obliquely upwards. Some portion of their power is therefore wasted from this indirectness, while to counteract the tendency to go upward, the point of the share is turned down a little, or the plough is set with a tendency to go deeper of itself. The draught-chains should therefore be as long as possible, consistent with convenience of handling, while a foot or so of chain between the whipple-trees and bridle is a great help. Practice has ruled that a total of about 10 feet from shoulder-hook to bridle-pin is the best mean.

Weight of Ploughs.—Ploughs, of course, must not be too heavy; but, on the other hand, they might be too light,

not only on account of the liability of the parts to be too weak, but also because a heavy article has more "inertia"—that is, power of its own weight or mass to resist little jerks or shocks from stones, &c. Practice in this case, again, has found that 15 to 20 stones are the handiest limits.

Advantages and Disadvantages of American Ploughs.—From these statements of elementary facts in mechanics, it will be seen that the short, dumpy, and light American ploughs are made contrary to the ordinarily accepted rules of proportion of parts. But on the lighter and easier-worked soils this does not hinder them from being successfully used, more especially as their pulverising power is a desirable point in such cases. The stilt is so short that wheels are a necessity in guiding, as the ploughman has little control over them, while the large angle of the breast increases the draught more than a long sloping one would do. Their superiority lies in the material of which they are made—the fine polish of the wearing surfaces reducing the draught to a very great extent. Their defective principles, however, prevent them from being suitable for stiff land; clay soil will not pulverise, while the ploughman has not sufficient leverage power to be able, even with the aid of wheels, to hold them steadily with any degree of comfort. If the ordinary style of plough were made of the same material as these, it would be found a better all-round implement.

Draught of Ploughs.—There is a very great variation in the draught of different ploughs—that is, in the amount of power required by the horses to pull them through the soil. By means of a dynamometer this force can be measured in pounds or hundredweights, and of course, if everything else is right, the less exertion required by the horses the better. In the older forms of the plough—made mostly by country blacksmiths of malleable and cast iron, and still in very common use—the draught for a furrow 10 inches wide and 7 inches deep in medium soil is from 3 to 5 cwt. This is quite within the power of two good ordinary farm-horses, but it may be looked on as the limit, and no one

who inquires into the matter will be satisfied nowadays with an implement requiring more power than this to work it.

From the introduction of improved forms of the wearing parts, and the use of chilled steel as a material, the resistance due to the tenacity of the soil and to friction has been so much reduced, that the same work can now be done with about half the expenditure of horsepower. We can therefore now plough much deeper with horses than it was possible to do at one time, and this is an additional reason in favour of deep work where the soil renders it desirable or beneficial.

Plough-staff.—A necessary accompaniment of every plough is the *plough-staff*, or plough-spade, fig. 18. It shovels off the mould that adheres to the breast of the mould-board, pushes away stubble or weeds which accumulate in the angle of the coulter and beam, and strikes out a stone when one fixes itself between the points of the coulter and sock. It lies upon the stilt, the spade being inserted into a staple in the bosom of the plough.

Swing-trees.—Horses are yoked to the plough by means of a set of levers named *swing-trees*, arranged so as to cause the united strength of the horses to be exerted at one point, by linking the ring of the swing-trees to the hook of the bridle of the plough. Swing-trees are used for attaching any number of horses to other implements besides the plough, such as harrows, small ploughs, &c.

In the plough-yoke a set of swing-trees consist of 3, as in fig. 19. The swing-trees are arranged in the position in which they are employed in working. The section of the main swing-trees is at the centre of attachment, with clasp and eye mounting, the scale of which is double the size of the principal figure in the cut.

Swing-trees are for the most part made of wood—oak or ash; sound English oak is by much the most durable—though good Scotch ash is the strong-



Fig. 18.—*Plough-staff.*

est, so long as it remains sound, but it is liable, by long exposure, to a species of decay resembling dry-rot, and thereby becomes brittle. They are now also very often made of iron, and of various patterns, designed to give strength with lightness and durability.

Yoking 3 Horses to a Plough.—Ploughing is sometimes performed by three horses, as in cross-furrowing, or in breaking up stubble in autumn, when

the land is clean, or in ploughing old rough lea ground. There are various ways of yoking *three* horses to the plough; the simplest is a pair working in the common swing-trees, fig. 19, with a light chain attached by a shackle to the middle of the main swing-tree. To this chain a third horse is yoked, taking his place in front of the other two, in unicorn fashion. This yoke is defective, inasmuch as there are no

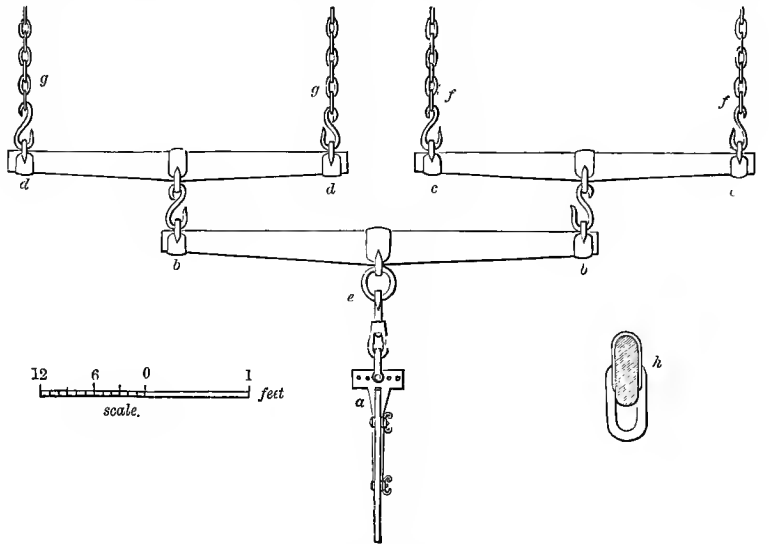


Fig. 19.—Swing-trees for two horses.

a Bridle of the plough.
b Main swing-tree.
e Ring of main swing-tree.

c c Furrow or off side swing-tree.
d d Land or near side swing-tree.
f g Trace-chains from the harness.
h Section of main swing-tree.

means of equalising the draught of the third horse.

Perhaps the most perfect method of yoking a 3-horse team is abreast, with *compensation levers*, fig. 20—a statical combination, which is at once correct in its equalisation, scientific in principles, and elegant in arrangement. Between the main swing-tree and the three small ones the compensating apparatus is placed. Two of these are levers of the first order, but with unequal arms, the fulcrum being fixed at one-third of the entire length from the outward end of each; the arms of these levers are therefore in the proportion of 2 to 1, and the entire length of each between the points of attachment is 27 inches. The two

levers are hooked by means of their shackles to the main swing-tree; and the three small swing-trees are hooked to the compensation lever.

Saving a Weak Horse.—The considerate farmer will frequently see the propriety of lightening the labour of some individual horse in this more than in the ordinary method of ploughing; and this is easily accomplished by the compensation apparatus. For this purpose, one or more holes are perforated in the levers *h i*, on each side of the true fulcrum *k*, to receive the bolt of the small shackle *k*. By shifting the shackle and bolt, the relation of the forces *h* and *i* are changed, and that in any proportion that may be desired; but it is neces-

sary to observe that the *distance* of the additional holes, on either side of the central hole or fulcrum of equilibrium in the system, should be in the same

proportion as the length of the arms in which the holes are perforated. Thus, if the distance between those in the short arm is half an inch, those in the

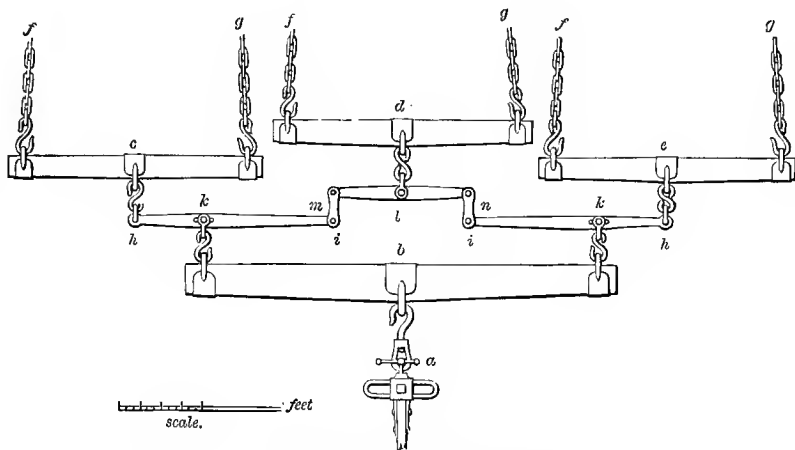


Fig. 20.—*Swing-trees for three horses.*

a Bridle of the plough
b Main swing-tree.

c d e Common swing-trees for a horse each.
f g Trace-chains from harness.
h i k l m n Compensating apparatus of three levers of iron.

longer arm should be an inch. By such arrangement, every increase to the exertion of the power, whether on the long or the short arm, would be equal.

Fig. 21 represents a set of trussed tubular iron whipple-trees made by

Kells, Meats, & Co., Gloucester. They combine lightness, strength, and durability, and are adapted for two and four horses. By shifting the hook on the balance-bar, these whipple-trees can be used at the plough, with two horses in

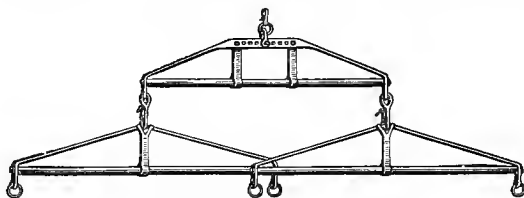


Fig. 21.—*Trussed iron whipple-trees.*

the furrow and one on the land, or with a colt or weak horse beside a strong one.

Yoking 4 Horses.—*In the yoking of 4 horses*, the best method is as in fig. 22. In this arrangement the balance of forces is perfectly preserved; for the hind horses and the leaders, as they pull at opposing ends of the chain, 11 feet in length, passing round a pulley, which must inevitably be always in equilibrium, each

pair of horses has an equal share of the draught; and from the principles of the common swing-trees through which each pair acts, the individual horses must have an equally perfect division of the labour. In order to prevent either the hind horses or the leaders from slipping too much ahead, it is common to apply a light check-chain of about 15 inches long, connecting the two parts of the main chain, so as to allow only a short

oscillation round the pulley, which is limited by the check-chain. When this is adopted, care should be taken never to allow the check-chain to remain upon

the stretch; for if it do so, the advantage of equalisation in the yoke is lost, and it becomes no better than the simple foot-chain. In all cases of using a chain,

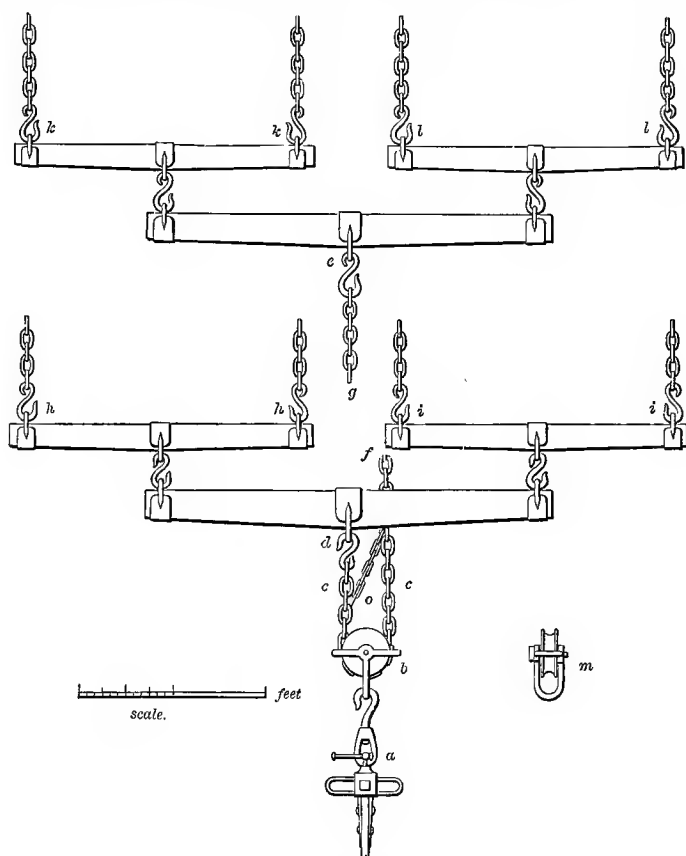


Fig. 22.—*Swing-trees for four horses.*

a Bridle of the plough.

b Pulley of cast-iron.

m Edge-section of pulley.

c Link-chain wove round the pulley.

d A set of common swing-trees.

e Another set of common swing-trees.

g *f* Chain connecting the two sets of swing-trees through the pulley.

h i k l Trace-chains from the harness.

o Check-chain.

that part of it which passes forward between the hind horses must be borne up by straps or cord attached to their back-bands, or suspended from their collars.

When more than four horses are yoked together, their strength is with difficulty simultaneously applied. It is therefore much better to work 2 sets of 4 horses than 1 set of 8.

Harness.—Besides swing-trees, horses require *harness* to enable them to apply

their strength to the plough. The harness, as used in Scotland, is simple and efficient.

Collar.—A form of collar long used in Scotland is shown in fig. 23. The collar surrounds the neck of the horse, and serves as a padding to protect the skin of the neck and the points of the shoulder, while the horse exerts his strength in the draught. The covering of this collar consists of leather stiffened in its upper part with stripes of whale-

bone to form the cape. The body of the collar is stuffed with wheat-straw, or, what is better, rye-straw, and covered with strong twilled woollen cloth.

It will be observed that the under part of the collar is wider than the upper, because the under part of the neck of a horse is thicker than the upper or mane, upon which the collar rests; but as the crown of the head of the horse is broader than the muzzle, the collar is slipped over the head in the inverted position, and turned round upon the neck.

Fig. 24 shows a form of cape common in England. In modern English collars the cape is frequently made of a separate flap of leather, so that it can be folded down for the purpose of protecting the withers of the horse in wet weather. Similar

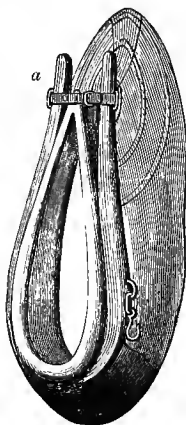


Fig. 23.—Scotch draught-horse collar and haims.

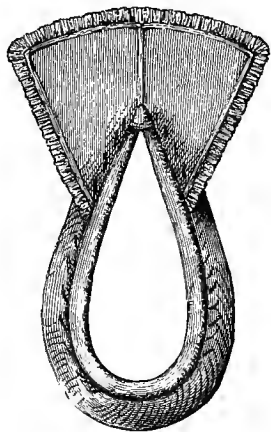


Fig. 24.—English draught-horse collar.

capes are now often seen in Scotland, and are in both countries occasionally seen ornamented with flaring red worsted fringes round the edge, or with large tassels from the corner and middle, and even with bells.

Haims.—The *haims* are placed immediately behind the outer rim of the collar at *a*, fig. 23. They consist of two pieces fixed below the throat of the horse with hooks and a link, and at the upper part at *a* with a leather strap. The pieces are formed entirely of iron, or of wood covered with thin sheet-iron, or of wood alone—now most frequently of iron. On each piece above the point of the shoulder of the horse is attached a staple with a hook, to which is fastened the trace-chains of the plough, or the draught-chains of the cart. In some parts of the country the haims are never removed from the collar; in most parts they are taken off every time the horse is unharnessed.

Bridle.—A part of the harness is the *bridle*, which serves to guide the horse's head. It is commonly of simple form, consisting of a head-stall, nose-band, blinders, bit, throat-lash, and bearing-reins. In some parts of the country the blinders are omitted. The plea for the use of blinders is, that they prevent the horse looking around and being frightened by distant objects he cannot distinctly see, and they keep his attention steady to his work. But it is found that horses accustomed to look around them are seldom frightened, whereas those used to blinders are easily scared when these are taken off, or when they hear any uncommon noise. The want of them keeps the head cooler in summer, and saves the eyes from injury by lateral pressure.

Bearing-reins.—In draught-horses, *bearing-reins* may be dispensed with, as unless the reins are allowed to hang loose, the animal has its head tied up, and cannot so easily lean forward to put its full power to the draught.

Back-band.—A piece of harness of the plough-gear is the *back-band*, which consists of a broad piece of leather passing over the horse's back, having small pads where it rests on the top of the back, both ends being fastened to the trace-chains of the plough by means of small iron hooks. Its office is to support the chains just *below* the line of draught; if above, the draught would become a strain upon the groins of the horse, through the medium of the back-band.

Plough-reins.—A necessary portion

of the equipment of a draught-horse in harness is the plough-reins, which are made of cord, on purpose light and strong, being fabricated of the best hemp. In some parts of the country, in the midland and northern districts, one rein is attached to the nigh horse in driving a pair in the plough, most of the horse's motions being performed by the command of the voice of the ploughman—the only use of the rein being to pull the horses to the nigh side. To give the ploughman a perfect command of his horses, double reins should be used—one passing from the left-hand stilt of the plough by the nigh side of the nigh horse, through one ring on the nigh side of the back-band, then through another ring on the nigh side of the haims, to the ring of the bridle-bit, to which it is fastened; the other rein goes from the right-hand stilt of the plough

by the off side of the off horse, through rings in the back-band and haims to the bridle-bit on the off side. The other ends of the reins are usually held in the hands of the ploughman, or looped upon the handles of the stils of the plough.

Weight and Cost of Harness.—The total weight of plough-harness may vary from 30 to 40 lb., and the cost from £2, 5s. to £3. Thus harnessed for the plough, each horse has not much weight to bear; nor is its harness costly, though made of the strongest harness-leather.

Some styles of English harness are much heavier, and also more costly. The harness required for a pair of horses for carts are 2 collars, 2 bridles, 2 haims, 2 saddles with breeching, and 2 belly-bands, costing in all from £9 to £12.

Ploughing with 2 Horses.—On examining the particulars of ploughing with two horses, fig. 25, the collars are

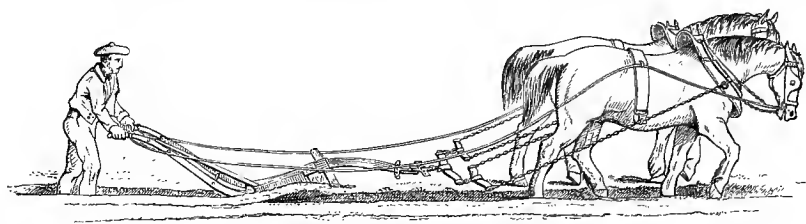


Fig. 25.—Scotch plough at work with two horses.

round the horses' necks; the top of the *haims* is seen at the upper part of the collar. The horses are yoked to the swing-trees by light *trace-chains*, linked on one end to the hooks of the haims, and hooked at the other into the eyes of the swing-trees. *Back-bands* of leather cross the back, near the groins of the horses, supporting the trace-chains by means of simple hooks. The *bridles* have blinders, and the *bearing-reins* are supported on the top of the haims. The *swing-trees* are hooked to the draught-swivel of the bridle of the plough; and being yoked abreast, the horses are enabled to exert their united strength much more effectually than if yoked one before the other. The two horses are kept together by a *leather strap*, buckled at each end to the bridle-ring, which prevents the horses separating beyond its length. The *reins* proceed from the

ploughman's hands to the horses' heads. The off-side horse—that is, the one nearest to the spectator in the figure—is walking in the *last-made* open furrow—the nigh horse walking on the *firm land*. The plough is in the act of turning over a furrow-*slice* of land, and the ploughman is walking in the *new-made* open furrow, leaning forward slightly upon the stils, to steady himself and the plough at the same time.

Ploughing with 3 Horses.—Fig. 26 shows the Scotch swing-plough at work with three horses. The yoking of the three horses through the instrumentality of the apparatus described in fig. 20 will at once be understood. The off horse—that is, next the spectator in the figure—is walking in the last-made furrow, the other two horses are on the firm land, while the ploughman is stepping in the new-made furrow. The depth

of the furrow in this case is 10 to 12 inches, instead of 7 or 8 inches—the usual depth of ploughing. The three horses plough to this depth in ordinary soils with great ease. The advantages of this method of ploughing are, that it uproots every tap-rooted weed; that the furrows being open to the influences of the elements in winter, the soil becomes

so completely pulverised by the spring that any further ploughing then is unnecessary; that a simple grubbing renders the soil fit to be done up for potatoes or turnips; that much labour is thus saved in the busy season of spring, and the additional depth of soil stirred gives more room for bulky manures to be effectually covered, and greater scope for

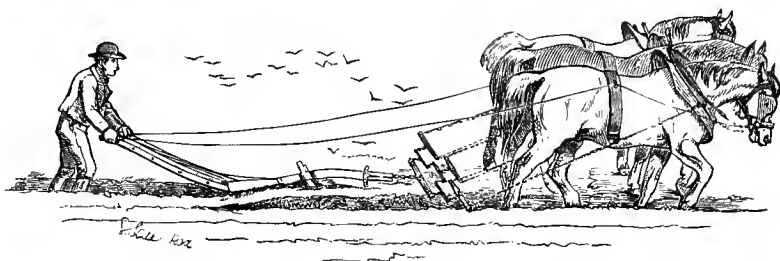


Fig. 26.—Scotch plough at work with three horses.

the roots of the cultivated plants to ramify in search of mineral food. These advantages from ploughing to this depth are, of course, derived only where the land is deep, and the subsoil of a suitable character. In all respects this mode of ploughing is similarly conducted to that with two horses, as plainly indicated in the two figures.

Language to Horses.—Besides the use of reins, it is customary to desire horses to go through their motions, when yoked to the draught, with the voice, using the *language to horses*. It would be quite possible to cause horses to perform all their motions by means of the double reins alone, but the voice keeps up an understanding between the men and horses. It is not practicable to make horses at the plough go through the requisite movements with a single rein, unassisted by the voice; but too much use of the voice makes horses become regardless of it.

The language addressed to horses varies in the different parts of the kingdom. The motions required of them at work are, to go forward—to step backward—to go to the right from you—to come to the left towards you—to turn round—and to stop. The word *Wo* is universally used to stop.

In all cases the speaker is supposed to be on the *near side* of the horse—its left

side. The word *hup* is often used to go from, and *hie*, to come to, when describing any piece of work in which horses are employed.

ACTIONS OF VARIOUS PLOUGHS IN USE.

Small's Plough.—It would be well to make a comparison between the actions of the various ploughs in use before entering on the different methods of ploughing land; and first, of ploughs designed on the principles laid down by Small, fig. 27.—

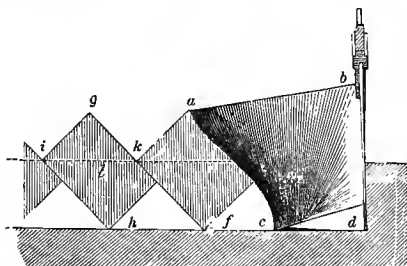


Fig. 27.—Effects of a rectangular furrow-slice.

a b c d Transverse section of mould-board.

f, g h Sections of furrow-slice.

g k a Right angle.

g k a Triangle equal to breadth of furrow-slice.

i g, g k Equal sides of triangle.

g l Half the breadth of furrow-slice.

h f c d Level sole of furrow.

In this example, the rectangular furrow-slice is 10 inches broad by 7 inches deep.

Wilkie's Plough.—Next of Wilkie's pattern, fig. 28 :—

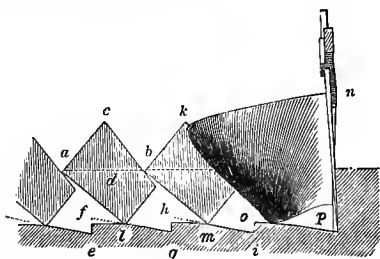


Fig. 28.—Effects of a crested furrow-slice.

- k n p o* Transverse section of mould-board.
k m, c l Sections of furrow-slice.
c Angle 84° or 75° .
a c b Isosceles triangle.
a c $6\frac{1}{2}$ inches, upper end of furrow-slice.
l h $4\frac{1}{2}$ inches, lower end of furrow-slice.
f h o p Crested furrow-sole.
e f g, g h i Triangular spaces $1\frac{1}{2}$ inch left unploughed.

In comparing the furrow-soles in figs. 27 and 28, besides the loss of time and labour in ploughing a breadth of furrow $8\frac{1}{2}$ inches, compared with a 10-inch furrow, the crested furrow-sole leaves part of the ground unploughed. Thus, in ploughing an imperial acre with a 10-inch furrow—leaving out of view the taking up of closings, turnings, &c.—the distance walked over by the man and horses will amount to 9.9 miles; with a 9-inch furrow the distance will be 11 miles; with an $8\frac{1}{2}$ -inch furrow, it will be $11\frac{1}{2}$ miles; and with a $7\frac{1}{2}$ -inch furrow, $13\frac{1}{4}$ miles.

Steam-ploughs and Diggers.—There are several forms of steam-ploughs, and these will be noticed in a subsequent chapter dealing with the application of steam-power to farm-work. This also applies to steam-diggers.

PLOUGHING AND PLOUGHING-MATCHES.

Tempering the Plough.—The plough, as now made, consists of a number of parts; but how well soever those different parts may be put together, if not *tempered*, or adjusted—if any part has more to do than its own share of the work—the entire implement will move unsteadily. It is easy to ascertain whether or not a plough goes steadily, and is so by the following means :—

Less "Earth" required.—On holding a plough by the handles with both

hands, while the horses are drawing it through the land, if it have a constant tendency to go deeper into the soil than the depth of the furrow-slice previously determined on, it is not going steadily. The remedy is twofold—either to press harder upon the stilts with the hands, and, by their power as levers, bring the share nearer the surface of the ground; or to put the draught-bolt of the bridle a little nearer the ground, and thus give the plough less "*earth*." The pressure upon the stilts should first be tried, as being the most ready at command; but should it fail of effecting the purpose, and the pressure prove too severe upon the arms of the ploughman, the draught-bolt should be lowered; and should both these expedients fail, there must be some error in another part of the plough. On examining the share, its point may possibly be found to dip too much below the base-line (fig. 9), which will cause it to go deeper than it should. This error in the share can be rectified only at the smithy.

More "Earth" required.—Again, the plough may have a tendency to come out of the ground. This cannot be remedied by supporting the stilts upwards with the arms, because the body of the ploughman having no support, he could not walk steadily in the furrow. Hence, a very short man can scarcely hold a plough steady at any time, and does not make a desirable ploughman. The draught-bolt should, in the first instance, be placed farther from the ground, and give the plough more "*earth*." Should this not effect the purpose, the point of the share will probably be above the base-line, and must therefore be brought down to its proper level by the smith.

More "Land."—It may be difficult to make the plough turn over a furrow-slice of the desired breadth. This tendency is obviated by moving the draught-bolt a little to the right, which gives the plough more "*land*"; but in case it arises from some casual obstruction underground, such as direct collision against a small stone or a piece of unusually hard earth, it may be overcome by leaning the plough a little over to the right or left for the time.

Less "Land."—The tendency, how-

ever, may incline to take a slice broader than is wanted; in which case, for permanent work, the draught-bolt should be put a little to the left, which gives the plough less "*land*"; and for a temporary purpose the plough may be leaned over a little to the left.

These are the ordinary causes of unsteadiness in the *going* of ploughs; and though narrated singly, any two of them may combine to produce the same result, as the going deeper, or shallower, with cutting a too narrow or too broad furrow-slice. The most obvious remedy should first be tried; but both may be tried at the same time if a compound error is apprehended.

Hold the Plough level.—Some ploughmen habitually make the plough lean a little over to the left, giving it less land than it would naturally have, and to counteract the consequent tendency to a narrow furrow-slice, move the draught-bolt a little to the right. The ploughing with a lean to the *left* is a bad custom, because it cuts the lowest end of the furrow-slice with a slope, which gives the horses a lighter draught than when turning over a square furrow-slice. Old ploughmen, feeling infirm, are apt to practise this deceptive mode of ploughing. The plough should always be level upon its sole, and turn over a rectangular furrow-slice.

Tall men, in having to stoop constantly, lean hard upon the stilts; and as this has the tendency to lift the plough up, they are obliged to put the draught-bolt higher to keep it in the ground.

A good ploughman will use none of these expedients, for he will *temper the irons*, so as there shall be no tendency in the plough to go too deep or too shallow into the ground, or make too wide or too narrow a furrow-slice, or cause less or more draught to the horses, or less or more trouble to himself, than the work requires to be performed in the best manner.

Tempering the "Irons."—In the attempt to temper irons, many ploughmen place the coulter in a position which increases the draught of the plough. When its point is brought down as far as that of the share, and projecting much to the left or land side,

a stone in light land is very apt to be caught between the points of the coulter and share, which will have the effect of throwing the plough out of the ground. Such an accident is of little consequence in ploughing land to be ploughed again; but it disfigures the land in ploughing lea, and must be rectified instantly; but in doing this, time is lost in backing the horses to the spot where the plough was thrown out. To avoid such an accident on lea-ploughing, in *stony land*, the point of the coulter should be put immediately above, and almost close upon, that of the share, when they will both cut the soil clean. In smooth soils, free of small stones, the relative positions of the points of the coulter and share have not the same influence upon the steadiness of the plough.

Plough - "irons."—The *state of the irons* themselves has a material effect on the temper of the plough. If the cutting edge of the coulter, and the point and cutting edge of the share, are steeled, the irons will cut clean, and go long in smooth soil. This is an economical treatment of plough-irons for clay soils. But in gravelly and all sharp soils the irons wear down so very fast, that farmers prefer them made of ordinary iron, and have them laid anew frequently, rather than incur the expense of steeling, which perhaps would not endure work much longer in such soils. Irons are now seldom if ever steeled; but whether steeled or not, they are always in the best state when sharp and of the requisite dimensions. In English smooth soils, cast-iron shares are often used. In Scotland the soil is commonly too stony for cast-iron to stand the work, but could cast-iron shares be procured very cheap, they might be as economical as malleable-iron shares. The best material now used for the wearing parts of ploughs is chilled steel, which, on account of its extreme hardness, resists wear for a long time, while the fine surface it takes on lessens the friction to be overcome by the horses.

Keep the Plough in good Order.—An imperfect state of the mould-board is another interruption to the tempering of a plough. When new and rough, the soil adheres to it, and if pressing heavily against the turning furrow-slice,

causes the plough to deviate from its right course. On the other hand, when the mould-board is worn away much below, it leaves too much of the crumbled soil on the bottom of the furrow, especially in loose soils. Broken side-plates easily admit the soil through them into the body of the plough, and cause a rough and unequal face on the firm land side; and when soil accumulates in the body, it affects the plough, both in temper and draught. These remarks on tempering are made on the supposition that ploughs are well made, and may therefore be tempered equally well; but ploughs are sometimes so ill constructed, that the best tempering the irons are capable of receiving will never make them do good work. It is more economical to have a good new plough than to work for a length of time with a worn-out one.

Good Ploughmanship.—When all the particulars which ploughmen should attend to in executing their work—in having their plough-irons in a proper state of repair, in tempering them according to the kind of ploughing to be executed, in guiding their horses, and in ploughing the land in a methodical way—are considered, it ceases to surprise one that so few ploughmen become first-rate workmen. Good *ploughmanship* requires greater faculty of observation than most people would readily imagine—greater than many young ploughmen possess,—greater judgment than most will take time to exercise,—more patience than most will bestow to become familiarised with every particular,—and greater skill than most can acquire. To be so accomplished, implies the possession of high talent for workmanship. “It is well known,” says Sir John Sinclair, “that the horses of a good ploughman suffer less from the work than those intrusted to an awkward and unskilful hand; and that a material difference will be found in the crops of those ridges tilled by a bad ploughman, when compared to any part of the field where the operation has been judiciously performed.”¹ Marshall contends that “one-fourth of the produce of the arable lands of the kingdom is

lost through a want of tillage.”² It must be owned that by far the greatest part of ploughmanship is of a mediocre description; and reasons for its mediocrity are not difficult to adduce. Thus—

Learning Ploughing.—*Ploughmen* cannot learn their art at a very early age, and every business ought to be learned then to reach a high attainment in it. Ploughing requires a considerable degree of strength, even from grown-up men, and it bears much harder on the learner; but even after young men have acquired sufficient strength to hold the plough, they are left to learn ploughing more through sheer experience than by tuition from those better acquainted with the art. Experience cannot be transmitted from father to son more in this than in any other art; and in this, as in other arts, improvement is more frequently effected by imitation than by efforts of individual ingenuity and study. A learner of ploughing often cuts an awkward figure.

The best Ploughmen and Stewards.—The best ploughmen are generally those who have been taught directly by their fathers, and work constantly upon their fathers’ farms; and they make, besides, the best stewards, because they have been accustomed to command servants, and have not associated freely with them. A steward promoted from the rank of a common ploughman is apt—unless he is a man of exceptional strength and firmness of character—to continue on too familiar a footing with them to sustain the authority due to his situation, and on being aroused to enforce authority perhaps becomes tyrannical.

Boy Ploughmen.—In England, boys are frequently employed to *tend* the plough, for they cannot be said to hold it, which is so constructed with wheels and apparatus as to turn over the soil without the aid of man, and his aid is required only for the turnings at the ends of the ridges.

Weight of Deep and Shallow Furrows.—It may be worth while to show the great difference in the weight of

¹ *Code of Agric.*, 298, 5th edition.

² Marshall’s *Gloucester*, i. 72.

soil turned over in a deep and shallow furrow. If 10 inches are taken as a fair width for a furrow-slice, there will be 18 such slices across a ridge of 15 feet in breadth; and taking 7 inches as a common depth for such a furrow-slice, a cross section of the slice will have 70 square inches. A cubic foot of earth is thus turned over in every 24.7 inches of length of such a slice; and taking 1.48 as the specific gravity of common earth, the 24.7 inches of slice will weigh 6 stones 8 lb. imperial. If a furrow of only 4 inches in depth is taken, with its breadth only of 9 inches, the area of the slice will be 36 square inches, and its weight will be 3 stones 5 lb., a considerable difference of weight for horses to turn over in the

same distance travelled. With the furrow of the 3 or 4 horse plough, say 14 inches by 10 inches, the weight of soil turned over would be 13 stones 2 lb.

Form and Placing Furrow-slice.—The proper form and position of the furrow-slice are requisites in good ploughing. The furrow-slice should be of such dimension, and laid in such position, that the two exposed faces in a series of slices shall be of equal breadth, and any departure from this rule is a positive fault. Laid up agreeably to this rule, furrow-slices will not only present the maximum of surface to the atmosphere, but also contain the maximum of cubical contents.

Fig. 29 represents the movement of

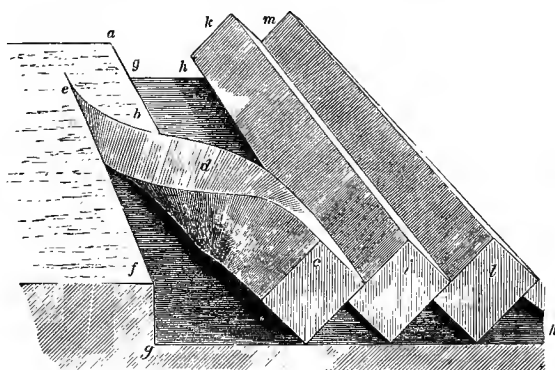


Fig. 29.—View of the movement of the furrow-slice.

a b Edge of land cut by preceding furrow.
c d Slice being turned over by the plough.
e f Edge of land being left by the ploughing furrow.

i k, l m Furrow-slices previously laid over.
g h Level sole of furrow.

the furrow-slice, as well as its position after it is laid by the plough. An examination of this figure also shows that the extension of the slice only takes place along the land-side edge, from *e* to where the backward flexure is given to it when rising on the mould-board at *d*; and where it is again compressed into its original length, in being laid down by the back part of the mould-board at *c*. The slices are laid over at an angle of 45 degrees; and in slices of 7 inches in depth and 10 inches in breadth, the altitude of the triangle is 5 inches, each side 7.071 inches, and the sum of the two exposed faces 14.142 inches.

These figures apply only to the rectangular furrow-slices by the common ploughs made after Small's type. Those of ploughs made on a different pattern will differ in the angle of the slice, and in the dimensions of the triangular crest.

Characteristics of correct Ploughing.—*Correct ploughing* possesses these characteristics: The furrow-slices should be quite straight; for a ploughman that cannot hold a straight furrow is unworthy of the name. They should be quite parallel as well as straight, which shows that they are of a uniform thickness; for thick and thin slices lying upon one another present irregularly

parallel and horizontal lines. They should be of the same height, which shows that they have been cut of the same breadth; for slices of different breadths, laid together at whatever angle, present unequal vertical lines. They should present to the eye a similar form of crest and equal surface; because, where one furrow-slice exhibits a narrower surface than it should have, it has been covered with a broader slice than it should be; and where it displays a broader surface than it should have, it is so exposed by a narrower slice than should be. They should have their back and face parallel; and to discover this property after the land has been ploughed requires minute examination. They should lie easily upon each other, not pressed hard together. The ground, on being ploughed, should feel equally firm under the foot at all places, for slices in a more upright position than they should be, not only feel hard and unsteady, but will allow the seed-corn to fall between them and become buried. When too flat, they yield considerably to the pressure of the foot; and they cover each other too much, affording insufficient mould for the seed. They should lie over at the same angle, presenting crests in the best possible position for the action of the harrows. Crowns of ridges formed by the meeting of opposite furrow-slices should neither be elevated nor depressed with regard to the rest of the furrows in the ridge; although ploughmen often commit the error of raising the crowns too high into a crest, the fault being easily committed by not giving the first furrow-slices sufficient room to meet, and thereby pressing them against each other.

The last furrow-slice should be uniform with those of the rest of the ridge; but ploughmen are very apt to miscalculate the width of the slices near the edges of the ridges; for if the specific number of furrow-slices into which the whole ridge should be ploughed are too narrow, the last slices of the open furrow will be too broad, and will therefore lie over too flat; and should this too broad space be divided into two furrows, each slice will be too narrow, and stand too upright. When the last furrows are ill

made, the open furrow cannot be proportionately ploughed out; because, if the space between the last furrows is too wide, the open furrow must be made too deep to fill up all the space; and if too narrow, there is not sufficient mould to make the open furrow of the proper size. If the last furrow-slices are laid too flat, the open furrow will throw too much mould upon the edges next the open furrow, and make them too high. When the last furrows of adjoining ridges are not ploughed alike, one side of the open furrow will have less mould than the other. From a consideration of these particulars, it is obvious that ploughing land correctly, which is best exhibited in lea-ploughing, is an art which requires a skilled hand and correct eye, both of which are much interfered with in the management of the horses. Hence a ploughman who has not his horses under strict command cannot be a good hand.

Speed of Horses Ploughing.—The usual *speed* of horses at the plough may be ascertained in this way: A ridge of 5 yards in breadth requires a length of 968 yards to contain an imperial acre; to plough which at 9 bouts (a *bout* being a walk along a ridge and back), with a 10-inch breadth of furrow-slice, counting no stoppages, will make the horses walk 9.9 miles, which in 10 hours gives a speed of 1742 yards per hour; at 10 bouts of 9-inch furrow-breadth, gives 11 miles of travel to the horses, or 1936 yards per hour; and at $7\frac{1}{2}$ bouts of 12-inch furrow-breadth, gives $6\frac{2}{3}$ miles of travel to the horses, or 1452 yards per hour. But as ridges of 968 yards in length are very rare, and as horses cannot draw a plough that distance without being affected in their wind, and as allowance must be made for time lost in turning at the ends of ridges, as well as affording rest to horses, those speeds will have to be considerably increased to do that quantity of work in the time.

In ploughing an acre on ridges of 270 yards in length, which is about the length of ridge considered best for horses in draught, the time lost by turnings, in ploughing 10 hours, with a 10-inch furrow-slice, is 1 hour 22 minutes. However easy the length of

ridge may be for the draught, horses cannot go on walking in the plough for 5 hours together (a yoking) without taking breaths. Now 270 yards of length of ridge give 3.6 ridges to the acre, or 32 bouts of 10-inch furrows; and allowing a rest of 1 minute in every other bout, 16 minutes will have to be added to the 1 hour 22 minutes lost—that is, 1 hour 38 minutes lost out of every 10 hours, for turnings and rest. Thus 17,496 yards will be ploughed in $8\frac{2}{3}$ hours, or at the rate of rather more than $\frac{1}{3}$ mile per hour, or $11\frac{1}{3}$ miles of walking in ploughing an acre in $8\frac{2}{3}$ hours. These results are perhaps near the truth in ploughing lea in spring; they are too little in ploughing bare land in summer, and perhaps too much in ploughing heavy stubble-land in winter; but as lea-ploughing is the standard by which all others are estimated, the results arrived at may be taken as an approximation to the truth.

Hence this table:—

Length of ridge.	Breadth of furrow-slice.	Time lost in turning.	Time devoted to ploughing.	Hours of work.
Yards.	Inches.	H. M.	H. M.	H.
78	10	5 11	4 49	10
149	...	2 44	7 16	...
200	...	2 1	7 59	...
212	...	1 56½	8 3½	...
274	...	1 22	8 32	...
270	12	1 8	8 52	...

Long and Short Ridges.—Thus it appears that a ridge of no more than 78 yards in length requires 5 hours 11 minutes out of every 10 hours for turnings at the landings, with a 10-inch furrow-slice; whereas a ridge of 274 yards in length only requires 1 hour 22 minutes for turnings—making a difference of 3 hours 49 minutes in favour of the long ridge as regards the saving of time.

Very short *butts* in a field, therefore, involve much loss of time with the plough, the harrow, and the sowing-machine.

Extent of Land ploughed at different Speeds.—Further data from similar experiments are the quantities of

land ploughed at different speeds at given breadths of furrow-slices, thus:—

Speed. Rate per Hour.	Breadths of furrows ploughed.	Distance walked in $8\frac{2}{3}$ hours.	Quantity of land ploughed in $8\frac{2}{3}$ hours at that speed.
Yards.	Inches.	Miles. Yards.	A. R. F.
1452 Miles.	12	6 520	1 0 0
1 {	9	8 1284	0 3 1
1 {	10	8 440	0 3 14
1½ {	9	12 642	1 0 21
1½ {	10	12 220	1 0 34
2 {	9	17 808	1 2 2
2 {	10	16 880	1 2 28

A Regular Pace best.—*Horses driven in the plough beyond their ordinary step* cannot draw equally together, and the plough is consequently held unsteadily, having a tendency to take too much land; to obviate which, the ploughman leans the plough over to the left, when it raises a thin broad furrow-slice, and lays it over at too low an angle. On the other hand, when the horses move at too slow a pace, the ploughman is apt to forget what he is about, and the furrow-slices will then, most probably, be made too narrow and too shallow; and although they may be laid over at the proper angle, and the work seem well enough executed, there will be a deficiency of mould in the ploughed soil. A regular pace is therefore the best for man, horses, and work.

Ploughing Steep Land.—The *steepness of the ground* is a circumstance which greatly affects the speed of horses at work on hilly farms; and it is not unusual to find the ridges traversing such steep slopes straight up and down. Ridges in such a position are laborious to plough, to cart upon, to manure, and for every operation connected with farming. The water runs down the furrows when the land is under the plough, and carries to the bottom of the declivity the finest portion of the soil. In such a position, a ridge of 270 yards is much too long to plough without a breathing to the horses. Although the general rule for making ridges to run N. and S. is the correct one, in such a situation as a steep acclivity they should slope across the face of the hill; and the

slope will not only be easier to labour, but the soil prevented being washed away in the furrows. But the direction of the slope should not be made at random,—it should so decline as that the plough shall lay the furrow-slice down the hill when in the act of climbing the incline; and on coming down, the horses will be better able to lay the furrow-slice up against the inclination of the ground. What the length of the ridges on such a slope ought to be, cannot be easily determined, but about 150 yards would be enough for the horses to draw at one breathing. It will be better for labouring an arable farm to have 2 fields each 150 yards long, one higher up the slope than the other, than have the whole ground in one field of 300 yards in length.

Ploughing-matches.—Although differences of opinion exist as to the usefulness of ploughing-matches, it can hardly be doubted that since their institution the skill of our ploughmen has risen considerably; not but that individual ploughmen could have been found before as dexterous as any of the present day. This improvement is not to be ascribed to the institution of ploughing-matches alone, for, no doubt, superior construction of implements, a better kept, better matched, superior race of horses, and superior judgment and taste in field labour in the farmer himself, have been potent elements in influencing the handicraft of ploughmen.

Highland and Agricultural Society Medals for Ploughing.—The *plough medals* of the Highland and Agricultural Society of Scotland being open in competition to all ploughmen in Scotland, numerous ploughing-matches take place every year in every district of the country. In 1886-87 the Society's silver medal was awarded at 150 ploughing-matches throughout Scotland. In 1864-65 the number was 145.

Besides stated competitions, a day's ploughing is frequently given to incoming tenants by neighbouring farmers as a welcome into the district.

How Ploughing-matches are Conducted.—Ploughing-matches are generally very fairly conducted in Scotland. They usually take place on lea ground, the ploughing of which is considered

the best test of a ploughman's skill, though drilling is perhaps quite as difficult of correct execution. The best part of the field is selected for the purpose, and the same extent of ground is allotted to each competitor. A peg, bearing a number, is fixed in the ground at the end of each lot, which are as many as ploughs entered in competition. Numbers, on slips of paper corresponding to those on the pegs, are drawn by the competing ploughmen, who take the lots as drawn. Ample time is allowed to finish the ploughing of each lot. Although quickness of time in executing the same extent of work is not to be compared to excellency of execution, it should enter as an element in deciding the question of skill; but this it seldom does at ploughing-matches. Each competitor is obliged to "feer" his own lot, assort and guide his own horses, and trim his plough-irons, without assistance.

Judges at Ploughing-matches.—The judges are brought from a distance, so that they can have no personal interest in the exhibition, and in some cases they have been requested to inspect the ground after all the ploughs have been removed, having been kept away from the scene during the time the ploughs were engaged. This appears to be an objectionable part of the arrangements, which is made on the plea that, were the judges to see the ploughs at work, some particular ones might be recognised by them as belonging to friends, and their minds might thereby be biassed in their favour. Such a plea is a poor compliment to the integrity of a judge; and any farmer who accepts that responsible and honoured office, that would allow himself to be influenced by so pitiful a consideration, would deserve not only to be objected to on every such occasion, but banished out of society. One consequence of the exaction of this rule is, loss of patience by the spectators, while the judges are occupying no more than the necessary time for deciding the ploughing of, it may be, a large extent of ground.

The judges ought to be present all the time of the competition, when they could leisurely, calmly, and minutely ascertain the position and depth of the furrow-

slices, and mature their thoughts on points which might modify first impressions. Inspection of the finished surface cannot furnish information whether the land has in all respects been correctly ploughed, which can only be obtained by comparing the soles of the furrows while the land is being ploughed. There is something also to be gained in observing the manner in which the ploughman guides his horses in making the best work in the shortest time.

Quantities of Earth turned over by different Ploughs.—Small's type of plough lays over a slice of a rectangular, and Wilkie's of a trapezoidal form, while making a high-crest slice and serrated furrow-sole, containing one-seventh less earth than the rectangular. Now when judges are prohibited seeing the work done in the course of execution, the serrated extent of the furrow-sole cannot so well be ascertained by removing portions of the ploughed ground here and there by the spade, as by constant inspection. As equal ploughing consists in turning over equal portions of soil in the same extent of ground, other things being equal, a comparison of the quantity of earth turned over by these two kinds of ploughs can only be made in this way: In a space of 1 square yard turned over by each, taking a furrow of 7 inches in depth, and the specific gravity of soil at 1.48, the weight of earth turned over by Small's type of plough would be 34 st. 9 lb., while Wilkie's would turn over only 29 st. 10 lb., making a difference of 4 st. 13 lb. in the small area of 1 square yard. With these results, is it fair to say that the horses yoked to Small's plough have done no more work than those yoked to Wilkie's? or that the crop for which the land has been ploughed will receive the same quantity of loosened mould to grow in in these cases, merely because the surface may please the eye more in the one case than in the other?

High-crested Furrows Objectionable.—The primary objects of ploughing-matches must have been to produce the best examples of ploughmanship—and by the best it must be understood that kind of ploughing which shall not only *seem* to be best done, but *has been* best done. The award should be given

to the plough that produces not only a proper surface finish, but also turns over the greatest quantity of soil in the most approved manner. That this combination of qualities has ceased to be the criterion of merit, is now sufficiently apparent to any one who will examine for himself the ploughing which has been rewarded in ploughing-matches; and the cause of such awards is this:—

Wilkie's plough gave rise to the high-crested furrow-slice. It cannot be denied that the ploughs made on this principle produce work on lea land highly satisfactory to the eye of any person who appreciates regularity of form; and as there are many minds which dwell with pleasure on beauty of form, but combine not that idea with usefulness, it is no wonder that work which thus pleases the eye, and satisfies the judgment through the sense of sight only, should become a favourite one. While the crested system of ploughing kept within bounds it was well enough, but in course of time the taste for the practice became excessive; and at length, losing sight of the useful, a depraved taste sacrificed utility to beauty, in as far as ploughing is concerned. This taste gradually spread itself over certain districts, and plough-makers vied with each other in producing ploughs that should excel in that particular quality. A keen spirit of emulation amongst ploughmen kept up the taste amongst their own class, and frequently the sons of farmers became successful competitors in the matches, which assisted to give the taste a higher tone.

Thus, by degrees, the taste for this mode of ploughing spread wider and wider, until in certain districts it became the prevailing method. At ploughing-matches in those districts, the criterion of good ploughing was generally taken from the appearance of the surface; furrow-slices possessing the highest degree of parallelism, exposing faces of unequal breadth, and, above all, a high crest, carried off the palm of victory. More than once have a quorum of ploughing judges been seen "plodding their weary way" for two hours together over a field, measuring the breadth of faces, and scanning the parallelism of slices, but apparently never considering the underground work of any import-

ance in enabling them to decide correctly. Under such regulations, it is not surprising that ploughmen devote their abilities to produce work to satisfy this vitiated taste, and that plough-makers find it their interest to encourage the desire, by exaggerating more and more the construction of those parts of the plough which produce such fine results. Thus have the valuable institutions of ploughing-matches, in the districts alluded to, been unwittingly made to engender an innovation which, though beautiful enough—and, when practised within due bounds, is also useful—has induced a deterioration in really useful and sound ploughing.

A useful Appendage of a Plough.—Ploughs should always be provided with the useful appendage of an *iron hammer*, fig. 30. The hammer and

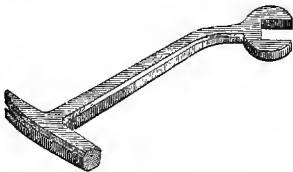


Fig. 30.—*Iron hammer nut-key.*

handle are forged in one piece of malleable iron, the handle being formed into a nut-key. With this simple but useful tool the ploughman has always at hand the means by which he can, without loss of time, alter and adjust the position of his plough-irons—the coulter and share—and perform other little operations which circumstances or accident may require, for the performance of which most ploughmen are under the necessity of taking advantage of the first *stone* they can find, merely from the want of this simple instrument. The hammer is slung in a staple fixed in the side of the beam in any convenient position. This little tool is now sent out by almost all makers as a regular appendage of the plough.

Plough-slide.—In removing ploughs from one field to another, or along a hard road to a field, instead of sliding them upon their sole-shoe, which is difficult to do when they have no hold of the ground, or upon the edge of the feather of the sock and the side of the

mould-board—which is a more easy mode for the ploughman than the former, and is consequently more commonly taken—every ploughman should be provided with a plough-slide, a simple and not



Fig. 31.—*Plough-slide.*

costly implement, as in fig. 31. It consists of a piece of hard wood board 3 feet 4 inches long, 8 inches broad, and 2 inches thick, in which a long staple *a* is driven to take in the point of the sock; and at *b* are fastened two small bars of wood, longways, and at such distance from one another as to take between them the sole-shoe of the plough. On the under side of the board are nailed two pieces of flat bar-iron, to act as skeds to the slide. Upon this implement the plough may be conveyed with comparative ease along any road or headridge.

PLOUGHING DIFFERENT FORMS OF RIDGES.

One might imagine that, as the plough can do nothing else but lay over the furrow-slice, ploughing would not admit of any variety; but the student will soon see the *many forms in which land may be ploughed*.

Modes of Ploughing.—The several modes of ploughing have received characteristic appellations—such as gathering up; crown-and-furrow ploughing; casting or yoking or coupling ridges; casting ridges with gore-furrows; cleaving down ridges; cleaving down ridges with gore-furrows; ploughing two-out-and-two-in; ploughing in breaks; cross-furrowing; angle-ploughing, ribbing, and drilling.

Varying Methods to suit Soil and Season.—These various modes of ploughing have been contrived to suit the nature of the soil and the season of the year. Clay soil requires more caution in being ploughed than sandy or gravelly, because of its being more easily injured by rain; and, indeed, it is a bad thing to plough any land in a wet state. Greater caution is therefore required to plough all sorts of land in winter than in summer. The precau-

tions consist in providing facilities for surface-water to flow away, and some sorts of ploughing afford greater facilities than others. Though the different seasons thus demand their respective kinds of ploughing, some modes are common to all seasons and soils. Attention to the various methods can alone enable the agricultural student to understand which kind is most suitable to the circumstances of the soil and the peculiar states of the season. To give the best idea of all the modes, from the simplest to the most complicated, let the ground be supposed to be perfectly flat on the surface.

The Parts of Ridges.—The supposed flat ground, after being subjected to the operation of the plough, is left in *ridges*, each of which occupies spaces of similar breadth. Ridges are composed of various parts—furrow-slices laid upon and parallel to one another, by the going and returning of the plough from one end of the ridge to the other: the middle line of the ridge receives the name of the *crown*,—the two sides, the *flanks*,—the openings between the ridges, the *open furrows*,—the edges of the furrow-slices, next the open furrows, the *furrow-brows*, and the last furrows, which are small, to narrow the open furrows, are the *mould* or *hint-end furrows*.

Direction of Ridges.—Ridges are usually made to lie in the direction of N. and S., that the crop growing upon both their sides may receive the light and heat of the solar rays in an equal degree throughout the day; but they, nevertheless, are made to traverse the slope of the ground, whatever its aspect may be, with the view of allowing rain-water to flow most easily away, without damaging the surface of the ground.

Width of Ridges.—Ridges are formed of different breadths, of 10, 12, 15, 16, and 18 feet, in different parts of Scotland, and in England they usually vary from 7 to 14 feet. These various breadths are occasioned partly by the nature of the soil, and partly by local custom. As regards the soil, clay soil is formed into narrow ridges, to allow the rain to flow off very quickly into the open furrows, and in many parts of England is ridged at only 14 feet in width, and in some localities are reduced to

ridglets of $3\frac{1}{2}$ or 7 feet. In Scotland, even on the strongest land, ridges are seldom less than 15 feet, in some localities 16, and on light soils 18 feet. In Berwickshire and Roxburghshire, the ridges have for a long period been 15 feet on all classes of soils—being considered the most convenient width for the ordinary manual and implemental operations. In other districts 18 feet are most common. In some parts of Ireland the land is not ploughed into ridges at all, being made with the spade into narrow strips called *lazy-beds*, separated by deep narrow trenches named *sheughs*. Where the plough is used, however, narrow ridges of 12 to 14 feet are mostly formed.

Ancient Form of Ridges.—More than half a century ago, ridges were made very broad—from 24 to 36 feet, and high on the crown—from an idea that an undulated surface affords a larger area for the crop to grow on, and that a crooked ridge like the letter S, from another mistaken notion, always presents some part of the crop in a right direction to the sun; which, although it did, removed other parts as far from it. Ridges were also made crooked to suit the lie of the land, so as to prevent the water in the furrows from gathering too great a force down-hill, and thus tend to wash away large quantities of useful soil. In parts many broad crooked ridges may still be seen; but the common practice is to have the ridges of moderate breadth, straight, and pointing to noon-day. For distinctness of description, let it be understood that only a ridge of 15 feet in width is spoken of hereafter.

Feering.—The first process in the ridging of land upon the flat surface is *feering*, which is done by placing upright, in the direction of the ridges, not fewer than three poles, and as many more as are necessary (fig. 32), $8\frac{1}{2}$ feet in length, graduated into feet and half-feet, and each painted at the top of a different colour, with bright blue, red, and white, to form decided contrasts with one another when set in line, and also with green trees and hedges, and brown ground.



Fig. 32.—
Feering-
pole.

Feering land is done in this manner: Suppose *a* and *b*, fig. 33, to represent the S. and E. fences of a field, of which *x* is the south *headridge* or *headland*, of the same width as the ridges—15 feet. There are two headridges in every field. To mark off the width of the headridge distinctly, pass the plough in the direction of *r e*, with a small furrow-slice lying towards *x*. The same is done along the other headland, at the opposite side of the field. Then take a pole

and measure off the width of a quarter of a ridge—viz., 3 feet 9 inches from the ditch-lip, *a e*—and plant a pole at *c*. With another pole set off the same distance from the ditch, *a e*, and plant it at *d*. Then measure the same distance from the ditch, at *e* to *f*, and at *f* look if *d* has been placed in the line of *f c*; if not, shift the pole at *d* until all the three poles are in a line. The plough-staff (fig. 18), set at *f*, will answer for a pole. Then plant a pole at *g* in the line

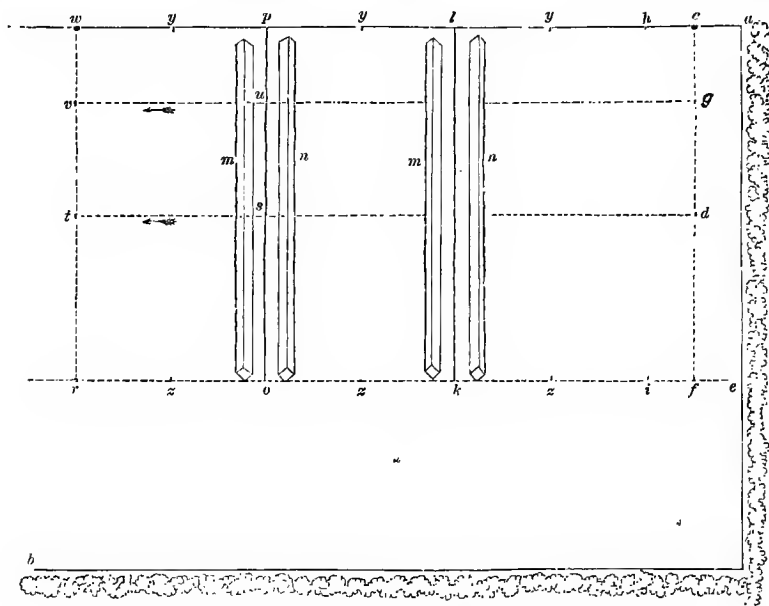


Fig. 33.—Mode of feering ridges.

a to *b* Fences of field.
x Headridge of field.

k l, *o p* Second and third feering of ridges; *f c* first feering of ridges.
m and *n* Furrow-slices of feerings.

f d c. Before starting to feer, measure off $1\frac{1}{4}$ ridge—namely, 18 feet 9 inches from *f* to *k*—and plant a pole at *k*.

To secure perfect accuracy in measuring breadths of ridges at right angles to the feerings, lines at right angles to *f c*, from *d* and *g*, should be set off in the direction of *t* and *v* by a cross-table and poles, and marked by a slight furrow drawn by the plough in each of these lines, previous to the breadth of the feerings being measured from *d* and *g* along them. Most people do not take the trouble of doing this, and a proficient ploughman renders it the less

necessary; but every careful farmer will do it, even at a little sacrifice of time and trouble, to ensure perfect accuracy of work, and especially when he is feering for a seed-furrow, which fixes the rigidity of the ridge during the entire rotation of the cropping.

It is essential to the correct feering of the whole field to have the first two feerings *f c* and *k l* correctly drawn, as an error committed there will be transmitted to the other end of the field; and to attain this correctness, two persons, the ploughman and the farm-steward, or farmer himself, should set the poles.

Only an experienced ploughman, and a steady pair of horses, should be intrusted with the feering of land. Horses accustomed to feering will walk up of their own accord from pole to pole standing before them within sight.

Now, start with the plough from *f* to *d*, where stop at the pole standing between the horses' heads, or else pushed over by the tying of the horses. Then measure with it, at right angles to *f c*, a line equal to the breadth of $1\frac{1}{4}$ ridge, 18 feet 9 inches, in the direction of *t*, which will be in the line of *k l*, where plant a pole. In like manner proceed from *d* to *g*, where again stop, and measure off $1\frac{1}{4}$ ridge, 18 feet 9 inches, from *g* in the direction of *v*, which is still in the line of *k l*, and plant a pole there. Proceed to the other headridge to the last pole *c*, and measure off $1\frac{1}{4}$ ridge, 18 feet 9 inches, from *c* to *l*, and plant a pole at *l*.

From *l* look towards *k*, to see if the intermediate poles are in the line of those at *l* and *k*; if not, shift them till they are so. On returning by the furrow from *c* to *f*, obviate any deviation which the plough may have formerly made from the straight line. In the line of *f c*, the furrow-slices of the feering have been omitted, to show more distinctly the setting of the poles at *d* and *g*. The furrow-slices are shown at *m* and *n*.

Proceed in this manner to feer the line *k l*, and also the line *o p*; but in all feerings after the first, from *f* to *k*, the poles are set up at the exact breadth of the ridge, as from *k* to *o*, *l* to *p*, and again from *o* to *r*, *p* to *w*, in the direction of the arrows. And the reason for setting off *c l* at so much greater a distance than *l p* or *p w* is, that the half-ridge *a h*, *e i*, may be ploughed first, and the rest of the ridges ploughed by half-ridges instead of whole.

The first half-ridge *a h*, *e i*, is, however, ploughed in a different manner from the other half-ridges: it is ploughed by going round the feering *f c* by always *hupping* the horses until the open furrow comes to *a e* on the one side and *h i* on the other. This half-ridge is ploughed before any of the others are begun to.

The line *h i* then becomes the feering

along with *k l* for ploughing the 2 half-ridges *z i* and *z k*, the open furrow being left in the line *z y*, corresponding to that in the line *e a*; and between these two open furrows is embraced and finished the full ridge of 15 feet *e z*, having its crown along *i h*. In ploughing these two half-ridges the horses are always *hied*.

As the plough completes each feering, the furrow-slices are laid over as at *m* and *n*. While one ploughman proceeds in this manner to feer each ridge along the field, the other ploughmen commence the ploughing of the land into ridges; and to afford a number of them space for beginning work at the same time, the feering ploughman should be set to work more than half a day in advance of the rest. On most farms now each ploughman does his own feering, although it may be doubted if it is usually performed so carefully as where the above method is pursued.

In commencing the ploughing of ridges, each ploughman takes two feerings, and begins by laying the furrow-slices *m* and *n* together of both the feerings, to form the crowns of two future ridges. One ploughman thus lays together the furrow-slices of *f c* and *k l*, whilst another is doing the same with those of *o p* and *r w*. These ridges are ploughed in half-ridges—that is, the half of one ridge is ploughed with the half of the adjoining ridge by always *hieving* the horses. The advantage of ploughing by half-ridges is, that the open furrows are made thereby exactly equidistant from the crowns; whereas, were the ridges ploughed by going round and round the crown of each ridge, one might be made narrower than the determinate breadth of 15 feet, and another broader, by a similar error of the ploughman.

Gathering up Ridges.—After laying the feering furrow-slices so as to make the crowns of the ridges at *f c*, *k l*, *o p*, and *r w*, the mode of ploughing the ridges from the flat ground is to *hie* the horses always towards you, on reaching the headridges, until all the furrow-slices between each feering are laid over as far as the lines *y z*, which become the open furrows.

This method of ploughing is called

gathering up, the disposition of the furrows in which is shown in fig. 34, where *a a a* embrace two whole ridges and three open furrows, on either side of which all the furrow-slices lie one way,

from *a* to *b*, and also contrariwise from *b* to *a*, until both sets of furrow-slices meet in the crowns *b b*. The open furrows *a a a* are finished off with the mould or hint-end furrows.

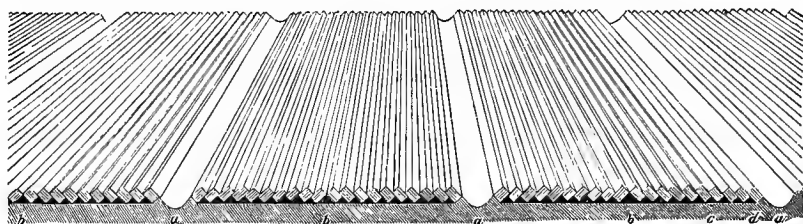


Fig. 34.—Gathered-up ridges from the flat.

- | | |
|--|---------------------------------|
| <i>a a a</i> Three open furrows of two ridges. | <i>b b</i> Crown of two ridges. |
| <i>a b</i> Furrow-slices lying from left to right. | <i>c d</i> Furrow-brow. |
| <i>b a</i> Furrow-slices lying from right to left. | <i>d</i> Mould-furrow. |

Number of Furrows in 15-foot Ridge.—The furrow-slices in fig. 34 are 20; whereas 10-inch furrow-slices across a 15-foot ridge would only be 18, which would be the number turned over in loose mould; but the figure represents gathered-up ridges in lea-ground, and the mould-furrows are shown as correctly formed as the others—which they ought

to be; but in ploughing lea, the mould-furrow scarcely ever measures 10 inches in breadth, most ploughmen regarding it as not forming a part of the regular ridge, but only a finishing to it.

The Finish or Mould Furrows.—The *mould* or *hint-end* furrow is made in this way: When the last two furrow-slices of the ridges *a a*, fig. 35, are laid

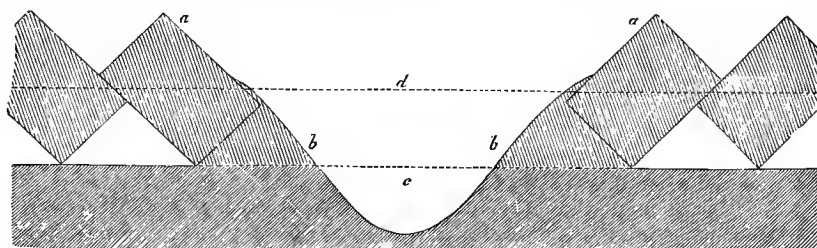


Fig. 35.—Open furrows with mould or hint-end furrow-slices

- | | | |
|---|--|--------------------------------|
| <i>a a</i> Two last-ploughed furrow-slices, and open furrow between them. | <i>b b</i> Two mould furrow-slices closing up the open furrow between <i>a a</i> . | <i>c</i> Finished open furrow. |
|---|--|--------------------------------|

over, the bottom of the open furrow is as wide as from *a* to *a*, and flat as the dotted line *c*. The plough goes along this wide space at *c*, and first lays over the triangular furrow-slice *b* on one side, and returning in the same furrow *c*, lays another slice of the same form *b* on the other side, up against and covering the lowest ends of the furrow-slices *a a*, by which action the ground is hollowed out in the shape represented below the dotted line at *c* by the sole of the plough. The dotted line *d* shows the place of the surface of the ground before it was

ridged up, and the furrow-slices *a a* the elevation attained by the land above its former level *d*.

Crown- and -furrow Ploughing.—*Crown-and-furrow* ploughing can easily be performed on land which has been gathered up from the flat. No feering is required, the open furrows answering the purpose. Thus, in fig. 34, let the last furrow-brow slices *d* be laid over into the open furrows *a*, and it will be found that they will just meet, since they were formerly separated by the same means; and in ploughing the

ridges in half-ridges, *a* will become the crowns of the ridges, and *b* the open furrows—hence the name of crown-and-furrow to this mode of ploughing. Its effect is to preserve the ploughed surface of the ridges in the same state as they were when gathered up from the flat.

When no surface-water is likely to remain on the land, as in the case of light soils, both these are simple modes of ploughing land; and they form an excellent foundation for drills for turnips on stronger soils, and are much practised in ploughing land for barley after turnips. But when the land for barley after turnips is to be *twice* ploughed, and it is inconvenient to cross-furrow the land,—which it will be when sheep on turnips occupy a field having long ridges, or the season is too wet to leave the land in a cross-furrow,—then the land should be so feered as, in gathering up from the flat, the crown-and-furrow ploughing may afterwards complete the ridges for the seed.

On looking at fig. 34, where the ridges are complete, it is obvious that, were they ploughed into crown-and-furrow, thereby making the open furrows *a a* the future crowns, a half-ridge would be

left at each side of the field,—a mode of finishing off a field displaying great carelessness and want of forethought. When the land is to be twice ploughed, the feering, therefore, of gathering up from the flat should leave a half-ridge on each side of the field, that the subsequent crown-and-furrow ploughing may convert them into whole ridges. Thus, the first feering for gathering up should be made at *e a*, fig. 33, instead of *f c*, and every other at the width of one ridge, 15 feet. On ploughing these feerings, the open furrows will be left at *i h*, *k l*, *o p*, and *r w*; and these will form the feerings of the subsequent crowns of the crown-and-furrow ploughing.

Casting Ridges.—Another mode of ploughing land from the flat surface is *casting* or *yoking* or *coupling* the ridges. The feering for this is done in a different manner from the two foregoing. The first feering is made in the line of *e a*, fig. 33, close to the ditch, and every other is made at 15 feet, the width of 1 ridge—as at *y z*, *y z*, *y z*. Two ridges are thus ploughed together, making a coupled ridge of 30 feet in width.

The true disposition of the furrow-slices is seen in perspective in fig. 36,

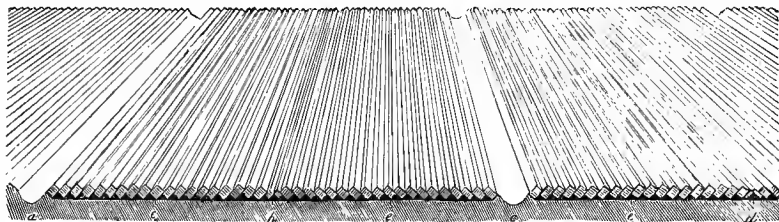


Fig. 36.—Cast, yoked, or coupled ridges.

a b One ridge with the furrow-slices lying to the right.
c d The other ridge with the furrow-slices lying to the left.

b Crown of the two coupled ridges.
c d Another ridge, with the furrow-slices lying to the right.

a and *c* Open furrows between the coupled ridges.

which exhibits a breadth of three entire ridges, *a b*, *b c*, and *c d*, two of which, *a b*, *b c*, are cast or yoked together, and meeting at *b*, the crown of the coupled ridge.

Ridges thus yoked can easily be recast, by reversing the furrow-slices of *b c* and *c d* into the open furrow *c*, and converting *c* into the crown of the yoked ridge *b d*, and making the crowns *b* and *d* open furrows.

Casting keeps the land in a level

state, and can most conveniently be formed on dry soils. It forms a good foundation for drilling, and makes an excellent seed-furrow on dry land. Lea and seed-furrow for barley, on light land, are generally thus ploughed. It is an economical mode of ploughing land in regard to time, as it requires but few feerings; the furrow-slices are equal, and the horses are always turned towards you. It is best performed upon the flat surface, and should the land be ploughed

again, it may be recast, and no half-ridges left at the sides of the field.

Gore-furrows.—Casting ridges is as suitable ploughing for strong as light land, provided the ridges are separated by a *gore-furrow*. A gore-furrow is a space formed to prevent the *meeting* of two ridges in a crown, and is a substitute for an open furrow between them; and can only be formed where a feering or an open furrow exists. It is made as shown in fig. 37. Let the dotted furrow-slices *a* and *e*, and the dotted line *i*,

form an open furrow, of which *c* is a point in the middle, and let it be converted into a gore-furrow. Make the plough pass between the centre of the open-furrow *c* and the left-hand dotted furrow-slice *e*, as at *i*, and throw up to the right the triangular-shaped mould-furrow-slice *b*, with the mould seen below *c*. Then turn the horses sharp from you on the headridge, and lay the dotted furrow-slice *a* upon *b*, which will thus become the furrow-slice *d*. Again turning the horses sharp from you on the

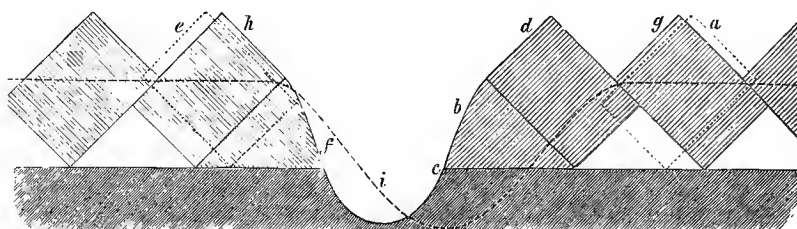


Fig. 37.—Mode of making a gore-furrow.

i The open furrow in a dotted line.
f c The gore-furrow.

a and *e* Brow-furrows, dotted, one on each side of the dotted old open furrow *i*.

headridge, take the plough lightly through part of the dotted furrow-slice *e*, and lay it of a triangular shape for the mould-furrow-slice *f*, the upper angle of *e* being left untouched; but a portion of *f* will trickle down towards *i*, and so will also a portion of *d* when it was ploughed. Turn the horses on the off headridge still from you, and bring the plough down behind *d*, and lay upon it the ordinary furrow-slice *g*. Turning the horses again from you on the nigh headridge, lay the ordinary furrow-slice *h* upon the triangular-shaped mould-furrow *f*, by destroying the remainder of the dotted furrow-slice *e*, and some more earth; and then turn the horses *from* you again on the off headridge for the last time, and come down the open furrow *i*, pushing the soil up with the mould-board from *i* against *f*, and clearing the furrow of any loose soil in it, and the gore-furrow is completed.

A gore-furrow is best made and preserved in clay soil, for in tender soil it is apt to moulder down by the action of the air, and prevent itself being a channel for running water; and is therefore never made on light soils.

Casting with a gore-furrow upon a

gathered ridge makes the open furrow barer of earth than the gore-furrow; but this is not an imperfection unavoidable in casting a ridge, as it is so only in casting after gathering up once or twice from the flat.

No Casting on Gathered Ridges.—Casting should never be practised on gathered ridges, to remain in a permanent state, though it may be used for a temporary purpose, as in fallowing, to stir the soil and overcome weeds; for observe its necessary consequences: Suppose two gathered ridges *a a a*, fig. 34, were cast together towards the middle open furrow *a*, the effect would be to reverse the position of the furrow-slices from *a* to *b*, on either side of *a*, and they would remain as flat as formerly; but what would be its effect on the furrow-slices on the other halves of the ridges from *b* to *d*? They would not be reversed, but heaped up in the same direction, so that the coupled ridge would have two high furrow-brows by two gatherings, and two low flanks by one gathering. They would be unevenly ploughed, and the open furrow on each side would be bared of soil, from being twice gathered

up. The distortion might be partially obviated by making the furrow-slices between *a* and *b* on each side of the middle open furrow *a* deeper and larger than those between *b* and *d*, and a uniform shape to the coupled ridge might be preserved; but it would be done by the sacrifice of good ploughing; so it is but right to confine casting within its own sphere.

The "Two-out-and-two-in" Method.—Nearly allied to casting is ploughing *two-out-and-two-in*, which may also be executed on the flat ground, and requires a particular mode of feering. The first feering should be measured of the breadth of 2 ridges, or 30 feet, from the ditch *a e*, fig. 33; and every sub-

sequent feering of 4 ridges breadth, or 60 feet. The feerings are thus but few.

The land is ploughed in this manner: After returning the feering furrow-slices, begin ploughing round the feering *c d*, fig. 38, keeping it on the right hand, and *hupping* the horses from you on both the headridges, until about the breadth of a ridge is ploughed on each side of *c d*, to *g g* and *h h*. While this is doing, 2 ridges to *i i* and *k k* are ploughed around *e f* by another ploughman. If there is not another ploughman, the same one ploughs round the feering *e f*, as he had done round *c d*. At this juncture open furrows occur at *h h* and *i i*, embracing between them 2 ridges, or 30 feet, from *h* to *i*. If

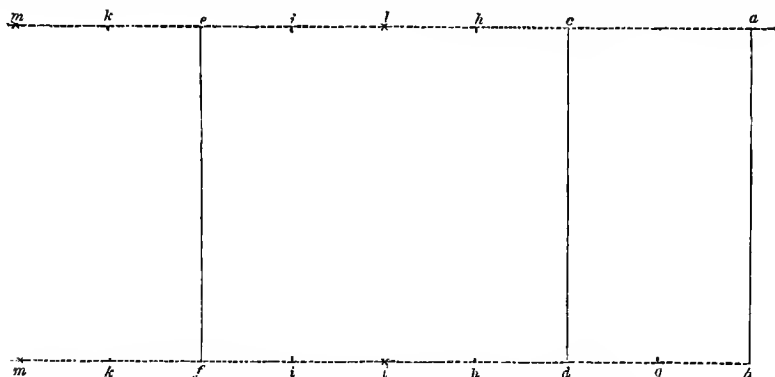


Fig. 38.—Feerings for ploughing ridges two-out-and-two-in.
c d and *e f* Feerings every 4 ridges or 60 feet. *l l, m m* Open furrows at every 4 ridges or 60 feet.

there is another ploughman, the ploughman who has ploughed round *c d* ploughs from *h* to *i*, laying the furrow-slices first to *h* and then to *i*, by *hieing* the horses towards him on both headridges, until the ground is all ploughed to *l l*, which becomes the permanent open furrow. If there is not another ploughman, the only one finishes the feering between *h i* as just described. The next permanent open furrow will be at *m m*, 60 feet or 4 ridges breadth from *l l*.

But as yet the ridge *g a* has not been ploughed, nor its corresponding ridge at the other end of the field. They are both ploughed along with the headridges *m a* and *b m* round the field, after all the ridges have been ploughed, laying their furrow-slices towards *g g*, in

the same direction to the left as the furrow-slices from *g* to *c*, and making the open furrow at *a b*.

The appearance of the ground on being ploughed two-out-and-two-in is seen in fig. 39, where the space from *a* to *e* is 60 feet, comprehending 4 ridges, between the open furrows *a* and *e*.

This method of ploughing places the land in large flat spaces, and as it dispenses with many open furrows, is only suitable for light soils or well-drained land, in which it may be used for seed-furrowing, and for drilling turnips and potatoes upon.

Gore-furrows again.—Were the gore-furrow, in fig. 37, applied to ploughing strong classes of soils, its introduction would change the char-

acter of ridges, inasmuch as the crown *c*, fig. 39, would not only be converted into an open furrow, but the crown transferred from *c* to *b* and *d*, where furrow-slices *not meeting* from opposite directions, but lying across it, there would be no true crown.

In a similar manner, were the gore-

furrow introduced into cast ridges, in fig. 36, the crowns at *b* and *d* would be converted into open furrows, and the crown *e* would not be a true crown, the furrow-slices lying across the ridges.

Ploughing in Breaks.—Nearly allied to ploughing two-out-and-two-in is *ploughing in breaks* or *divisions*. It

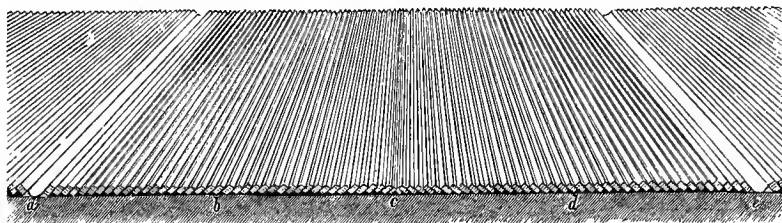


Fig. 39.—Ploughed ridges two-out-and-two-in.

a c Furrow-slices of 2 ridges lying to the right.
e e Furrow-slices of 2 ridges lying to the left.

c The crown of the 4 ridges.
a and *e* Open furrows of the 4 ridges.

consists of making *feerings* at indefinite distances, and ploughing large divisions of land without open furrows, comprehending 8 ridges or 40 yards; but so great a distance incurs considerable loss of time in travelling from furrow to furrow at the landings. Instead, therefore, of a given number of ridges, 30 yards are chosen; and this particular breadth has the advantage of causing the loosening of any hard land that may have been left untouched by the ordinary ploughing. Land is ploughed in breaks only for temporary purposes, such as pulverisation for seed-furrowing, or drilling up immediately thereafter.

Time lost in ploughing wide breaks might be easily estimated in fig. 38, where, the *feerings* *c d* and *e f* being 60 yards asunder, the ploughs would have to go round *c d* and *e f* until they reach *h* and *i* respectively, thus travelling in a progressive increasing distance to 30 yards for every furrow-slice laid over, of whatever breadth.

Twice - gathering - up.—Another mode of ploughing is *twice-gathering-up*. Its effect is in fig. 40, where twice-gathered-up furrow-slices rest upon the formerly gathered-up ground. It may be practised both on lea and red-land. On red-land that has been already gathered-up from the flat, it is begun by making *feerings* in the crowns of the ridges, at *b*, fig. 34. The furrow-slices

of the *feerings* are laid together, and the ridges ploughed by half-ridges, in the manner of gathering-up from the flat. The half-ridge left by the *feerings* at the sides of the field must be ploughed by themselves, even at the risk of losing time, because it would not do to *feer* the first ridge so as to plough the half-ridge as directed to be done in the first gathering-up, in fig. 33, around the *feering* of the quarter-ridge *f c*, because the furrows betwixt *f* and *i*, when ploughed in the contrary direction they were before, would again lower the ground; whereas the furrow-slices from *e* to *f*, and from *z* to *i*, being ploughed in the same direction as formerly, the ground would be raised above the level of *i f*, and disfigure the ploughing of the entire ridge *z e*. Gathering-up from the flat, in fig. 34, preserves the flatness of the ground; and the second gathering-up would preserve the land in the same degree of flatness, though more elevated, were there depth enough of soil, and the furrow-slices made in their proper form; but a roundness is imposed upon a twice-gathered-up ridge by harrowing down the steep furrow-brows, and by ploughing the furrow-slices of unequal size, from want of soil at the furrow-brows and open furrows.

In twice-gathering-up *lea* no *feering* is required. The plough goes a little

to the left of the crown of the ridge, and lays upon its back a thin and narrow furrow-slice, *a*, fig. 40, to serve as a cushion upon which to rest the

future crown furrow-slices *c* and *b*. The horses are then *hopped* sharp round from you, and the furrow-slice *b* is laid so as to rest upon *a*. *Hopping*

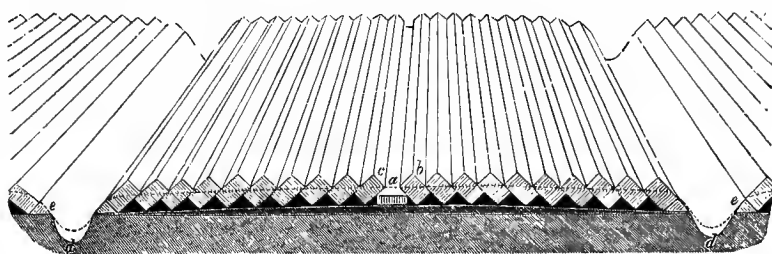


Fig. 40.—Twice-gathered-up ridges.

d to *d* Section of the ground by the first gathering-up.

e to *e* Dotted line indicating the rise in the ground after the second gathering-up.

the horses again sharp round from you, the furrow-slice *c* is laid upon the other side of *a*; but *c* and *b* should not meet so as to cover over *a*, but leave a space of 3 or 4 inches between them, the object being to form an open rut for seed, which, were *c* and *b* to meet and make a sharp angle, would slide down when sown, and leave the crown, the best part of the ridge, bare of seed. The ridges are ploughed in half-ridges to the open furrows *d*, which are finished with mould-furrow-slices, but

these are formed with some difficulty for want of soil. The dotted line *e e* represents the configuration of the ground before the second gathering-up was begun, and the open furrow at *d* must now be deeper than it was with one gathering-up.

Cleaved-down Ridges.—Exactly opposite to twice-gathering-up is *cleaving* or *throwing-down* ploughing. Open furrows of twice-gathered-up land constitute deep featherings, which are filled up with slices from the mould-furrows

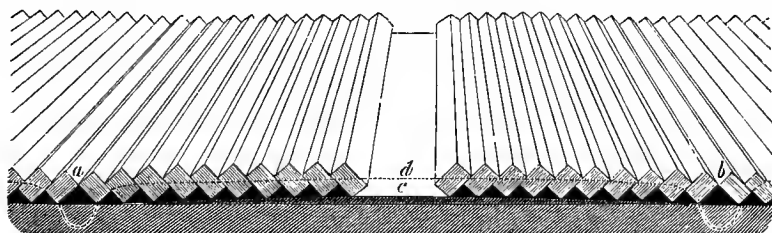


Fig. 41.—Cleaved-down ridges without gore-furrows.

d Dotted line showing the former surface of the ground.

a and *b* Dotted line showing the former open furrows.

and furrow-brows of the adjoining ridges; and to fill them up fully, the plough takes a deep hold of those furrows. The furrow-slices are ploughed exactly the reverse way of twice-gathering-up, but also in half-ridges. The effect of cleaving-down is to bring the ground again to the level from which it had been elevated by twice-gathering-up. The open furrows are left at the crowns, at *a*, fig. 40, the mould-furrows being seldom ploughed, cleaving-

down being done to prepare land for ploughing again.

But when clay land is cleaved down in winter, it is so sometimes with gore-furrows, and these, with the open furrows, afford a convenient channel, at every half-ridge, for the water to flow off to the ditches; and as twice-gathering-up is practised only on clay soils, and cleaving-down can be executed only after twice-gathering-up, it follows that cleaving-down is only suitable to clay

soils. The effect of simply cleaving-down ground is in fig. 41, where are no open furrows at *a* and *b*, and only at *c*; but in fig. 42 the gore-furrows are shown at *a*, and the open furrow at *b*. Gore-furrows are going fast out of

practice since the success of thorough draining, and are necessary only on stiff wet stubble-land.

Cross-ploughing.—*Cross-ploughing* is at right angles to the furrow-slices of ridges. Its object is to cut the furrow-

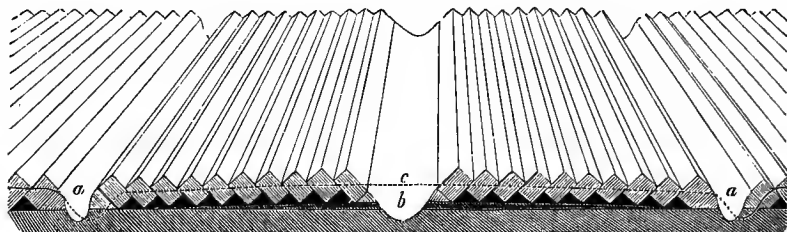


Fig. 42.—*Cleaved-down ridges with gore-furrows.*

c Dotted line showing the former surface of the ground.

a and *a* Dotted line showing the former open furrows.

slices into small pieces, so that the land may afterwards be easily pulverised. It is commonly executed in the spring, and should never be attempted in winter; because the altered position of the furrow-slices would retain the rain or melting snow, so that the land would remain wet. But even if cross-furrowing were executed quickly in winter, and the weather allowed the soil to be safely ridged up, the soil would become so consolidated during winter that it would have to be again cross-furrowed in spring before it could be pulverised. The object of cross-furrowing being to pulverise land, it is practised on every kind of soil, and exactly in the same manner.

It is ploughed in divisions, the feerings being made at 30 yards asunder, and executed in the same manner as for two-out-and-two-in, fig. 38, by going round the feerings, *hopping* the horses constantly from you, until about half the division is ploughed, and then *hieing* them towards you, still laying in the furrow-slices towards the feerings, until the division is ploughed.

In cross-ploughing, no open furrow is left, it being closed with two or three of the last furrow-slices being reversed, and all existence of furrows obliterated by the plough filling loose soil into them with the mould-board, laid over and retained in that position by a firm hold of the large stilt only. Obliteration should be complete, otherwise a hollow at the furrows would be left across the future ridges.

Angle-ploughing.—Another mode, having a similar object to cross-ploughing in pulverising furrow-slices by cutting them into pieces, is *angle-ploughing*, so named because of the feerings being made in a diagonal direction across the ridges of the field. The ploughing is conducted in divisions of 30 yards each, and in exactly the same manner as cross-ploughing, with the same precautions as to the season, and obliteration of open furrows. It is never practised but *after* cross-ploughing, and not always then, and only in clay soil, when cross-ploughing has failed to produce pulverisation or sufficient cleansing of the land.

Bad Ploughing.—These are all instances of good ploughing with rectangular furrow-slices; and were they constantly executed, there would be no instances of bad ploughing, as shown in fig. 43; no high-crowned ridges as at *a*, caused by bringing two feering-slices or two open furrows too close from opposite directions; no *lean* flanks, as at *b*, by making the furrow-slices broader than they should be, with a view to ploughing the ridge quickly, and which constitute hollows that become receptacles of surface-water to sour the land. When the soil is strong, lean flanks are so low, and become so consolidated, that they are almost sure to resist the action of the harrows when passed across the ridge; and in light soil they are filled up with the loose mould by the harrows, at the expense of the surrounding heights. No *proud* furrow-brows as at

c, by setting up the furrow-slices more upright than they should be, to the danger of being drawn bodily into the open furrow on the harrows catching them too forcibly in cross-harrowing; and no *unequal-sided* open furrows, as at d, by

turning over one mould-furrow flatter than the other.

Every sort of crop grows *unequally* on ill-ploughed ridges, growing better on spots where the soil is most kindly, and worse on the hard portions; but the

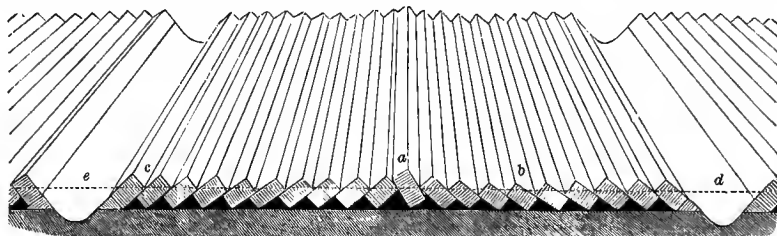


Fig. 43.—*Ill-ploughed ridge.*

a Too high-crowned ridge.
b Too low flank of ridge.
c Too proud furrow-brow.

d Unequal-sided open furrow.
e d Dotted line showing the former surface of the ground and the

unequal positions of the furrow-slices by bad ploughing.

evil effects of bad ploughing are not confined to the season it is executed, for it renders the soil *unequally* hard when ploughed up again.

Some are of opinion that land when ploughed receives a curvature of surface, whereas correct furrow-slices cannot give the surface any other *form* than it had before it was ploughed. If that form were curved or flat, the new ploughed surface would be curved or flat. In gathering-up a ridge from the flat ground, the earth displaced by the plough occupies a smaller area than it did by the extent of the open furrows; but the displacement only elevates the soil above its former level, and the act of elevation cannot impart a curvature to it. True, ridges on being harrowed become curved on the surface, because the harrows draw the soil into the open furrows, having the least resistance presented to them at the furrow-brows, but the curvature thus given has no connection with the ploughing.

The steam-plough, laying all its furrows in the same direction, by means of its balanced mould-boards, dispenses with ridges and open furrows. The even surface proves advantageous in certain operations—as drilling for potatoes and turnips—and it looks well; but in sowing grain by hand or machine, or drill, the guidance for the breadths in sowing the ridges will be missed, and some expedient must be substi-

tuted to have as sure a one as defined ridges.

TURN-WREST OR ONE-WAY PLOUGHS.

For hilly land the turn-wrest plough is a most useful implement. It turns the furrow over in one direction, so that by ploughing with it across steep land, the furrows can all be thrown down-hill, an advantage which every practical farmer will readily understand and appreciate. One of the best of these "one-way" ploughs is that represented in fig. 44, and made by Ransome, Sims, & Jefferies. This plough acts in the same

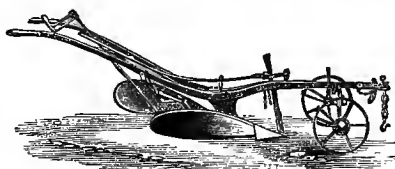


Fig. 44.—*Ransome's One-way plough.*

manner as the common plough, when the mould-board is set as seen in the figure, the furrow-slice being turned over to the right hand; and on coming to the land's end, the other mould-board is brought into action on the left-hand side of the plough, and by it the furrow-slice is turned over to the left hand—where it is placed in the same position as did the ploughing in turning over the fur-

row-slice to the right hand, while moving in the opposite direction. The even surface without open furrows, executed by this mode of ploughing, is highly favourable to the action of reaping-machines in harvest. But, as has been indicated, its chief value is its adaptability for ploughing steep land. Fig. 45



Fig. 45.—Cooke's One-way plough.

represents another form of the turnwrest — an excellent implement also, made by Cooke & Sons of Lincoln, and specially designed to turn over wide well-broken furrows.

PLOUGHING STUBBLE AND LEA GROUND.

When the crop has been gathered into the stackyard, the student will perceive that a large proportion of the land is in stubble, some fields containing grass, others none. The stubble which contains no grass is ploughed, the other not, and the ploughing is determined by the nature of the soil and crop.

Ploughing Stubble-land.—It is rare that stubble-land is ploughed in any other mode in winter, than in reversing the form in which it was previously ploughed. If it had been twice gathered up, fig. 40, on clay soil, it should now be cloven down with gore-furrows, fig. 42; if so ploughed on loam, cleaving down without gore-furrows, fig. 41, answers best. If it had been cast on strong soil, it should now be recast with gore-furrows; but if it had been cast on loam, recast it without gore-furrows. If it had been ploughed two-out-and-two-in, renew the furrow-slices, with gore-furrows between every two ridges. And if it had been ploughed crown-and-furrow, reverse the furrow-slices. A good general rule for all winter-ploughing is to reverse the former furrow-slices with gore-furrows on heavy, and without them on lighter soils; and it is the safest rule even on recently thorough-drained land, until

sensible effects of draining have been ascertained.

Clay Land not to be ploughed Wet.—Strong clay soil should never be ploughed in a wet state, as it will become very hard in spring, and difficult to pulverise, and even to work.

No Ploughing in Frost and Snow.—Snow should never be ploughed in under any pretext, nor the soil when in a frozen state. Ice and snow concealed under the soil remain a long time unaltered, and spring may be far advanced ere its warmth will reach them, to relieve the soil from its chilled condition.

Stubble-land ploughed Deep.

When soil is tolerably clean and dry, either by thorough-draining or naturally porous subsoil, it is desirable to plough stubble-land deep with three horses instead of two. The horses are yoked according to the arrangement in fig. 26. The form of ploughing may either be crown-and-furrow if the soil is light, or cast together when somewhat heavy. One ploughman can direct three horses well enough. The three horses may easily turn over a furrow-slice 10 to 12 inches deep and with a proportionate breadth, and this should be done when the soil and subsoil are of a suitable nature for this depth of ploughing.

Rain-water Channels.—In every variety of soil, ploughed in the forms just described for winter, care should be taken to have plenty of channels cut in the hollowest places for the surface-water to escape into the nearest ditch. The channels are first made by the plough laying them open like a feering, taking the hollowest parts of the ground, whether across ridges or along open furrows, across the head-ridge into a ditch; and they are immediately cleared out by the hedger with the spade of all loose earth, which is spread over the surface. The precaution of channel or gaw cutting should never be neglected in winter in any kind of soil, the clayey soil, no doubt, requiring more gaws than the lighter; but as no foresight can anticipate the injuries consequent on a single deluge of rain, or a great melting of snow, it should never be neglected, and never

is by the provident farmer, his great object being to keep his land in the driest condition all winter. It is certain, however, that as land is more extensively thorough-drained, it will require less gaw-cutting; but it is to err on the safe side, to have too many rather than too few of them in winter.

Deep Ploughing.—Modern experience has rather upset the faith which was formerly placed in deep ploughing. This, of course, is a relative and a very indefinite term. What one farmer has considered deep ploughing might not be so regarded by another. Not very long ago there was quite a rage for deep ploughing. It was thought, and indeed so expressed, that the steam-plough, by enabling the farmer to add a few more inches to the workable soil, would thereby vastly increase the productiveness of his land. But it was found that harm instead of good was done by burying useful soil and bringing up in its place sour unkindly subsoil. It has therefore come to be recognised that deep ploughing may easily be carried too far. What the depth of furrow should really be, depends mainly upon the character of the soil and subsoil.

As a general rule, it may be laid down that the furrow should be as deep as the nature of the soil and subsoil will advantageously permit. This rule, it may be said, is still indefinite,

but deep ploughing is one of many subtle points in farm management as to which it would be worse than useless to lay down precise and unvarying directions. It must be left to practical men of good judgment to decide what is best to be done in each individual case.

Generally speaking, it may safely enough be said that for ordinary grain crops 7 inches is quite as deep as need be desired. In ploughing stubble-land as a preparation for root crops, the depth should, if possible, be much greater; and where the good soil is too shallow for deep ploughing, other means may be found of stirring of the ground to the desired depth.

Digging and Grubbing.—This stirring of the soil is effected by the digger, the grubber, or cultivator—an implement differing from the plough, inasmuch as it operates by means of tines. Tines, in action, strip the soil, and even subsoil, into ribbons, leaving the ground in the same position as it was before—that is, leaving the good soil on the surface and the subsoil still underneath. This stripping does the soil much good, by changing the relative positions of its component parts, and by opening it up so as to admit the air. Indeed, there are many soils in which the action of the digger is more effectual than that of the plough, and is therefore preferred.

Subsoiling.—Still the digger does not so thoroughly expose the under soil

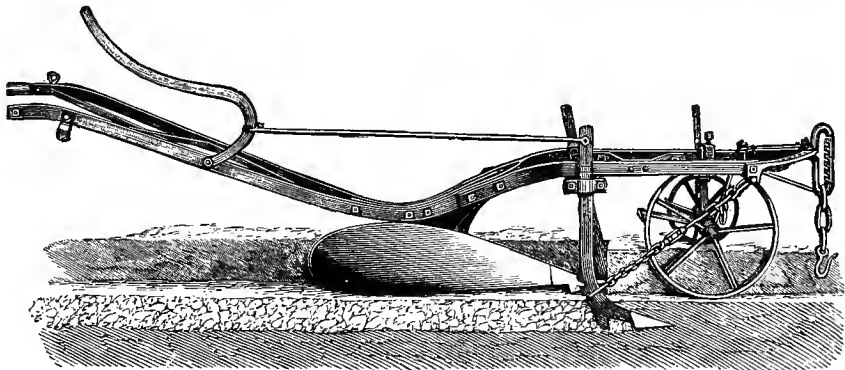


Fig. 46.—Single plough and patent subsoiler combined.

and subsoil to the action of the atmosphere as does the plough. Many therefore prefer the more effectual method of

stirring soil and subsoil each by itself simultaneously, by means of the subsoil trench-plough. Fig. 46 represents both

operations of ploughing and subsoiling performed at one time by Ransome's combined plough and subsoiler. An ordinary furrow-slice is turned over by the wrest, while the tine bearing the subsoiling share precedes it in the open furrow. It may be set to break up the bottom to any depth the horses can pull, while the covering with a furrow-slice immediately prevents any trampling on the stirred soil by the horses the next time they come round.

Very often the subsoiling is done by a separate implement (as is seen in fig. 47) following in the bottom of the fur-

row turned by the plough. In this case the work can generally be done deeper than where the two form parts of the same implement.

To plough deep at *once* into a subsoil, impregnated with oxides of iron, might run the risk of injuring the scanty upper soil. But such a subsoil has a tendency to *pan*, which subsoiling can best destroy by breaking it up and exposing it to the air, which converts the iron into a harmless peroxide.

Shallow Ploughing.—A preference for the rectangular furrow-slice has been evinced, and this on the safe principle



Fig. 47.—Conjoint operation of the common and subsoil trench-plough.

b The plough going before.

a Trench-plough following after, with bearing-wheel.

c Tail-board over which the subsoil falls 9 inches.

d Depth of furrow by the plough, 10 or 12 inches.

e Surface of ground.

f Stilts of trench-plough.

that, in suitable soil, deep ploughing ought to be the rule, and shallow the exception.

Shallow ploughing for a seed-furrow is common in the case of fields of grass that have been pastured by sheep, and their droppings form too good a top-dressing to be buried by deep ploughing. The reason is plausible, but is not admitted by all to be entirely unassailable. It is well known that the roots of plants push themselves everywhere in pursuit of nutriment, even through media which afford little nourishment, in order instinctively to reach the one in which they can luxuriate. With the largest vegetable productions, as trees, this is remarkably the case; and with cereals the roots are known to extend 6 feet and more into the subsoil. Hence a strong argument for deep ploughing or stirring. In shallow ploughing weeds are apt to exert an ascendancy over the crops.

Smashing up the Soil.—Amongst the earliest and most energetic advocates of digging or stirring, as opposed to deep ploughing, was Mr William Smith, Woolstone, England. His system has been to stir the soil to the depth of 15 inches with steam-power by means of a grubber, by which he *smashes up* the soil, as he expresses it. He disapproves of the

plough, and even of the principle by which it operates, and prefers, and has adopted, and strongly recommends, the grubbing system. The steam-grubber or cultivator has certainly been more successful than the steam-plough, and it is now freely acknowledged that there was much truth in Mr Smith's reasoning, although his wholesale condemnation of the plough would not be generally supported. The chief defect in the grubbing or cultivating system is that in the main it always leaves the surface-soil at the surface, and cannot, even where it is desired and desirable, bring up any considerable quantity of fresh earth to the surface. Cultivating or grubbing, therefore, while a most useful operation, can never to any great extent supersede judicious ploughing.

Ploughing Lea.—The most common form of ploughing *lea* in *strong soil* and *light soils* is to cast it; whilst on *lightest soils* the crown-and-furrow is most suitable. Gathering-up is a rare form of ploughing *lea*, though it is occasionally practised on strong soil.

The oldest *lea* is first ploughed, that the tough slices may have time to mellow by exposure to the winter air, and for the same reason the strongest land should always be ploughed before the light.

Unseasonable Ploughing.—Lea should never be ploughed when affected by frost or snow, or even rime, or when soft with rain. Ice or rain ploughed down chills the ground to a late period of the season, and when rain softens the ground much, horses cut the turf with their feet, and the furrow-slice is squeezed into a pasty mass by the mould-board. Nor should lea be ploughed when hard with drought, as the plough will take a shallow furrow, and raise the ground in broad thin slabs. A semi-moist state of ground in fresh weather is the best condition of soil for ploughing lea.

Water-runs.—Gaws or water-runs should never be neglected to be cut after lea-ploughing, especially in the first ploughed fields, and on strong land, whether early or late ploughed. To leave a ploughed field to be injured by wet weather, shows great indifference to future unfavourable consequences. No doubt, on thorough-drained land, less dread of evil consequences from neglect of gaw-cutting may be felt; but even in the best drained land it is imprudent to leave isolated hollows in fields in winter without a ready means of getting rid of every torrent of rain that may fall unexpectedly. Land which lies dry all winter may be worked a week or two earlier in spring than land which has been wet.

Headridges.—It is a slovenly practice to leave headridges unploughed for a time after the rest of the field. The neglect is most frequent on stubble-land, but it should be avoided. Ploughing headridges in winter requires some consideration. In stubble, should the former ploughing have been cast, fig. 36, with or without a gore furrow, fig. 37, reversing it, will leave a ridge on each side of the field, which will be most conveniently ploughed along with the headridges by the plough going round parallel to all the fences of the field, and laying the furrow-slices towards the ridges. The same plan may be followed in ploughing lea in the same circumstances.

Should the ploughing in stubble on clay land have been cleaving-down with or without gore-furrows, figs. 41, 42, the headridges should be cloven down with a gore-furrow along the ends of the ridges, and mould-furrowed, fig. 35, in the crowns.

On ridges being ploughed crown-and-furrow, the headridges may be gathered up in light soils, and in stubble, on strong soils, cloven down without a gore-furrow along the ends of the ridges.

The half-ridge on each side of the field may be ploughed by going the half of every bout empty; but a better plan is, *where the ridges are short*, to plough half of each headridge towards the ends of the ridges, going the round of the field, and then to plough the other half-ridge with the other half of the headridges in the circuit, laying the furrow-slice still towards the ends of the ridges, which would have the effect of casting the headridges towards the ends of the ridges, and of drawing the soil from the ditches towards the ridges.

When ridges have been ploughed in a completed form in lea, headridges of clay soils should be gathered up, and in light soils cloven down from the gathering.

A difference of opinion is entertained of the manner in which a headridge should be formed, where a great length of ridges, from opposite directions, meets in a common line. The practical question is, whether these ridges should meet in an imaginary line or at a common headridge? An answer may be given thus: When ridges meet from opposite directions, they cannot be ploughed at the same time without risk of the horses encountering one another upon the common headridge; and where no headridge exists, the ridges first ploughed will be trampled upon when the others are ploughed. There should therefore be two headridges—one belonging to each set of ridges.

APPLICATION OF STEAM-POWER TO AGRICULTURE.

Since 1850 a complete revolution has taken place in the use of steam-power for agricultural purposes. It is now used for all kinds of hard work, and on some modern holdings may be found as many as five or six steam-engines of various sorts profitably employed in the various operations of the farm.

In the early days of steam the engines were heavy and cumbrous. As they worked with steam at a very low pressure, they required cylinders of large area to develop the necessary power; but now that higher pressures are invariably employed, the engines can be made much lighter and more compact. Many farm-engines work with steam at a pressure of from 120 to 150 lb. on the square inch. For these high pressures high-class boiler-work is absolutely necessary.

In dealing with this subject it will be convenient to notice the various points in the following order: (1) the boiler—the apparatus by which the steam is generated; (2) the kinds of fuel employed in raising steam, the principles of combustion, and the properties of steam; (3) the construction of the steam-engine and the action of steam; (4) the different types of steam-engines; and lastly, the various methods by which land is cultivated by steam-power.

The Boiler.

The functions of a boiler being to generate steam, its efficiency is estimated by the rapidity with which it does this duty, and the economy of fuel with which the required result is obtained. The form of the boiler—its proportions—the nature, extent, and disposition of the heating-surfaces—have a most important bearing upon its efficiency. The greater the area of the surface of the boiler exposed to the action of the fire and heated gases, the greater will be the amount of water which will be evaporated by it. As a general rule, the comparative efficiency of steam-boilers may be fairly estimated by the relative area of the heating-surfaces which they present to the action of the fire.

Egg-ended Boilers.—Amongst the earlier forms of steam-generator used with agricultural engines was that known as the ordinary cylindrical or “egg-ended” pattern. This consists of a plain shell of wrought iron, of a diameter varying from 3 feet 6 inches to about 5 feet, with a thickness of plate of about $\frac{3}{8}$ of an inch, and hemispherical ends riveted in. These boilers are fixed in brickwork seating, and fired externally. The fire-grate is underneath one end of the boiler, and is sometimes so arranged that the flame and hot gases can play freely on the whole of the underneath external surface of the boiler up to about its horizontal axis. In other cases the heated gases pass along a portion only of the under surface, and return by means of a flue or belt passing round the centre of the boiler, by which means the gases are made to traverse a longer distance in contact with the plates of the boiler before they pass away into the chimney. They thus have a better chance of imparting some of their heat to the boiler itself.

This kind of boiler is, however, nearly obsolete; for although there are still large numbers of old ones at work, no one with any regard for economy of fuel would now think of putting down a boiler of this antiquated description.

The mountings of this class of boiler are of almost as simple a character as the boiler itself. They frequently consist of only a safety-valve and a “float”—the former to prevent any dangerous excess of pressure, and the latter to indicate the height of the water within the boiler. The “float” generally consists of a stone suspended inside the boiler, fastened to a rod coming through the boiler-plate. The rod is coupled to a chain which passes over a pulley, and sustains a weight which partly counterbalances the weight of the stone, so that it floats on the surface of the water within the boiler. By observing the position of the balance-weight, which rises and falls with the level of the water in the boiler, it can be seen at a glance whether this

is being maintained at the proper height or not.

At the period when these "egg-ended" boilers were in general use, the element of safety was more considered than that of efficiency; but now that every means are used to secure economy as well as safety, this type of boiler has almost become a thing of the past. The usual amount of heating-surface in egg-ended boilers varies from 5 to 7 square feet per nominal horse-power.

Cornish and Lancashire Boilers.—

A much more economical and altogether preferable form of steam-generator is that known as the "Cornish" or "Lancashire" type. These, like the former, consist mainly of an outer cylindrical shell of stout iron plates. They have flat ends, and may have one or two large tubes or flues running through their whole length. The outer shells of these boilers vary from 12 to 30 feet in length, and from 4 feet 6 inches to 8 feet diameter. The diameter of the flues varies from 2 feet to 3 feet 6 inches, according to the size of the boiler. The flues contain at one end a fire-grate, with fire-door and other necessary fittings. They are consequently fired internally. The heated gases pass along the interior of the tubes or flues as far as the end of the boiler, and return underneath in a single or double brickwork flue, so that a much larger surface of the boiler-plates is exposed to the action of the flame and heated gases in these boilers than is possible in those of the "egg-ended" description. The heating-surface may also be considerably increased by inserting in the flues beyond the fire-grate and at short intervals a series of cross tubes, or "Galloway tubes," as they are sometimes called. These consist of conical tubes, varying in diameter from 5 or 6 inches at one end to 10 or 12 inches at the other. They are placed transversely in the main flues at different angles, so that they obstruct the free passage of the heated gases. These impinge against the cross tubes, which are of course full of water, constantly exposed to the fiercest action of the heat; and the effect of a number of these cross tubes fixed in the flues of a Cornish or Lancashire boiler is to greatly increase its evaporative efficiency.

These boilers are generally fixed in brickwork seatings, and as they present a greater amount of heating-surface to the action of the flame, and in very close contact with the same, they have the advantage of generating a great deal more steam per lb. of fuel than the "egg-ended" boiler. They are known as "Cornish" boilers when they have but one flue, and as "Lancashire" when they have two. In both classes of boiler the best practice is to allow about 14 square feet of heating-surface to each nominal horse-power. If properly constructed, the wear and tear upon these boilers is not at all excessive. On the other hand, if badly designed, or if the water-supply contain lime or other impurities in suspension or solution which may be precipitated by heat, they are somewhat more difficult to keep clean internally than the old-fashioned "egg-ended" boilers.

Objection to Brickwork Seatings.—

The brickwork seatings are a considerable source of wear and tear in both these classes of boiler, as they prevent external examinations being conveniently made, so that in the event of leakage, corrosion may go on for years before being discovered. Indeed it often happens that it is not discovered until too late, and after fatal consequences have resulted both to the boiler and its attendants. Every steam-boiler ought to have both its outer and inner surfaces easily accessible for periodical examination, so that in the event of corrosion taking place, it may be speedily attended to and arrested.

Vertical Boiler.—Another class of steam-generator largely used in agriculture is that known as the vertical boiler. It has the advantages of occupying very little space and being very cheap, although it is by no means economical of fuel. The outer shell of these boilers consists of a plain vertical wrought-iron cylinder, containing an internal circular chamber or fire-box somewhat smaller in diameter than the outer shell, so that the whole surface of the fire-box is continually surrounded by an envelope of water, to which the heat is communicated directly through the plates of which the fire-box or chamber is formed. From the centre of the crown of the fire-

box a vertical flue or uptake rises, and passes through the flat or convex plate which forms the crown of the outer shell of the boiler. This pipe not only serves as a chimney, but acts as a stay to prevent the pressure of steam in the boiler from depressing the crown of the fire-box, or bulging outwards the crown-plate of the boiler. It will thus be understood that the vertical boiler gives a greater proportion of fire-box heating-surface (which is the most valuable of all) than either of the two previously described classes of boilers. Unfortunately it gives us very little else than fire-box heating-surface, as, except for the short length of uptake already described, and which passes through the water and steam space of the upper part of the boiler, it presents no other heating-surface whatever.

In order to make up to some extent for this deficiency, it is usual to fix in the fire-boxes of these boilers what are known as "cross tubes." These resemble in some respects the "Galloway tubes" already described. They consist of hollow iron tubes, 8 or 9 inches in diameter, passing through the interior of the fire-box from one side to the other at different angles, so they are constantly exposed to the full heat of the interior of the fire-box, and greatly increase the efficiency of the boiler as a steam-generator. These tubes are, of course, always full of water, being in communication with the interior of the boiler. There is, however, a limit to the number which can be got into a boiler, and even in the most favourable cases the heating-surface in this class of boiler seldom exceeds 10 square feet per nominal horse-power, which is a very small allowance, and accounts for the low evaporative duty obtained from them.

Hundreds of patents have been taken out for improving the efficiency of vertical boilers. Some, such as the Field tubes, have been very successful, but few are generally practicable, and most are of no value whatever.

Simplicity in Engines.—In agricultural machinery simplicity of construction is of the utmost importance, and in cases where economy can be attained only at the cost of simplicity, it may be advisable to sacrifice somewhat of the former in order to make sure of the latter. It

must be borne in mind that agricultural steam-engines are often put into the hands of men unskilled in the management of machinery, and sometimes very careless and negligent in the use of the expensive apparatus which they are called upon to direct. The advantages of simplicity are therefore obvious.

Tubular Steam-generators.—Many leading engineers on both sides of the Atlantic have bestowed much attention upon the construction of steam-generators, built up of tubes of comparatively small diameter so arranged that, while the inside of the tubes is filled with water, the outer surfaces are exposed to the fierce heat of variously arranged furnaces. These boilers have the advantage of extraordinary strength, and wonderful rapidity in the generating of steam; but they have never come into anything like general use. This is no doubt owing to the complicated nature of their construction, the numerous joints which it is necessary to make, their liability to prime, and the extreme difficulty in effecting any requisite repairs. They do not therefore possess any particular merits for agricultural purposes.

Locomotive Multitubular Boiler.—The most important as well as the most generally efficient description of steam-generator is what is known as the locomotive multitubular type. It consists of an internal chamber or fire-box of rectangular shape entirely surrounded by water, as in the case of the vertical boiler already described. The heated gases after leaving the fire-box pass through a large number of small iron or brass tubes, disposed horizontally along the inside of the barrel of the boiler, and forming a connection between the fire-box and the smoke-box. These tubes are entirely surrounded by water, contained within the cylindrical portion of the boiler. The hot gases in passing along these tubes from the fire-box to the smoke-box impart a great deal of their heat to the water through which they pass, thus increasing the evaporative power of the boiler.

This form of generator has proved in practice the most economical extant; while for safety, convenience of size, and weight, it leaves little to be desired. Recent experiments have shown that with

this class of boiler, specially constructed for agricultural purposes, as much as $12\frac{1}{2}$ lb. of water can be evaporated with 1 lb. of good Welsh coal. This is an exceedingly good result, and is no doubt mainly due to the large amount of heating-surface which these boilers possess, which varies from 18 to 20 square feet per nominal horse-power.

Advantages of the Locomotive

Type.—A considerable amount of prejudice exists in the minds of many agriculturists against this very useful and effective type of boiler. It seems to be based upon the supposition that it is either more dangerous, more difficult to fire, or more liable to run short of water than the more clumsy types already described. As a matter of fact, nothing could be more mistaken than such ideas or prejudices. With regard to danger, a boiler of this class, properly constructed and efficiently stayed, has a much larger factor of safety than any of the other types of boiler already described, and it may be worked without danger at a much higher pressure of steam than it would be judicious to use in any of the others. The difficulty of firing, instead of being greater, is very much less. Twice the quantity of water can be evaporated with the same weight of fuel by the one boiler as by the other, so that the mechanical labour of stoking is reduced by one-half. The question of height of water is simply one of degree. A careless driver could no doubt ruin one of these boilers quickly enough by neglect or inattention, but the same carelessness if applied to the older-fashioned types of boiler would lead to exactly the same result in an almost equally short time. Except as the result of the grossest ignorance or culpable neglect, there is no more danger with the one description of boiler than with the other.

Amongst the many advantages of the locomotive type of boiler must be mentioned the facility with which all the parts can be examined, and the accessibility, both internally and externally, for repairs. No masonry foundations are required, so that the expense of setting

them down, as well as the space occupied by them, is very much less than that of any other description of boiler of equal power. Their use is therefore to be recommended in all cases wherever practicable.

Boiler-mountings.—Whatever kind of boiler is used, it is of the utmost importance that the mountings should be both sufficient and efficient. No respectable boiler-maker would now turn out a boiler without double safety-valves, safety fusible plug, steam-pressure gauge, water-gauge to show the level of the water in the boiler, and test-cocks to check the working of the water-gauge, which is liable to get choked with dirt, and so mislead the attendant. A man-hole as large as possible should be provided on all boilers, to give easy access for examination and repairs. These man-holes were formerly simply an oval hole cut in the top or side of the boiler. No compensation was made for the large amount of material cut away to form this hole, which naturally considerably weakened the structure of the boiler, and has thereby caused many explosions. In all cases the man-hole should be strengthened by riveting a stout iron ring round the opening, or, better still, by having a strong cast-steel or wrought-iron man-hole mouthpiece riveted round the opening, having the cover bolted to the top flange.

Proportions of the Fire-grate.—A very important point in steam-boiler economy, and one which is very often overlooked in the fixing and working of steam-boilers, is the proportion of fire-grate, the thickness and length of the fire-bars, and the spaces between them. In practice it is a disadvantage to have a fire-grate longer than 6 feet, and the width and consequent area of course depend upon the size of the boiler, and the amount and quality of the fuel to be consumed. The following proportions of grate area, per nominal horse-power, may be taken as approximately suitable for the different boilers having the respective amounts of heating-surface already given:—

Egg-ended boilers should have about $1\frac{1}{4}$ square feet of grate area per nominal horse-power.					
Cornish	"	"	1	"	"
Lancashire	"	"	1	"	"
Vertical	"	"	1	"	"
Loco-type, multitubular do.			$\frac{5}{8}$	"	"

As a general rule, fire-bars $\frac{3}{4}$ inch thick, with $\frac{3}{8}$ inch air-spaces between them, give a very fair result; but narrower bars and still narrower spaces may be used where the fuel is good and clean, and where a high evaporative efficiency is aimed at.

Skill in Firing.—With all boilers the efficiency very much depends upon the skill or otherwise of the stoker. This was shown in a marked manner at the trials of steam-engines held by the Royal Agricultural Society of England at Newcastle in 1887, where the difference in fuel economy which could be attained by skilful firing, as compared with careless or reckless firing, was most manifest.

In an ordinary way a thin fire, say 3 or 4 inches thick, frequently replenished with fuel, will give a much better evaporation per pound of coal than a thick fire replenished by larger quantities at long intervals.

Wear and Tear in Boilers.—A very important matter for the consideration of users of steam-boilers is the question of wear and tear. No doubt certain boilers are more economical than others in this respect. It must, however, be borne in mind that the treatment which boilers receive at the hands of their attendants in nearly every case determines the amount of wear and tear. Many boilers which have been at work for years in the hands of careful men show no signs of depreciation further than those due to natural causes, such as corrosion, &c.; while others of similar construction, which have been subjected to careless treatment, will have cost a large amount for repairs in the same time.

Durability of the Locomotive Type.—Provided the boiler is sufficiently large for the work it has to do, the locomotive multitubular type will be found as economical of repairs and renewals in the long-run as any other description. Boilers of this class, supplying steam to the extent of a considerable (say 20 or 30) nominal horse-power, have been at daily work for 20 years without costing as many pounds for repairs, and no better result could be expected under this head from either "Cornish" or "Lancashire" boilers doing the same amount of work.

Weak Points.—It is important that boiler-users should make themselves ac-

quainted with the weak points of their construction, so that they may know where to look for signs of wear and tear.

Corrosion in Built-in Boilers.—In the egg-ended description of boiler, the natural limits to the lasting qualities are those of corrosion, and wear and tear from expansion and contraction. The former may go on for years unsuspected and undiscovered. The boiler being embedded in a huge pillar of brickwork, with a very small portion of its surface exposed for examination, may be secretly eaten almost through before the owner's attention is directed to it. Cases of such corrosion are extremely common, and account for a great many fatal explosions. Should there be a leaky rivet or joint in any of the surfaces covered by the brickwork, the water which escapes serves to keep the brickwork seating damp, and the corrosion goes on very quickly, and will soon eat through the boiler-plates, no matter how thick they may have originally been.

Expansion and Contraction.—The wear and tear from expansion and contraction is one which cannot very well be guarded against. It is due to the property of the metal of which the boiler is made to expand under heat and contract when cooled. In externally fired boilers, that portion subject to the influence of fire naturally becomes heated before the other portions which are more remote from the action of the fire. The boiler being thus hot on the under side and cold on the top, becomes considerably strained, inasmuch as the under side has been elongated a little, causing a buckling or bending action. Then, again, when the fire has gone out, and the boiler has cooled down, the parts resume their normal position, and the strain due to the buckling action of the boiler ceases. This expanding and contracting action (slight though it may be), repeated at frequent intervals, has a very marked effect upon the plates of which the boiler is made. They not only become brittle and liable to crack, but in many cases the cracks quickly manifest themselves, and it is no uncommon thing to find many of the plates dangerously cracked between the rivet-holes.

The same causes which tend to destroy the plain "egg-ended" boiler are also present in the "Cornish" and "Lancashire" types. Corrosion, of course, is always most active in the outer shell, which is most exposed to the detrimental effects of the brickwork seating. The effects of expansion and contraction are more observable in the flues, where the heat of the fire is most active.

Corrugated Boiler - flue.—Many plans have been tried for giving a certain amount of elasticity to the flues, so that when they become heated and commence to expand, they should do so without damaging the ends of the boiler to which they are attached, and which they are always tending to thrust outwards. Amongst these, the most successful is undoubtedly the corrugated boiler-flue, perfected by Mr Samson Fox, whose name will always be associated with this particular form of furnace-flue.

Internal Tear and Wear.—The action of internal corrosion is more serious in "Cornish" and "Lancashire" boilers than in the older type. This is no doubt owing to the greater difficulty of keeping the inside of the boiler perfectly clean, and free from sediment. In internally fired boilers there is also a source of wear and tear due to the burning of the fire-box plates, caused by scale and sediment lodging upon the plates in contact with the fire. Wherever the sediment lodges, it keeps the water away from contact with the plates, which are naturally quickly destroyed. The nature of the iron is speedily burnt out of it, causing the plates to crack in all directions.

"Grooving."—A very frequent source of failure in all kinds of boilers is that known as "grooving." The causes of this action are most difficult of explanation, but the fact remains that the internal examination of a boiler will often reveal deep grooves in the plates forming the outer shell. Sometimes this action takes place on the bottom plates of the boiler, and sometimes at and around the water-line. The grooves are sometimes longitudinal, sometimes transverse. They are often so deep as to cut nearly through the plates, and occasionally so narrow that they can be observed only by very carefully scraping all the scale from the surface of the plates. The appearance

of the groove sometimes shows a clean V groove, as sharp as if it had been cut in with a chisel.

Certain kinds of water are supposed to have more tendency to cause this action than others, but in many cases it is certainly due to the racking strain arising from the expansion and contraction already referred to. In every case it is a source of great danger, and emphasises the necessity of periodical internal as well as external examination of all boilers.

Examining Locomotive-type Boilers.—The prejudice against the locomotive multitubular boiler for stationary engines is no doubt largely due to the fact that it is somewhat more intricate in its construction than the other kinds of boilers. The annular water-space round the fire-box is certainly more difficult of access than the plain cylindrical interior of the old "egg-ended" type. Nevertheless, in properly constructed locomotive-type boilers, every part is sufficiently easy of access for perfect cleansing and examination. The inside of the circular or barrel portion can generally be examined from the man-hole. The tubes can be taken out for scaling, and replaced when necessary, and at such times a complete internal examination of the boiler-shell can be made.

The weak spots in this class of boiler are the fire-box and tubes—the latter especially. They require to be made of very thin material, so as to offer as little resistance as may be to the passage through them of the heat which is to be applied to the generating of steam. They are therefore sooner destroyed by the action of ordinary corrosion than the other parts of the boiler, which are made of much thicker material. Apart from the fact that a set of tubes can be taken out, cleaned, and replaced a considerable number of times, it may be remarked that the cost of a completely new set is comparatively little, and will be saved many times over in the economy of the coal bill.

With regard to the other portions of the boiler, the depreciation from corrosion and wear and tear is so slight that many locomotive-type boilers have been at work for 30 years without the outer shell being

dangerously affected. It may therefore be taken that the cost of repairs and renewals to boilers of this class which have been properly cared for will amount to a very small sum in proportion to the amount of work done by them, and will come out favourably if compared with the cost of repairs to any of the other classes of boiler already described, and worked under similar conditions. On the other hand, the saving in fuel, &c., effected by their use, is great beyond all comparison.

Soft Water best for Boilers.—The effect of different kinds of water upon the tubes of a boiler of the locomotive multitubular type is very marked. Soft water, of course, is the best; and where this can be obtained, the life both of the tubes and the shell of the boiler will be very long. In other cases where the water contains injurious acids, the destruction of the tubes and outer shell begins at once. Deposits of scale and dirt upon the tubes and in the annular water-space surrounding the fire-box are a frequent cause of premature failure in boilers—causing the material to burn and crack, as already described in connection with the other descriptions of boiler.

Neglect of the precautions suggested by everyday experience—such as failing to keep the boiler properly washed out, and allowing the accumulation of solid matter in the water-spaces—speedily causes overheating and excessive wear and tear.

Having thus described the principal kinds of boilers used in agriculture, and referred to the causes of failure, and indicated where such failures may be looked for, and how they may be identified, we will now consider the efficiency of the different kinds of fuel, the theory of combustion, and some of the properties of steam.

Fuel—Combustion—Properties of Steam.

Coal.—Coal, of course, takes the leading place as a material for generating heat. In this country we have many varieties and qualities of this substance, but the purest and best is that found in the South Wales coal-field. Not only does the evaporative power of different coals vary greatly, but the useful effect which is obtained from the same qualities

of fuel also varies with the construction of the furnaces, the conditions under which they are consumed, and the amount of air which is admitted in each case to support the combustion.

Oxygen and Combustion.—The great supporter of combustion is the oxygen which is ever ready to hand in large quantities in the atmospheric air. This combines with the combustible constituents of the fuel at a sufficient temperature, and when this combination takes place in proper proportions, perfect combustion is the result.

Smoke Wasteful.—Where there is an insufficient supply of air, the combustion will be imperfect; and, with most kinds of coal, a portion of the unconsumed products of combustion will be carried off in the form of smoke. This not only pollutes the atmosphere to a greater or less extent, but causes an actual waste of fuel. Smoke consists of unconsumed particles of carbon; and all that is necessary for its consumption is the admission of a sufficient supply of air, so that it comes in contact with the carbon while the latter is at a sufficiently high temperature to combine with the oxygen in the air, which combination then passes off as carbonic acid gas, which is invisible.

Amount of Air for perfect Combustion.—The amount of air necessary for the complete combustion of 1 lb. of coal is $11\frac{1}{2}$ lb., or 150 cubic feet. It is therefore necessary, in order to secure full economy, that there shall be sufficient draught to cause this quantity of air to pass through the fire. In the absence of a sufficient supply of air, not only is smoke emitted, but carbonic oxide is formed, which carries away with it in a gaseous state, and unutilised, a large portion of the heating qualities of the fuel.

On the other hand, too great a draught causes an excessive quantity of air to pass through the fire, which is also a source of waste, as the heating of a greater volume of air than is necessary for the perfect combustion of the fuel absorbs a large amount of heat which should be applied to heating the water in the boiler and converting it into steam.

Kinds of Fuel compared.—For convenience of stating and comparing the relative heating-value of different kinds of fuel, the quantity of water which can

be evaporated by 1 lb. of the particular fuel from a temperature of 212° is generally taken as a standard, and by it the following theoretical values of different kinds of fuel may thus be expressed:—

Description of fuel.	Pounds of water evaporated from a temperature of 212° by 1 lb. of the fuel.	Units of heat contained in 1 lb. of the fuel.
Petroleum	22.0	21,260
Best Welsh coal (Ebbw Vale)	16.8	16,240
Patent fuels (average)	15.6	15,100
Best Newcastle steam coal	15.3	14,820
Scotch coal	14.7	14,200
Coke	13.0	12,560
Dry peat	10.0	9,670
Dry wood	7.5	7,250

These theoretical values are, however, never realised in practice. The best recorded results fall at least 25 per cent short of the above standard, and in most cases it will be found that not more than 50 per cent of the theoretical value of the fuel is being utilised for the production of steam.

Heat the Source of Energy.—Heat, which is the great agent in the production of steam, may be said to be the source of all energy. It is many years since scientific men demonstrated this truth, but only in recent years has it been accepted, and the relation between heat and work recognised by practical men. The English standard unit of heat is the amount of heat necessary to raise the temperature of 1 lb. of water 1° Fahr. Joule and others proved by experiment that a certain force, represented by a weight of 772 lb. falling a distance of 1 foot, was equivalent to an expenditure of heat sufficient to raise the temperature of 1 lb. of water by 1° Fahr.; so that the unit of heat may be described as the equivalent of 772 foot-pounds.

“Foot-pound” and Horse-power.—The “foot-pound” is the convenient expression fixed upon by James Watt as the unit of work, and the meaning of the expression is simply “one pound lifted to a height of one foot in one minute.”

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Watt estimated the work of one horse to be equal to 33,000 of these units of work,—that is, 33,000 lb. raised to a height of 1 foot in one minute, or 330 lb. raised 100 feet in one minute, or 1000 lb. raised 33 feet in one minute—and so on. This standard is still accepted, and in all mechanical calculations 33,000 “foot-pounds” is taken as the actual power of a horse.

Actual and “Nominal” Horse-power.—It may be here stated that there is a great difference between the actual horse-power of a steam-engine and the “nominal” horse-power. The former is a clearly defined duty, but the latter is merely a trade-term, vague and indefinite. It is generally based upon the diameter of the cylinder of the engine, without regard either to the pressure of the steam or the stroke of the piston. Moreover, almost every maker of engines has his own standard of piston-area per nominal horse-power, thus increasing the vagueness of the term.

The Royal Agricultural Society of England probably gives the most sensible proportion of piston-area—viz., 10 circular inches per nominal horse-power. By giving the area in circular inches, the power may be more easily calculated than in square inches, as of course it is obtained by merely multiplying the diameter of the cylinder by itself. Thus a 9-inch cylinder gives 81 circular inches, which, divided by 10, is equal to 8.1 nominal horse-power. A 10-inch cylinder gives 10 nominal horse-power, and a 12-inch cylinder 14.4 nominal horse-power.

Amount of Fuel per Horse-power.—It will be seen by reference to the above table that a pound of Welsh coal contains 16,240 units of heat, and as each unit of heat is equivalent to 772 foot-pounds, the theoretical value (or duty) of one pound of this description of fuel is 12,537,280 foot-pounds, equal to about $6\frac{1}{3}$ actual horse-power per hour. Hitherto, however, the best engineers have been entirely unable to construct engines which would give off anything like the amount of work due to this theoretical duty of the fuel. In the very best recorded experiments, the very best duty got out of the best fuel under most favourable circumstances has been about 1 horse-power per hour from 1 lb. of coal. This is equal

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to only 1,980,000 foot-pounds, or less than one-sixth of the theoretical value of the coal. The data published by the Royal Agricultural Society of England have been considered unreliable, in consequence of the inaccuracy of their testing apparatus; but independent scientific tests give about twice the above consumption as necessary for the best constructed agricultural engines (viz., about 2 lb. of coal per horse-power), which thus give off only about one-twelfth of the theoretical duty of the fuel.

Dissipation of Heat.—The causes of this enormous loss of energy are legion, but they are mainly due to the waste of heat in the various processes of combustion, and the loss of heat by radiation. No sooner has the heat been generated by combustion, than it manifests a tendency to disappear. Where the furnace in which it has been generated has free communication with the atmosphere, the heat speedily escapes and dissipates itself in the surrounding air. Where it cannot escape so freely, it imparts itself with greater or less readiness to whatever comes in its way. A bar of cold iron thrust into a hot fire speedily robs the fire of some of its heat, which it goes on absorbing until it becomes red-hot, or even burnt away. If the red-hot bar be taken out of the fire and held in the open air it gradually gives off its heat to the surrounding atmosphere, which it warms by *radiation*.

Radiation is the term used to describe the action of the heat in passing off from a heated body into the atmosphere. If the bar be quickly plunged into a trough of cold water it is speedily robbed of its heat, which is absorbed by the water, which is thereby increased in temperature to the extent due to the amount of heat absorbed.

Conductors of Heat.—Some materials are better conductors of heat than others. For example, a bar of copper, which is a good conductor, plunged into a hot fire, would absorb a greater amount of heat in a given number of seconds than a similar-shaped body of a more refractory material, such as fireclay.

Economical Use of Heat.—It will thus be seen that in order to get the best duty out of fuel it must be properly consumed, so that the utmost possible

amount of heat may be generated, and the heat must be so utilised that the greatest evaporative duty may be got out of it. For this purpose boilers are designed and fixed in such a way that the heated gases shall be kept in close contact with the boiler-plates or heating-surfaces for as long a period as possible, so that they may communicate as much as possible of their heat to the water in the boiler before they are allowed to escape into the atmosphere.

Preventing Loss by Radiation.—But after the heat has been generated from the fuel, and effectually applied to the production of steam, it is of the utmost importance that all loss of heat by radiation from the boiler, steam-pipes, and cylinder of the engine should be prevented, as every unit of heat so lost is equivalent to a loss of energy equal to 772 foot-pounds. No part of the boiler should therefore be exposed to the cooling action of the atmosphere, but all such exposed parts, as well as the steam-pipes and cylinder, should be carefully covered over with some non-conducting material, so as to prevent as far as possible all loss of heat, and consequent waste of fuel.

High-pressure.—High-pressure steam—i.e., from 80 to 140 lb. on the square inch—is now universally employed in all first-class engines, for the reason that only a comparatively slight extra amount of fuel is necessary to raise a cubic foot of steam to a pressure of 120 lb. on the square inch beyond what is necessary to raise it to 45 lb. on the square inch. The power exerted by high-pressure steam is not only enormously greater to begin with, but the energy it exerts by its expansive power, after the admission to the cylinder has been arrested or cut off, is very great as compared with the lower pressure.

Condensing Waste Steam.—During the process of expansion the steam is not only exerting a considerable energy, but it is parting with a proportionate amount of its heat, which decreases in a due ratio with the pressure. Nevertheless, when the utmost has been got out of the steam by expansion, there still remains in it a certain amount of heat, which may be used for heating the feed-water on its way to the boiler. Or, better still, it

may be conducted by means of pipes to a condenser, where its remaining heat is finally absorbed by the water of condensation. The result of this condensation is, that a vacuum is formed in the cylinder (on the opposite side of the piston from that upon which the steam-pressure is acting), which is equivalent to a force equal to the pressure of the atmosphere (say 15 lb.) exerted on every square inch of piston-area.

Condensing Engines.—For fuel economy, therefore, high-pressure steam, used expansively and condensed, will give the very best result. The principal obstacle in the way of the universal use of condensing engines is the necessity for a considerable supply of cold water. The action of the condenser, although not fully understood by many steam-users, is extremely simple. The waste-steam pipe, instead of conducting the exhaust-steam into the atmosphere, conducts it into a small chamber rather more than half the cubic capacity of the cylinder, where, on entering, it is met by a stream of cold water, which immediately cools it and causes it to *condense*. In other words, the condensing chamber exactly reverses the action of the boiler, in which the water was originally converted into steam. The stream of cold water absorbs nearly the whole of the heat contained in the exhaust-steam, which then ceases to be steam, and resumes its original form of water. But the space occupied by the steam in its vapoury form is many times greater than the bulk which it assumes on resuming its watery form; so when the steam is condensed the most of the space previously occupied by it becomes void, and a vacuum is formed which exerts a suction on the side of the piston from which the steam had been exhausted, and consequently exerts a power auxiliary, and sometimes superior, to that due to the pressure of the steam.

If a perfect *vacuum* could be obtained, the force of the suction due to it would as stated be equal to the pressure of the atmosphere. A perfect vacuum is, however, never attained in steam-engine practice. The nature of the vacuum is generally expressed by the height of a column of mercury. Thus the weight of the atmosphere and the power of a per-

fect vacuum would both be equivalent to a column of mercury 30 inches high. A vacuum equal to 27 inches of mercury is a usual thing in fairly efficient condensing engines.

The use of a condenser involves a little extra first cost, and a few extra working parts, but these are of little importance in comparison with the economy of fuel which results from condensation. The extra parts consist of the condenser itself, with an air-pump, and the necessary valves in connection therewith. It will be easily understood that in a very short time the influx of cold water, and the water resulting from the condensed steam, would soon fill up the condenser and choke it. Some means must therefore be taken to get rid of its contents, which are pumped out by the air-pump. In small engines, up to, say, 50 horsepower nominal, the condenser may be most conveniently arranged behind the cylinder, and in a line with it, so that it can be worked by a tail-end rod from the piston. This rod passes through the back cylinder cover, and is coupled up direct to the bucket of the air-pump, forming a very simple, neat, and effective arrangement.

Construction of the Steam-engine, and the action of the Steam.

Before proceeding to describe in detail the various kinds of engines used in agriculture, it may be well to explain briefly the action of the steam. The economical use of steam is quite as important as its economical production, for it would be manifestly absurd to take great pains with the design and construction of boilers to generate steam economically, and then, by the use of badly designed or badly constructed engines—by wastefully using it in the process of converting it into useful work—to lose all the benefit which had been gained.

After having been compressed in the boiler to the requisite pressure, the steam is conveyed in pipes to the motor, or engine in which it is to be utilised. Owing to the rapidity with which steam parts with its heat, these pipes, whether long or short, should be carefully covered with some non-conducting material, so

that the loss by radiation and consequent condensation in the steam-pipes may be reduced to a minimum. The motor or engine consists primarily of a cast-iron cylinder in which the steam exerts its force, and of the various moving parts by which that force is converted into useful work. The cylinder of the steam-engine, which is shown at A in fig. 48, is

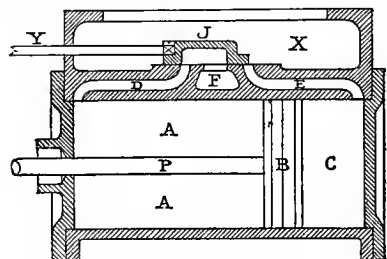


Fig. 48.—The steam-engine cylinder.

bored out to a perfectly smooth surface. A piston or plug (B) is made to fit accurately inside the cylinder, and is fitted with expanding rings, so that the pressure of steam can exert its force on either side without blowing past the piston. The steam is admitted alternately on different sides of the piston, and by its pressure it forces the piston to move from one end of the cylinder to the other. The distribution of the steam, whereby it is alternately admitted to the opposite ends of the cylinder, is regulated by a small slide-valve J, working in the steam-chest X of the cylinder, which receives the steam from the steam-pipes in which it was conveyed from the boiler. The slide-valve, which is moved back and forward by means of a rod Y, not only admits the steam at one end of the cylinder, but allows it to escape out of the other end after it has done its work.

In the sketch, the valve J is shown in such a position that there is a free communication from the steam-chest X to the right-hand end of the cylinder C by means of the steam-port, or passage E. The space F in the diagram is the exhaust-port, communicating with the atmosphere, through which the spent steam, which has already done its work at the other end of the cylinder, is allowed to escape by means of the steam-port D. When a sufficient supply of steam has been admitted to the end of the cylinder

at C, and has forced the piston B to the other end of the cylinder, the position of the slide-valve J is changed, so that it not only closes the admission of steam to the end C of the cylinder, but it opens the steam-passages D to the high-pressure steam at the other end, and makes a communication between the passage E and the exhaust F, by which the spent steam escapes from C, and allows the piston B to be forced back again to C from the other end of the cylinder.

This reciprocal motion having been obtained, it is necessary to control and regulate it so that it may be turned to useful purposes. The most useful method of utilising the force is to convert the reciprocating into a rotary motion, whereby, with the aid of a belt or some kind of gearing, the motion may be communicated to any desired machine. The reciprocating motion is converted into rotary motion by means of a connecting-rod and crank.

The connecting-rod is jointed at one end to the piston-rod, P, fig. 48, which, we have seen, has a reciprocating motion imparted to it by the force of the steam acting on the piston, and at the other end it is attached to a crank, a species of handle familiar to all who have watched the working of a steam-engine. The reciprocating motion of the piston-rod is communicated through the connecting-rod to the crank-pin by alternate pulls and pushes, causing it and the axle upon which it is fixed to rotate.

In order to prevent the intermittent motion due to the sudden action of the steam upon the piston, which would cause a jerky movement of the crank, a heavy fly-wheel is keyed upon the crank-shaft or axle. This wheel serves to steady and regulate the motion of the crank, and prevents the waste of power which would assuredly take place, even if it were possible to communicate the jerky motion of the piston direct to a machine. The fly-wheel is simply an accumulator storing up the energy imparted by the piston to the crank when exerting its utmost power, and imparting it to the shaft when the piston is exerting its smallest power. Thus, although the crank-shaft without a fly-wheel would rotate with a jerky and irregular motion, the movement when furnished

with such a wheel is steady and uniform.

The engine must also be fitted with a suitable arrangement of gear to work the slide-valve, which is generally driven by an excentric keyed upon the engine-shaft, and so set with regard to the position of the piston in travelling backwards and forwards in the cylinder, as not only to open the steam passage for the admission of the high-pressure steam to do its work on the piston, but also to allow the steam which has already done its work to escape through the exhaust into the atmosphere or into the condenser.

The arrangement of steam-distribution here described is a very simple and fairly effective one. It is that which is used upon nine-tenths of the engines in ordinary use, and answers well for all practical purposes. It is not, however, by any means the most perfect or economical arrangement for the purpose, as there are many beautiful and efficient expansion arrangements in everyday use on the better class of large engines, for a description of which space cannot be spared here.

The object aimed at in all these arrangements is the same—viz., to obtain the advantage of the expansive action of the steam upon the piston. This can be fully realised only by suddenly admitting it with its full pressure into the cylinder when the piston is at the beginning of its stroke, and cutting it off equally quickly when a sufficient quantity has been admitted to do the necessary work. The steam, being an expansive body, continues to exert a considerable though gradually diminishing force in the cylinder long after its further admission from the steam-chest to the cylinder has been arrested. It is by taking the fullest advantage of this expansive power that the greatest economy in working can be obtained.

Expansive Action of Steam in Single Engines.—In using steam expansively in a single-cylinder engine, there is a considerable loss caused by the cooling action of the expanded steam upon the inner surface of the cylinder. The temperature of steam is in exact proportion to its pressure, so that when high-pressure steam is admitted to a cylinder, it possesses a correspondingly

high temperature. But when it has been cut off early in the stroke, and has done its work by expansion until the moment of its release approaches, the pressure and corresponding temperature will have been greatly reduced. The metal of which the cylinder is composed is a fairly good conductor of heat, and the moment the hot high-pressure steam is admitted the temperature of the metal is immediately raised. But when this hot steam has become cooler by the reduction in temperature due to expansion, the cylinder (which has the same facility of parting with its heat which it has of absorbing it) is instantly cooled by imparting some of its heat to the cold steam. The consequence is, that when the next supply of hot high-pressure steam comes in contact with the cool surface of the cylinder, it is partially condensed, and its initial pressure and consequent force is considerably decreased.

Compound Engines.—To minimise this effect, recourse has been had to what is known as the "*compound*" system. This consists of making the engine with two or more cylinders. The first, and smallest, is that into which the high-pressure steam is primarily admitted. Here it is allowed to exert its full force upon a piston of comparatively small area for a considerable portion of its stroke, so that when the moment of its release arrives, the pressure has not been greatly reduced by expansion. Consequently the inner surface of the cylinder has not been so much cooled as to cause any considerable condensation on the admission of the hot high-pressure steam for the next stroke. After having thus done a portion of its work in the first cylinder, the steam passes into a second one of larger diameter, where it further exerts its power at a lower initial pressure on a larger piston, in which it gives off its utmost expansive power before it is discharged into the air or into the condenser.

The advantage of compounding is thus obvious. It not only prevents a large measure of injurious condensation of valuable high-pressure steam by providing for its expansion in a second cylinder, but it distributes the strains on the working parts more evenly, and ensures steadier and smoother running than is

generally obtainable with single-cylinder engines working with steam at high pressures.

In *compound* engines the cylinders are so proportioned that the small one working at the higher pressure gives off about the same amount of power as the larger one working at the lower pressure. This equalises the strains upon the crank-pins and other portions of the mechanism, and reduces the wear and tear and liability to breakages. By confining the action of the high-pressure steam to the comparatively limited area of the smaller piston, the violent and injurious shock at the beginning of each stroke is very much less than if the whole power of the steam had been utilised in a single cylinder of larger diameter, even although by expansion of the steam the total power given off should be the same in each case. Moreover, when a condenser is used, the effect of the vacuum is very much greater by acting upon the increased area of the larger piston, which, of course, is the one in communication with the condenser. In engines of large power the compound principle has been extended till three cylinders in a series are very common, and give excellent results; while four and six cylinders have been tried for large marine engines.

Different Types of Engines.

Vertical Engines.—In the early days of steam on the farm, large independent vertical engines were generally used; but they are now, like their contemporary the egg-ended boiler, almost obsolete. Formerly, when all considerable powers were transmitted by spur-gearing, the vertical engine was used with advantage, as the height of the crank-shaft above the ground was convenient for the arrangement of the various wheels and pinions by which its power was to be given off. Now, however, all such powers as are likely to be required for driving any kind of agricultural machinery may be more easily, silently, and quite as effectively transmitted by belting, so that the height of the motive shaft is of no consequence, as in any case it simply means a few feet of belting more or less. Unless, therefore, there are other reasons to the contrary, no one would now choose

an engine of the vertical construction for ordinary farm-work.

Horizontal Engines.—The horizontal engine is distinguished for convenience of fixing, accessibility for cleaning or repairs, and absence of vibration in running. It is therefore generally employed where the work is of a permanent nature. It consists of a strong cast-iron bed-plate, which may be bolted down to a brickwork or masonry foundation. This bed-plate forms a support for the cylinder, motion-bars, crank-shaft bearing, and condenser, if any. The joints of these various parts should all be planed, and fitted to facing-pieces cast solid with the bed-plate, which should also be planed true to receive them. They are then bolted firmly together with turned bolts, so that the thrust-and-pull of the piston does not cause any shake or vibration of the different parts. The crank-axle, which bears at one end upon the plumb-block on the bed-plate, is supported at the other by a bearing fastened to a wall-box built into the engine-house wall. The fly-wheel is carried upon this shaft, as well as the excentrics for working the valves and pump.

In an ordinary farm-engine, which is required to revolve only in one direction, no provision is made for reversing gear, which, if necessary, could be attached by the addition of another excentric and the ordinary link motion. The governors, which are a most important part of the engine, are generally driven by a belt from the crank-shaft. They may be made either to act upon a throttle-valve, which regulates the admission of steam to the steam-chest, or they may be made to act directly upon the slide-valve itself, controlling the period of admission of the steam to the cylinder. This latter is decidedly the best means of regulating the speed of an engine; because it will be seen, from the remarks already made upon the use of high-pressure steam, that to obtain the full benefit of expansion it should be admitted at full boiler-pressure to the cylinder, and then suddenly cut off. But where the governors act upon a throttle-valve, they exercise their functions by reducing the initial pressure of steam admitted to the steam-chest (technically called *wiredrawing*); whereas, in the other case, the full

boiler-pressure is admitted direct to the piston, and the power and speed are regulated by the period at which such admission is closed by the action of the governor upon the slide-valve.

A most simple and effective governor, acting directly on the slide-valve and controlling the cut-off of the steam, is that invented and perfected by Mr Wilson Hartnell and Messrs E. R. & F. Turner, and known as the Hartnell-Turner governor, which has been applied with most satisfactory results to thousands of agricultural engines. In this governor the usual balls revolving round a central spindle are dispensed with. The apparatus consists of two plates forming a disc or drum keyed upon the crank-shaft of the engine. Between them are two weights acting upon excentric trunnions, and held in position by spiral springs. Until the requisite speed has been attained these weights lie inactive against the crank-shaft; but as soon as the required speed is attained, the springs, which are regulated so as to become compressed by the centrifugal force of the weights, allow the latter to fly outwards, and thus alter the position of the excentric trunnions upon which they are mounted. This gives a forward movement to the excentric for working the valve, and so causes it to cut off the admission of steam to the cylinder at an earlier period than before. This naturally retards the speed of the engine. As soon as the speed falls below the proper limit, the force of the springs causes the weights to resume their former position, and thus lengthens the period of admission of steam, and so increases the speed of the engine.

When a condenser is not used, the exhaust-steam should be utilised for heating the boiler feed-water in a proper feed-heater before being carried by the waste-pipe through the roof or into the engine-chimney. When a condenser is used, the waste steam is conveyed to it by pipes, and is there condensed, as already described.

Horizontal Condensing Engine.—For engines of 20 horse-power and upwards, where sufficient space is available, and where the character of the work is permanent, the most convenient and economical plan is to put down a horizontal

condensing engine, and a double-flue "Lancashire" boiler to correspond.

Vertical Boiler and Engine.—For the smallest sizes of engine, say from 1 to 6 horse-power, where economy of space may be a great consideration, and where economy of fuel is not of great importance, the vertical boiler is frequently used in conjunction with a vertical engine with inverted cylinder working

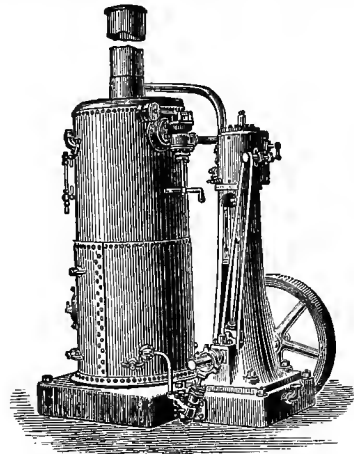


Fig. 49.—Vertical boiler and engine.

downwards on to a crank-shaft, as in fig. 49, made by Marshall & Sons, Gainsborough.

It is also occasionally used in conjunction with a small horizontal engine bolted to the foundation-plate upon which the boiler rests. These types of engines are very convenient for dairy purposes and for food-preparation, chaff-cutting, grinding, &c.; but they are wasteful of fuel, as was shown at the trials of farm-engines at the Glasgow Show in July 1888, where one of these engines used more than three times as much fuel as the prize engine, which had a boiler of the locomotive multitubular type.

Semi-portable Engine.—What is known as the semi-portable or semi-fixed type of engine is one which has been deservedly growing in popular favour during recent years. There are two descriptions of this class of engine—one in which the cylinders and working parts are bolted to the top of the boiler, as in the case of the ordinary portable engine;

and the other in which the working parts are erected upon a foundation-plate, and placed underneath the barrel of the boiler, as shown in fig. 50. Both these types of engine have their special advantages. The former combines lightness of weight and fewness of parts with a ready accessibility for overhauling, examination, and repairs, and is very suitable for all purposes where small powers,

say up to 10-horse nominal, are required. The description of this engine practically corresponds with that of the ordinary portable, with the exception of the wheels, which are taken off, and in their place are substituted a cast-iron ash-pan underneath the fire-box, fitted with a draught-regulating door; and a pillar of cast-iron or brickwork, which is placed underneath the perch-bracket at the front

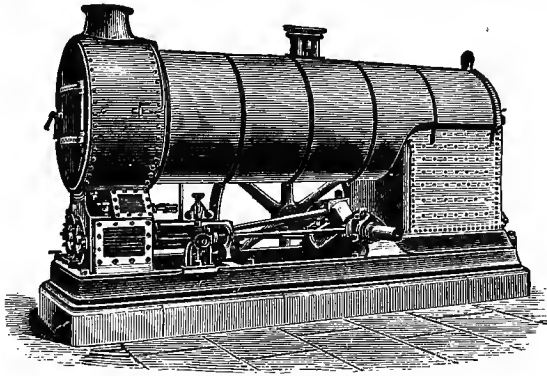


Fig. 50.—Semi-fixed engine and boiler combined.

end of the boiler. The type of semi-fixed engine with working parts underneath the boiler as illustrated is very convenient for powers varying from 10 to 50 nominal horse. It is made by J. & H. M'Laren, Leeds.

Many well-known firms of agricultural engineers have brought great skill in design and excellence of workmanship to bear upon the construction of these engines, until they have attained a perfection of working which can scarcely be equalled, and has never been excelled, in any other type of steam-engine. It may be interesting as a historical fact to record that the first engine of this type was constructed some thirty years ago by Messrs Manning, Wardle, & Co., the well-known locomotive engineers of Leeds, from the designs of their manager, the late Mr Robert M'Intyre.

Amongst the great advantages possessed by this class of engine may be named the following: Expensive foundations are dispensed with, as the engine can be set so as to work steadily and well merely fixed upon two baulks of timber; economy of space, inasmuch as both engine and boiler can be fixed in the room

which would be necessary for either one or the other if they were fixed separately; and facility for removal if required, as it can be lifted bodily on a trolley, or mounted on a set of temporary wheels and axles, by which it can be moved from place to place. No brick chimney is required, as the wrought-iron chimney, which should be sent out with each engine, in conjunction with the blast caused by the exhaust-steam, is sufficient to give the necessary draught for the perfect combustion of the fuel. The larger powers of these engines are generally made on the compound principle, which has been already described.

Where economy is a desideratum, these, like all other steam-engines, should be fitted with the best automatic expansion arrangements and condensers, so as to economise to the utmost the consumption of steam, and consequent expenditure of coal and water. The locomotive type of boiler, which is acknowledged to be the most economical steam-generator extant, combined with perfect-expansion gear, and proper proportion of the various working parts, whereby the loss from friction and other causes is reduced to a

minimum, unite to make this class of engine one of the most suitable and popular forms for use in agriculture.

Portable Engines.—The portable engine (fig. 51), which has been employed to such a great extent for farm-work, is almost too well known to call for any description. It has stood the test of 30 years' steady work, during which time it has developed to the almost perfect

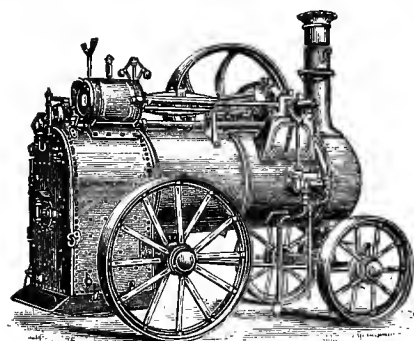


Fig. 51.—Portable steam-engine.

machine which it now undoubtedly is. The boiler is of the locomotive type, covered with wood and sheet-iron to prevent radiation of heat. The fire-box should be large, not only for the purpose of giving a large area of available heating-surface, but also to give sufficient grate-area to burn the necessary amount of fuel without forcing and consequent waste. The tubes are generally made of iron fitted at both ends to the tube-plates, which have been bored out to receive them, expanded in position with tube-expanders, and protected from the fire by steel ferrules. All fire-boxes ought to be provided with a lead safety-plug which, when the level of the water in the boiler gets dangerously low, is melted, the fire being thus put out. The cylinder ought to be steam-jacketed, and all the various covers so arranged that they can be easily and quickly removed for examination of the various working parts, without the necessity of blowing off the steam. The portable engine illustrated is that made by Ransome, Sims, & Jefferies, Ipswich.

The crank-shaft is invariably bent out of a single solid round bar, so that the fibre of the iron or steel is always in the

best position to resist the strain, and consequently the chances of breakage are reduced to a minimum. The crank-shaft brackets are generally made of wrought-iron riveted to the barrel of the boiler, and carry the journals or bearings in which the crank-shaft revolves. These ought to be made of phosphor-bronze, as it has a much greater wearing power than even the best gun-metal. The slide-bars, slide-rods, &c., should all be made of the best iron, case-hardened, otherwise the wear and tear and consequent deterioration will be very rapid and great.

The Hartnell-Turner type of governor, which has already been described, is also applicable to this class of engine, and, in practice, may be said to give the highest efficiency. The excentric should be so arranged that, in case of need, it can in a few moments be set so that the engine will work in either direction. This can be done without trouble by making the excentric loose upon the crank-shaft, and keying the circular disc alongside of it securely to the shaft. This disc has two holes, by one of which the excentric may be bolted for the forward gear, and by the other for the backward gear.

It is a matter of necessity that each engine should be fitted with two safety-valves, one at least being in a locked-up iron casing, so that it cannot be tampered with by the attendant. They should also have a steam jet for drawing the fire quickly when raising steam; a man-hole and cover for convenience of cleaning, examining, and repairing the boiler; and mud-holes for washing-out purposes.

The engines are generally provided with a waterproof cover, so that they may be left out in the rick-yard or in the field in all weathers. They are also fitted with a drag-shoe, for use when going down steep hills. In very hilly countries the engine is also fitted with a screw-brake for this purpose.

Highland and Agricultural Society's Trials.—At its annual show at Glasgow in July 1888, the Highland and Agricultural Society of Scotland conducted a very useful trial of agricultural steam-engines. A prize of £75 was offered for the best fixed steam-engine of 6-horse-power nominal, with boiler combined or separate, suitable for

erection in a farm-steading, the price being limited to £150, delivered at Glasgow. The Society decided to award the prize to the engine which embodied in the highest degree the following points of merit of the relative value stated:—

	Points.
Price	20
Simplicity of construction and fewness of working parts	25
Economy of fuel	20
Rapidity of raising steam	5
Facility of erection and cheapness of foundations	5
Economy of water	5
Steadiness and regularity in running	15
Economy of lubricant	5
Total	100

Four engines were tried on the brake, and the results of the trial were such as to demonstrate the imprudence of purchasing any class of engine merely because it happens to be offered at a low price. Between the lowest and the highest price the difference did not amount to more than £35, or thereby; while as to economy of working, the result was out of all proportion.

The prize was awarded to Messrs J. & H. McLaren, Midland Engine Works, Leeds, for a 6-horse-power nominal engine and boiler combined, which, during the trial, worked at 14 actual or brake horse-power, with a consumption of 4.13 lb. of Scotch coal per brake horse-power per hour, and a water consumption of 33.97 lb. per brake horse-power per hour. The engine which did worst in the trial consumed 13.63 lb. of coal and 63.79 lb. of water for every brake horse-power given off, which means that the one engine would use £10 worth of coal to do a certain amount of work for which the other engine would require over £30 worth,—showing clearly that a few pounds extra in the first cost of an engine might be saved off the coal-bill in a very few months' working.

The engine which took the prize was mounted on the top of the boiler with which it is combined. It can, however, be lifted bodily off the top of the boiler and fixed as an ordinary self-contained horizontal engine, so that it can be placed inside the barn or other building, and the boiler put in an outhouse and coupled up

to the engine with pipes. This engine was fitted with a very efficient feed-heater, which heated the water nearly up to boiling-point before it entered the boiler, which, of course, effects a great saving of fuel.

Traction-engine.—The traction-engine, fig. 52, made by J. & H. McLaren, is now largely used in agricultural operations, although not yet to the same extent as the portable engine. The reasons for this are probably because it costs about twice as much as a portable engine of equal power; that there are many legislative restrictions imposed upon their use on public roads; and that, until comparatively recently, they were made so clumsy and heavy that they were difficult to manipulate. Now, however, that steel-casting has been brought to such great perfection, the spur-gearing is generally made of that material, which gives much greater strength with very much less weight. Additional experience has also enabled the makers of traction-engines to simplify their construction to such an extent that they are not only very much lighter, but less cumbersome in appearance, and more easy to handle. Indeed they have long passed the experimental stage, and are rapidly superseding the portable engine for driving travelling threshing-machines.

Traction-engines have the great advantage not only of moving themselves from farm to farm, but also of hauling their machine and straw-elevator with them, so saving the user the trouble and risk attendant upon moving these heavy articles by horses. The locomotive type of boiler is almost invariably adopted for traction-engines, and as the working steam-pressure is generally from 100 to 130 lb. on the square inch, it requires to be made of the very best materials, and put together in the strongest possible way. They should be able to stand a test-pressure, by cold water, of 240 lb. on the square inch, without showing any signs of weakness.

The power of the traction-engine is conveyed from the crank-shaft to the travelling-wheels by means of spur-gearing, which ought to be of the best quality of cast-steel. It is a great advantage for the engine to be fitted with double speed to the road motion, the slow gear

causing it to travel at the rate of two miles per hour, and the fast speed at four miles per hour. The advantage of this arrangement is, that when the engine is travelling on level roads with a good load, it can maintain the higher rate of speed, but might not be able to do so if it should be necessary to mount a stiff hill. In that case, however, the slower and more powerful speed can be thrown into gear, thus giving the engine a greater "purchase" or leverage, and enabling it to mount the hill without distress.

This variation of the speed is accomplished by means of two pinions of different size sliding upon keys on the

crank-shaft. One or other of these pinions, as the case may be, gears into a double-speed wheel fixed on the second motion shaft. This double-speed wheel consists of two spur-wheels of different diameters cast together, of such a size that, when the smaller crank-shaft pinion is thrown into gear, it works in contact with the larger of these two wheels, imparting a slow motion to the engine; and when the larger pinion on the crank-shaft is thrown over into gear, it communicates the motion to the smaller of the double-speed wheels, thus increasing the rate at which the engine will travel.

When it is desired to change the speed,

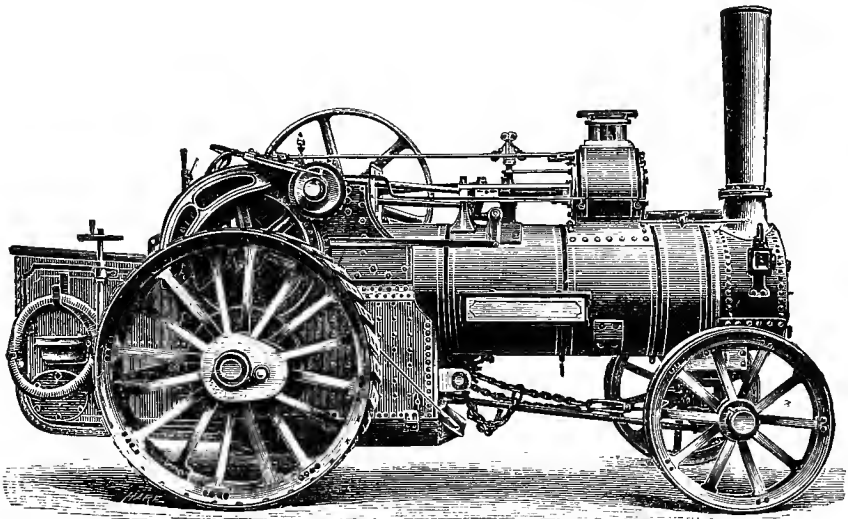


Fig. 52.—Agricultural locomotive or traction-engine.

it is only necessary to stop the engine for a moment, and by simply moving a lever, either pinion may be thrown out and the other thrown into gear; or they may both be thrown out of gear, when the engine will remain stationary, and may be used for driving any description of machinery by means of a belt from the fly-wheel.

For guiding the engine when travelling upon the road, it is necessary that it should be fitted with some description of steering. This generally consists of a shaft across the front of the fire-box shell, underneath the barrel of the boiler, having upon one end a worm-wheel.

This worm-wheel is worked by a worm on the end of a shaft, which is carried back to the place where the driver stands. This shaft has, at the opposite end to the worm, a hand-wheel, by means of which the driver, by a very slight effort, can turn it either way, thus causing the steering shaft to revolve in whatever direction may be required. By connecting-chains from this steering-shaft to the front axle, the front wheels may be drawn into either lock, so that when the engine is in motion it can be guided either to the right hand or to the left, and will turn a very acute angle, or in a very small circle.

In order to facilitate turning sharp curves, what is known as a differential gear has been applied on the main axle of these engines. This consists of a pair of bevel-wheels face to face, the one keyed firmly upon the axle, the other keyed or otherwise secured to one of the driving-wheels, which is loose upon the axle. There are two bevel-pinions fixed upon pins or studs, and carried between and in contact with the two aforesaid bevel-wheels.

The power of the traction-engine is communicated through these bevel-pinions to the bevel-wheels in such a way that either of the road-travelling wheels may move a little quicker than the other without surging or waste of power. Thus, in turning sharp curves, the inner wheel may travel slowly, and the outer wheel may travel quicker, having the greater distance to move. This complicated motion was invented forty or fifty years ago for use in cotton-spinning, and is now employed largely, not only on traction-engines, but for vehicles, such as tricycles, &c., which have to work under similar conditions. The arrangement relieves the axle of a large amount of strain which would otherwise be caused by the inner wheel slipping, and when necessary it can be so locked that both wheels will revolve with the axle. This is of great service when the engine is sunk in a soft place, and all the power is required to be applied on one side to lift it out.

Every traction-engine should be fitted with a winding-drum fixed on the main axle, containing about 50 yards of steel rope. By throwing the road-wheels out of gear, and putting the winding-drum in motion, the rope may be used for a great variety of useful purposes. For instance, in soft stack-yards the engine may be moved on to the hard road after work has been finished, and the threshing-machine drawn up to it by the rope, thus avoiding cutting up the ground by the shunting necessary to couple up the engine direct to the machine. The machine or traction-waggons may also be drawn out of awkward places, where it would not be practicable or convenient to take the engine. For road-work the drum is also extremely useful, as a much larger load can be attached to

the engine; and in the event of a steep hill having to be encountered, the engine may be detached and taken to the top, then the rope can be unwound and secured to the load, and the latter drawn up and coupled to the engine again. The rope may also be used for hauling timber out of plantations, pulling up roots of trees or the stumps of hedges, or, by being passed over a pulley, it can be used for loading timber, &c., &c.

These traction-engines should also be furnished with a water-lifter, which is a little instrument on the same principle as the Giffard Injector. It consists of a small outer casing of metal, having a water inlet pipe on one side and a steam inlet pipe on the top. The steam is blown through a conical nozzle inside the instrument, and in its passage creates a vacuum, which sucks the water through the inlet and throws it forward into the tank. It is generally fitted with a length of india-rubber suction-hose, so that in a few moments the tank of an engine can be filled with water from any convenient brook or pond. This not only saves a great deal of time and manual labour in filling the tank with water, but it ensures the water being delivered into the tank, and consequently into the boiler, in a much cleaner state than where buckets are used for filling the tank. It can also be used in very shallow places where there is only sufficient water to cover the nozzle on the end of the suction-pipe, and where any attempt to lift the water with buckets would stir up the sediment, and lead to a great deal of dirt and grit being deposited in the tank, which would eventually find its way into the boiler.

Traction-engines can be employed for driving every class of machinery used on the farm, such as for threshing, steam-cultivation, &c., and also for hauling the produce of the farm to the nearest town or railway station, and bringing back manure, feeding-stuffs, lime, &c.

They are also used by contractors for threshing, who drag the machine about with them from place to place, and thus do away with a great deal of hard work which formerly used to be very trying to horses.

STEAM-CULTIVATION.

One of the most important and interesting uses to which the steam-engine has been applied is that of the cultivation of the soil. By its agency the land may be ploughed, grubbed (or cultivated), harrowed, and rolled, much more expeditiously than would be possible with the ordinary number of horses usually kept upon the farm. The owner of a steam-plough tackle is therefore in a position to take full advantage of any brief intervals of suitable weather which may occur in an otherwise unfavourable season, for the preparation of his land and getting in his crop. The greatest advantage of the steam-plough is obtained in dealing with strong land, where a large amount of working is required to bring it into condition.

Injury by too deep Ploughing.—At the same time, the power which is available for tearing up the soil requires to be judiciously exercised, as many British farmers have found to their cost. When the steam-plough was introduced, some seemed to expect that it would revolutionise agriculture, and many farmers, unaware of, or neglecting the real principles of cultivation, had their land ploughed to the utmost depth of which the tackle was capable. In rich loamy lands where there was a sufficient depth of fertile soil, this was no doubt attended with advantageous results. But in shallower and strong clay lands, where the ground had been cultivated by horse-power to the full depth of its fertility, the consequences were most disastrous. In such cases the injudiciously deep ploughing amounted to nothing short of burying what little good soil there was under a great depth of cold sour stuff, which it would take years of expensive working and manuring to bring into fertile condition.

Prejudice against Steam-ploughing.—This circumstance naturally aroused considerable prejudice against steam-ploughing, and now one often hears farmers state that they would not employ a steam-plough on any account, adding that in such and such a year they had a field entirely spoiled by it. But in most cases it will be found that the blame is not due to the steam-plough itself, but to

the imprudent manner in which it has been employed.

It used also to be claimed for the steam-plough that by its use the land could be cultivated at all times and in any condition. No doubt the mechanical operation of stirring or turning over the soil could be done at any season, and in any condition; but the mere fact of cultivating land by steam instead of by horses makes no difference in the effect of the cultivation. If a certain class of soil, say a strong clay, cannot, without disadvantage, be ploughed by horses, it cannot advantageously have the same operation performed upon it by steam.

Complaints have also been urged against the steam-plough on account of the weight of the engines disturbing and deranging the drains. These complaints may be well or ill founded, according to the state of the ground when the steam-plough is used, the suitability of the tackle for the ground on which it is to be used, and the expertness or clumsiness of those who have charge of it.

Advantages of Steam-ploughing.—When the steam-plough is judiciously used, its employment is attended with the utmost advantage to the farmer. By its means large areas of land can be quickly and cheaply prepared for the seed. The moment the first of the cereals are cleared from the land, the steam-plough can and should be set to work, the horse-power of the farm having still some weeks' work to do in completing the saving of the harvest. It enables the number of horses necessary for a large farm to be considerably reduced, thus effecting an important saving in forage and wages. It can also be used to break up the subsoil, so as to greatly assist the drainage. The changes made in this respect in certain lands in which there was a "pan" underneath the soil are very remarkable. In land on which the water used to stand for days after a heavy rain-fall, before the steam-plough was used, it now gets so freely away that after a few hours no water can be seen, even though it may have rained heavily for several days. This breaking up of the subsoil can be accomplished without having the useless matter of the subsoil brought to the surface.

The following are the different systems of steam cultivation :—

Double-engine System.

For large occupations, or for letting out on hire, the double-engine system is

no doubt the best, owing to the ease and rapidity with which it can be moved from field to field and set to work; to the large area of land which can be cultivated, owing to the economy of time in shifting; and to the large percentage of

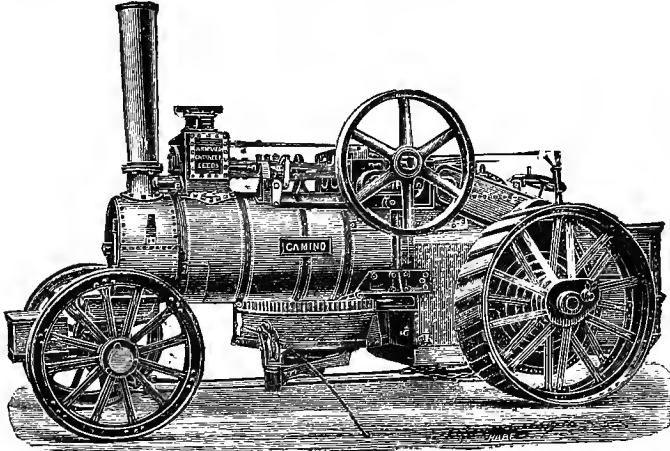


Fig. 53.—Ploughing engine.

power brought to bear upon the implements, which may be much broader in proportion for this than for any other system.

The tackle consists of a pair of traction-engines, as manufactured by J. & H

M'Laren, Leeds, and shown in fig. 53. They are fitted with winding-drums underneath the barrel of the boiler, worked by bevel-gearing from the crank-shaft, each drum containing from 400 to 500

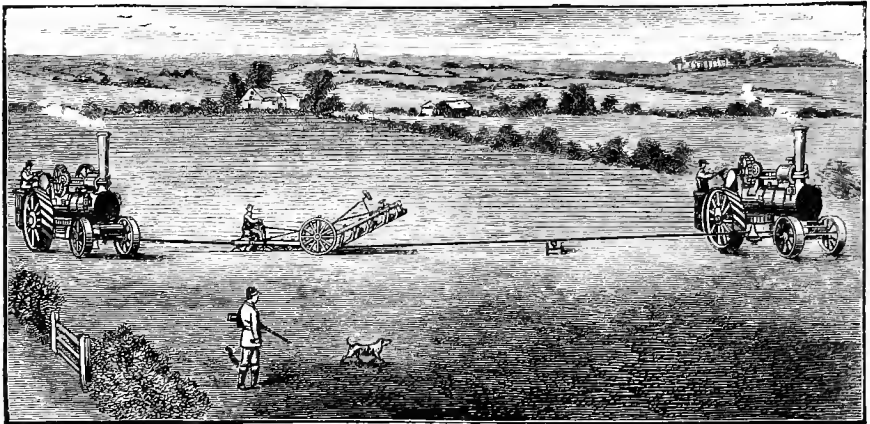


Fig. 54.—Double-engine steam-plough.

yards of specially strong steel-wire rope. The engines are placed on opposite head-lands of the field to be cultivated, as shown in the engraving, fig. 54, and they work

alternately—the one hauling the implement across the field, while the other is paying out the tail-rope and moving forward into position for the next “round.”

The whole power of the engine can thus be directly applied to the implement by means of the wire rope. This rope is evenly coiled upon the drum by means of coiling-pulleys, which swing upon an arm on the same centre as the drum, so that they accommodate themselves to any angle at which the rope may be working, and which move up and down automatically as may be required for the "lay" of the rope.

Steam-plough Engines.—Like the traction-engines already described, the steam-plough engines should be fitted throughout with cast-steel spur-gearing for the road motion, and double speed for travelling on the road. Where the work of cultivation is excessively heavy, the spur-gear for the ploughing motion should also be of steel. Steel axles and shafts should also be used, as they are not only stronger than iron but much stiffer, and consequently not so liable to bend. The road-travelling wheels should be of extra width to prevent sinking in soft land. The engines should be fitted with an injector, as well as a pump, for feeding the boiler. A water-lifter with india-rubber suction-hose should be fixed

in the tank for replenishing it with water; and as a pretty large stock of spare tools and duplicates are generally carried with each engine, a tool-box of large capacity is generally fixed upon the front axle.

Cost of Steam-ploughing Plant.—

The most convenient size of steam-ploughing engines for very large holdings, and for letting out on hire, is about 14 horse-power nominal. These will haul a 6-furrow plough with ease, turning over from 12 to 14 acres for a good day's work, or an 11-tined turning cultivator, tearing up and loosening the soil to a depth of from 7 to 9 inches, to the extent of about 25 acres for an average day's work. The *cost* of the complete plant, consisting of the two engines (with 400 yards of steel rope on each), 6-furrow plough, with steel skifes, 11-tined turning cultivator, and 6-framed flat reversible harrow, amounts to about £1800. Assuming the owner of such a set of tackle to have sufficient employment for it, the amount of work done by it, and the net cost price to the proprietor, would be about as follows, assuming the tackle to work 120 days in the year:—

Cost of working steam-plough for season of 120 days.

Dr.

By interest on £1800 capital expenditure at 5 per cent per annum . . .	£90	0	0
" depreciation, wear and tear, repairs, renewals, and redemption of capital, say 10 per cent per annum . . .	180	0	0
" 2 enginemen and 1 ploughman, at 4s. per day each . . .	0	12	0
" 1 man and horse leading water to engines, per day . . .	0	7	6
" coal for two engines per day, and leading (say) . . .	0	16	0
" oil, waste, stores, &c.	0	4	6
Total wages per day	£2	0	0
Making for 120 days	240	0	0
Total annual expenses	£510	0	0

Cr.

To 40 days' ploughing, 12 acres per day=480 acres, at 6s. 6d.	£156	0	0
" 60 " cultivating, 25 acres per day (once over)=1500 acres, at 3s. 6d.	262	10	0
" 20 " harrowing, 40 acres per day (once over)=800 at 2s. 3½d.	91	13	4
	£510	3	4

This leaves a balance of 3s. 4d. in favour of the tackle, after doing the work at the extremely low net cost price of 6s. 6d. per acre for ploughing, 3s. 6d. per acre for cultivating, and 2s. 3½d. per acre for harrowing. The cost of hiring steam-ploughing tackle from contractors for the same work, including cost

of fuel and leading coal and water, would be about as follows:—

Ploughing—8 inches deep . . .	10s. 6d. per acre.
Cultivating <i>twice over</i> . . .	12s. od. "
Harrowing <i>twice over</i> . . .	6s. od. "

These prices are based on the standard of fair medium loamy soils. For stiff

clays or specially hard or stony ground, of course they would not apply, the prices in these cases depending entirely upon the governing circumstances.

Tackle for 1000 Acres.—For holdings of about 1000 acres, a pair of 8 nominal horse-power ploughing-engines would probably be the most convenient size. They will haul a 5-furrow balance-plough, or a 9-tined turning cultivator, doing from 8 to 12 acres of ploughing, and from 15 to 20 acres of cultivating, per day.

The cost of this tackle, including the two engines, with 400 yards of rope on each, 5-furrow balance-plough with steel skifes, 9-tined turning cultivator, and 5-framed flat reversible harrow, is about £1500.

The 8-horse size of tackle has the further advantage that the engines are more convenient for road-haulage, threshing,

&c. With a little trouble the ploughing-drums can be detached, and the engines correspondingly lightened, when they can be used for most of the purposes of ordinary agricultural locomotives, for which the stronger engines are too heavy and unwieldy.

All the different sizes can, however, be used for the ordinary work of the farm—such as driving threshing, grinding, sawing, or other machinery—by means of a belt from the fly-wheel.

Single-engine Systems.

There are various systems of steam-ploughing tackle before the public for working with one engine only. The most successful appear to be those manufactured by Messrs Barford & Perkins of Peterborough. They may be divided into two classes: (1) That in which the implements are worked by ropes

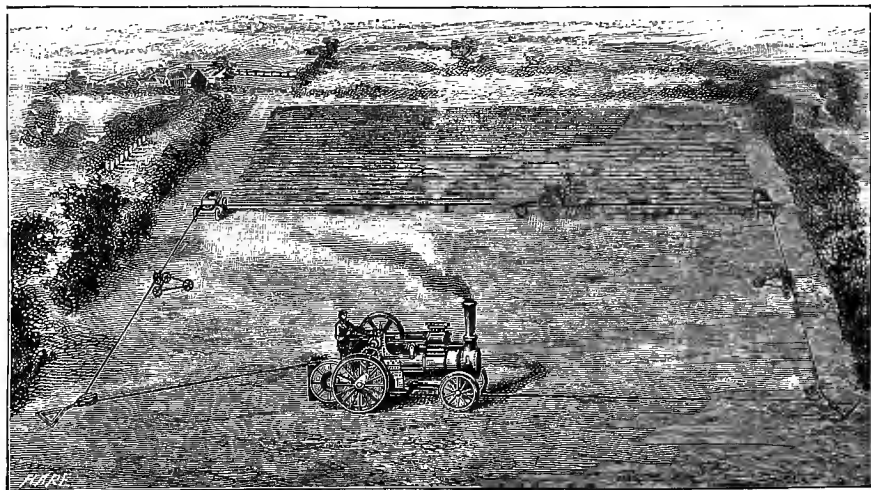


Fig. 55.—Single-engine steam-plough.

from a self-moving engine having double drums mounted upon it; and (2) That in which the implements are worked by ropes from a portable windlass, carrying the two drums, which are driven by means of a pitch-chain or universal coupling from the crank-shaft of an ordinary traction or portable engine.

The former system (No. 1), as illustrated in fig. 55, consists of a traction-engine carrying two winding-drums, one on each side of the tender. These drums

are driven direct from the road driving-gear of the traction-engine, the travelling wheels being thrown out of gear while the engine is required for ploughing. The drums each contain about 900 yards of steel rope—sufficient to set round a field of about 20 acres. They are fitted with automatic brakes, which fly off of their own accord when the drum is winding up the rope (*i.e.*, hauling the implement), and drop into contact when the motion is reversed and the drum begins

to pay out the tail-rope. The drums are mounted upon excentric studs, and can be easily thrown in and out of gear by levers under the control of the engine-driver.

The tackle used in connection with this engine consists of certain snatch-blocks with claw-anchors, two self-acting travelling anchors, sundry steel-rope porters, and the implement, plough, cultivator, or harrow, as the case may be.

The self-moving anchors consist of a strong guiding-pulley carried on a suitable wrought-iron or wood frame. This frame, when the anchor is in use, travels on 4 sharp disc-wheels, which sink into the ground, and prevent the anchor pulling sideways with the strain of the rope. In order to press these discs well into the ground and prevent it tipping over, the anchor is generally weighted with stones, or other heavy material, carried in a box fixed on it for the purpose.

The front axle is provided with a simple form of steerage, which enables the anchor to be guided along uneven and crooked headlands. The hind axle, which revolves when travelling, is fitted with a series of 4 sets of claw-tines which are fixed thereto and revolve with the axle. This axle also carries a pawl-wheel, which can be locked and unlocked by means of a pawl-lever. This lever can be worked by hand, or it can be controlled automatically by the steel rope. In the latter case, a ball is fixed on the steel rope, a few yards in advance of the implement. When the implement approaches the headland, this ball strikes a forked lever turning on the same centre as the guide-pulley. This forked lever raises the pawl-lever out of gear, and the forward strain on the steel rope causes the anchor to advance as far as may be required for the next round. The movement of the engine is then reversed, and the pulling rope now becomes the tail-rope, causing the implement to travel in the opposite direction.

As the implement begins to travel in the opposite direction, the pawl-lever again drops into gear with the pawl-wheel and locks it, causing the claw-tines (which have revolved harmlessly with the forward motion of the anchor) to take a firm hold in the ground like

the claws of a claw-anchor, so that when the tension again comes round the self-moving anchor in question, it cannot pull forward till the pawl-catch is again liberated.

An accident through the plough being pulled into the self-moving anchor is manifestly impossible, as the ball on the steel rope liberates the anchor before the plough can reach it; and the worst consequences of any neglect on the part of the engine-driver to stop the engine would be that the anchor would be hauled too far along the headland, with the plough following a yard or two behind.

The mode of working this system will be easily understood by a reference to the drawing, fig. 55. The engine is placed in a convenient position at one end or side of the field. The steel rope is taken off one drum and led out in front of the engine, and round a fixed snatch-block pulley secured by a claw-anchor in one corner of the field. It is then led at right angles down the side of the field to the far corner, where the self-moving anchor is fixed. Round the pulley of this anchor the rope is led, and attached to the implement.

The other steel rope on the other drum is led out behind the engine, and round the other side of the field in a similar manner, and attached to the implement. The implement is then drawn to and fro between the self-moving anchors, which gradually move forward the width of the implement at each round till the whole of the field has been cultivated. The position of the engine and the anchors, &c., can then be changed, and the land can be cultivated or ploughed crosswise if required.

The cost of a complete set of tackle for working on this system, including an 8-horse-power double-drum traction-engine, 1800 yards of steel rope, necessary anchors and snatch-blocks, four-furrow plough, and 7-tined turning cultivator, is £900. The advantages it possesses over other sets of single-engine tackle are,—fewness of parts composing the tackle, facility of setting to work (the engine is set the moment it is steamed to its place), small number of hands required to work it—two men only, one for the engine and the other for the implement.

The engine has also the great advan-

tage of being much lighter than any other double-drum engine, owing to the drums being driven off the road-gearing instead of by heavy independent shafts and gearing. The drums can also be dismounted in an hour or two at the end of the ploughing season, and the engine, relieved of all extra weight, can then be used without encumbrance as an ordinary farm traction-engine.

In order to prevent excessive wear and tear upon the ropes, they should be carried on rope-porter pulleys, placed at such intervals as will prevent the ropes trailing on the ground, which is very inju-

rious to them, especially in sharp gritty soils. In such land it will pay to keep an additional hand to attend to these porters, taking them out in front of the advancing implement, and putting them in again after it has passed.

Messrs Barford & Perkins's No. 2 system is identical in its operation with the system just described, the only difference being in the application of the motive power, see fig. 56. This system has the great advantage that it can be worked by an ordinary portable engine. The winding-drums are carried on a separate windlass, which is dragged into position

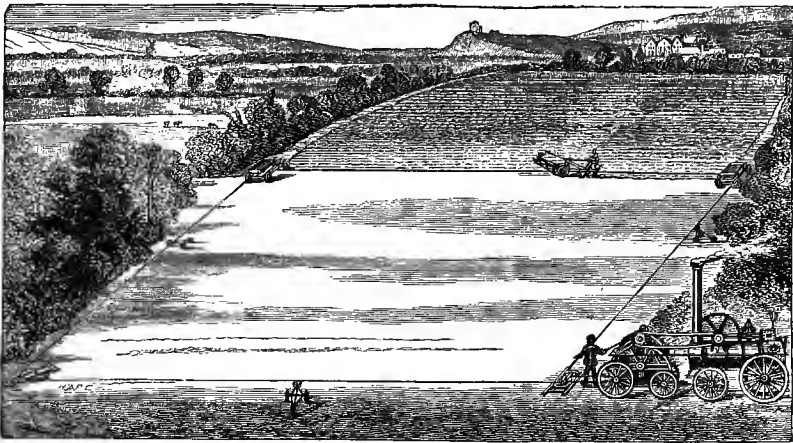


Fig. 56.—Single engine and windlass steam-plough.

by horses. The power is conveyed from the engine to the windlass by means of a pitch-chain, and the drums are worked by spur-gearing from the main driving-shaft. They are fitted with brakes for paying out the steel rope, and, as in the former case, one drum is winding on or pulling up the implement, while the other is unwinding or paying out the tail-rope. The mode of working will be easily understood by a reference to the engraving (fig. 56).

The price of a set of tackle of this description, with windlass, 1800 yards of steel rope, 5-tined turning cultivator, and necessary appurtenances, but exclusive of engine, is about £360. This set has therefore the advantage of being comparatively cheap, and can be worked at small expense, only two men being absolutely necessary to work it. There

is, however, a good deal more tackle to be moved into position by horses, and considerably more time required for fixing and getting ready for work. Nevertheless many hundreds of such sets have been sold for farmers' own use; and on small occupations, or where the land is not too strong, their use has been attended with great advantage.

STEAM-DIGGING.

One of the most modern developments of the use of steam on the farm has been its successful application to "digging" the soil. Hitherto all efforts had been directed to the provision of a substitute for the spade, and however perfect the action of the steam-plough or steam-cultivator may have been, it was very inferior in point of efficiency to spade-cultivation.

The problem of "digging" by steam has occupied the attention of many mechanical minds of the first order, but the credit of its practical solution is largely due to Mr T. C. Darby of Pleshy Lodge, Chelmsford. This gentleman is a tenant-farmer with strong mechanical tastes, and having set himself to the production of a steam-digger, he devoted large sums of money and years of patient toil to the perfection of his ideas.

The benefits of digging the soil as against ploughing it, must be evident to all who are familiar with these two modes of cultivation, and who have carefully considered the subject. Apart

from the waste of power in drawing a plough through the ground, as compared with that required for turning over the same depth of soil by means of digging-forks, the quality of the work done in the latter case is much superior to that of the former. The ground is more perfectly pulverised, and left in a better form for the action of the atmosphere; while, owing to the "lifting" action of the clod, which is raised and turned over by the motion of the digging-forks, the subsoil is left more open for the escape of surface-water and the penetration of the roots of the plants. This action leaves no "pan"; but as the spit of earth

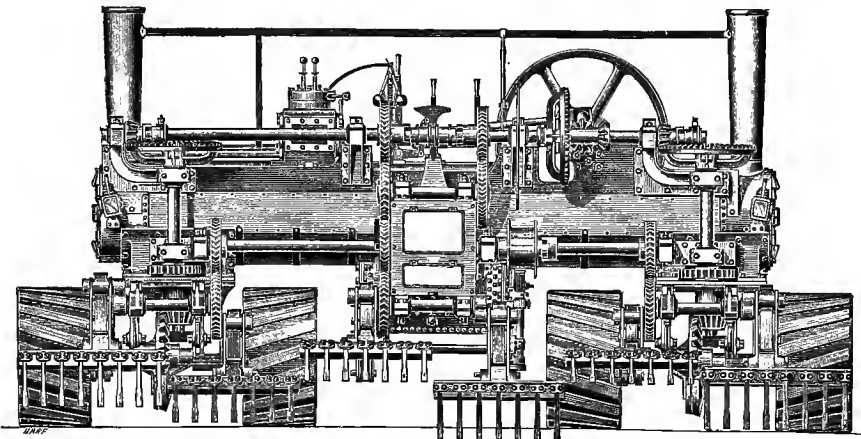


Fig. 57.—*The Darby digger.*

about to be turned over has been torn, as it were, from the subsoil on which it rested, and to which it adhered, the subsoil is partly shaken up and loosened with the most beneficial effect.

Darby's Digger.—The steam-digger first came prominently into notice at the Carlisle Show of the Royal Agricultural Society of England in 1880. In that year Messrs M'Laren of Leeds manufactured and exhibited a digger on Mr Darby's system, for which they were awarded the Society's special silver medal. There had been no trials of steam-cultivating machinery for the previous nine years, the last having been held at Wolverhampton in 1871. At the Carlisle trials in 1880, it was found that the *Darby digger* did the same amount of work with an expenditure of over 15

per cent less power than the steam-plough tackle which took the first prize at Wolverhampton in 1871.

It is matter for regret that the great Agricultural Societies, especially the Royal of England, give so little encouragement to the makers of agricultural machinery. The amount distributed in recent years in prizes to implement-makers is but a fraction of that distributed to the exhibitors of stock, and the consequence is, that for many years no marked improvement has been made in agricultural machinery. Farmers are reluctant to purchase new machines until they have been well tested, and it is a duty the societies owe to their members to encourage the invention of useful implements, and by official tests to ascertain their capabilities, so that their mem-

bers may be guided what machines to select and warned what to avoid. But for their remissness in this respect, many useful farm-implements which have never got beyond the experimental stage would have been perfected, and machinery would have been made practically available for many operations of the farm which are still done only by hand.

Cost of Steam-digging.—Notwithstanding the slight encouragement received from agricultural societies, Mr Darby has continued to improve his machine, so that now he claims to be able to dig about 10 acres per day with one machine, at a net cost—including men's wages, coal, interest on capital, and depreciation—of about 9s. per acre. The cost of his digger is £1200.

The Darby digger, fig. 57, consists of a steam-engine having working parts similar to those of an ordinary traction-engine fixed on the top of a double locomotive boiler, similar to those known as the *Fairlie type*, from their having been employed by the late Mr Robert Fairlie for the locomotives of many of the lines of railway with which he was connected.

By means of steel spur-gearing this power is communicated to a long horizontal shaft running parallel with the centre line of the boiler. The power is transmitted from this shaft to the digging-cranks by means of wheels and pinions of cast-steel. Each digging-fork is about $3\frac{1}{2}$ feet wide, and as there are six such forks, the machine is capable of digging a width of 21 feet at a time. The depth may be varied within certain limits down to a maximum of about 14 inches. By means of mechanical arrangements the action of the digging-forks resembles as nearly as possible that of digging by hand with a spade or fork.

The machine travels sideways when at work digging—hence its designation *Broadside digger*. It travels at the rate of half a mile per hour, so that, excluding stoppages and time lost at the ends turning, it would dig a little over an acre per hour. It is guided by means of a steerage on the opposite side of the boiler from the digging-forks. When required for travelling on the road, its travelling-wheels are turned at right angles to the centre line of the boiler,

instead of being parallel with it as when the machine is at work; and in this manner it travels along ordinary roads without taking up any more width of road than an 8-horse traction-engine of the usual construction.

In Essex, where Mr Darby and his machine are better known than in any other part of England, the digger is a general favourite. Many farmers prefer it to any other system of steam-tillage, and express the opinion that the crops are better and weeds fewer after the use of the digger, than is the case with any other mode of cultivation.

Proctor's Digger.—Mr Frank Proctor, The Elms, Stevenage, Herts, has also, among others, given much attention to the production of steam-diggers. The arrangement of his digger will be readily understood by reference to its illustration in fig. 58. It consists, it will be seen, of an ordinary traction-engine geared into a crank-shaft which works three forks at the rear, so that wherever the engine travels the land is left dug up behind. These forks can be thrown out of gear, or hinged up, or entirely disconnected from the engine when required, and thus the machine can be used either as an ordinary traction-engine for threshing and other purposes, or as a steam-digger. An important point claimed for this system is its comparative cheapness. The cost of an 8-horse-power digger is £800. Mr Proctor states that his digger of this size will dig about 10 acres per day of 10 hours, consuming about 11 cwt. of coal, and requiring the attendance of two men.

Weeds killed by Digging.—The late Mr John Algernon Clarke gave a very rational explanation of the curious fact of the comparative absence of weeds on land broken up by the digger. In examining work which had been done by this machine, he observed that the fork, lifting the spits of earth, drew out most of the long roots of the weeds from the subsoil, and threw them over to the action of the sun, which withered and killed them, and as the roots were not left in the ground they could not spring up again. On the other hand, the plough in cutting through the ground at a certain depth merely turned over those

weeds whose roots did not penetrate below the sole or pan of the furrow, and cut in two the roots which went lower than this, leaving the ends in the ground ready to spring forth again at the first opportunity.

Advantages of the Digger.—

An important advantage of the steam-digger is that it requires very little attention to work it. One man is sufficient for the purpose, and one attendant with a horse to supply the digger with coal and water. The time occupied in turning at each end of the field is a

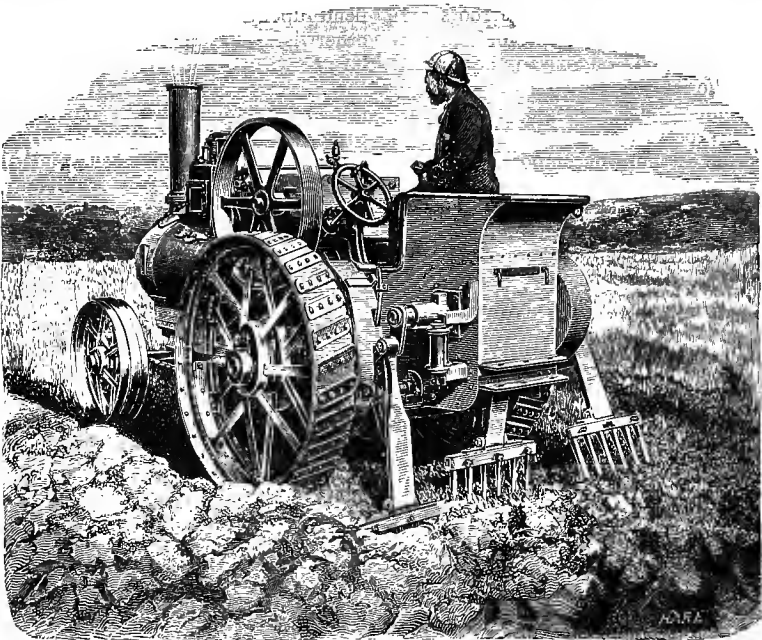


Fig. 58.—Proctor's digger.

little over two minutes, but the digger may be worked continuously without stopping, either by commencing in the centre of the field and working round and round till the whole is finished, or by commencing to dig round the outside of the field and working inwards to the

centre. The cost of wear and tear may fairly be assumed to be very light, as there are no steel ropes to maintain, nor any loose tackle or implements to keep in order, all of which are fertile sources of expense in other systems of steam-cultivation.

STORING ROOTS.

Advantages of Storing Roots.— The advantages which arise from the storing of roots are manifold. Chief amongst these are, the preservation of the crop from the effect of the frosts and thaws of winter, the procuring of

a regular supply of fresh and clean food for the animals upon the farm, the prevention of the growth of the tops in spring, and keeping the land free from carting and consequent poaching in unsuitable weather. Roots, like fruit,

ought to be stored before they become over-ripe; the months of October and November are therefore the most suitable for the work. The other operations of the farm allow time for it at this season; and the crop is generally in a fit state of maturity, as well as the land being dry.

Chemistry informs us that roots and fruit which are to be kept for any considerable period ought to be pulled before the starch which is present in their composition is changed into sugar, as this process goes on after they are pulled, and thus decomposition is retarded, as there is little or no liability to decay until this change in their substance is completed.

Turnips Consumed on the Ground by Sheep.—When different sorts of live stock are supported on the same farm, as is the case in mixed husbandry, the sheep are usually provided with the turnips they consume upon the ground on which they grow, which saves the trouble of carrying off a large proportion of the crop, and the proportion removed is for the use of the cattle in the steading. The proportions carried off are not taken from the ground at random, but according to a systematic method, which requires attention.

One object in leaving turnips on the ground for sheep is, to afford a greater quantity of manure to the soil than it received in its preparation for the turnip crop; and as sheep can withstand winter weather in the fields, and are not too heavy for the ground, they are selected to consume them on it. This is a convenient method of feeding sheep, affording them ample accommodation, giving them their food on the spot, and returning great part of the food to the land in the form of manure.

Quantity of Roots to be left for Sheep.—The quantity of roots left upon the field to be consumed by sheep depends upon the weight of the crop, and whether the land is in a high state of fertility or not.

In ordinary practice on a mixed farm, worked on the five-shift rotation, one-half the crop will be required to be consumed by cattle to convert all the straw into manure. The other half then remains to be consumed

where grown by sheep, which are left in the manner described in the paragraphs which follow. When a small crop is the result of the growth of the season, the foregoing plan must be modified, and two-thirds or even a larger portion of the crop may have to be left for the sheep; but this will depend upon the soil, whether fertile or otherwise. However arranged, it must be always kept in view that cattle will thrive much better on artificial feeding than sheep, and that it is sound economy to give a certain portion of dry food, along with roots, to cattle and sheep, so that the proper ratio of nutrients be established, and every constituent of the food be economised and waste prevented.

Ascertaining Weight per Acre.—To ascertain the weight of roots per acre, the following method may be adopted, which is simple and effective: Let a couple of drills be pulled in three parts of each field, and the turnips carted off; count the loads, and allow 8 cwt. to be the weight of each cart-load; the matter then becomes a simple question to ascertain the tons per acre, after which the farmer can readily apportion the quantity to be consumed by sheep and cattle.

Thus consideration is required to determine the proportion of the turnip crop to be pulled, the standard proportion being one-half.

Plan of Stripping Turnips.—Fig. 59 shows how turnips are stripped off the ground in the various proportions. The *half* can be pulled in various ways, but not all alike beneficial to the land: for example, it can be done by leaving 2 drills *a* and taking away 2 drills *b*; or by taking away 3 drills *c* and leaving 3 drills *f*; or by taking away 6 drills *i* and leaving 6 drills *h*; or by taking 1 drill *l* and leaving 1 drill *k*.

In ordinary farm practice, where half the crop is to be eaten off by sheep, the plan of taking 6 drills and leaving 6 drills is generally adopted, as in the other methods shown in fig. 59, there is not sufficient space left clear of roots to allow a cart and horse to turn without damaging the roots. The advocates of taking 2 drills and leaving 2 drills have overlooked this, and in consequence

more damage would be done to the growing roots than any seeming injury done by the sheep to the outside rows, where 6 drills are left.

The first break of turnip given to the sheep ought to be as large as possible, and therefore 8 drills should be taken and 4 drills left. This plan should also be adopted when it is desirable to leave a smaller quantity for consumption

by sheep than one-half, which may be either due to a high state of fertility of the soil or to a short crop of turnips.

Whatever the proportion removed, the rule of having 2 or more empty drills for the horses and carts to pass along when taking away the pulled turnips, without injury to those left, should never be violated.

The plan of leaving 2 and taking 2

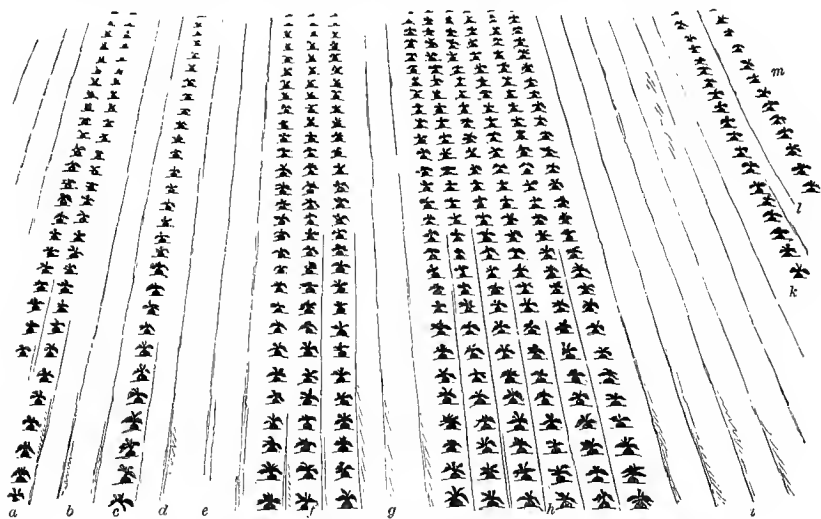


Fig. 59.—Methods of stripping the ground of turnips in given proportions.

a 2 drills left, and b 2 drills pulled, when half is left on.
b 2 drills pulled, and c 1 drill left, when one-third is left on.
d e 3 drills pulled, and c 1 drill left, when one-fourth is left on.

drills, when the half of the crop is to be eaten on, will be best shown in fig. 60, where the drills are represented on a large scale. One field-worker clears 2 drills at *a*, in rooting and topping, and another simultaneously other 2 at *b*; and in doing so, the turnips are dropped in the act of rooting and topping, in heaps at regular distances, as at *c* and *d*, amongst the standing turnips of the two drills *e* and *f*, on the right hand of one worker, and on the left of the other; and thus every alternate 2 drills left unpulled become the receptacle of the turnips pulled by every 2 workers from 4 drills. The cart then passes along *a* or *b* without touching the turnips on *e* and *g*, or on *f* and *h*, and clears away the heaps from the line *c d*.

In the figure the turnips are repre-

sented much thinner on the ground than they usually grow, to be more conspicuous; but the size of the bulb in proportion to the width of the drills is preserved both in the drills and heaps. The seats of the pulled turnips are shown upon the bared drills.

Pulling Turnips.—The most common state in which turnips are thrown in the temporary heaps, *c* and *d*, is with their tops on, and the tails or roots cut away.

In this condition they are most suitable for sheep, when the weather will not allow of their being kept on the turnip break. When this occurs the sheep ought to be laid upon old lea or pasture, and the turnips sparted or scattered thinly out of the carts in rows at regular intervals.

The cleanest state for the turnips themselves, and the most nutritious for cattle, is to take away both the *tops* and *tails*.

Turnip-tops as Food.—The tops of turnips possess greater value as manure than as food, and should therefore, as a rule, be left to be ploughed in on the ground. But when food for sheep is scarce, the tops may be given to ewes up to the latter end of December. This practice good farmers have for years

pursued with excellent results. Then many farmers have the idea that turnip-tops make good feeding for young beasts or calves at the beginning of the season—not from the knowledge that the tops really contain a larger proportion of bone-producing matter than the bulbs, as chemical analysis informs us, but from a desire to keep the turnips for the larger beasts, and to rear the young ones in any way. But such a notion is a mistaken one, as might easily be proved

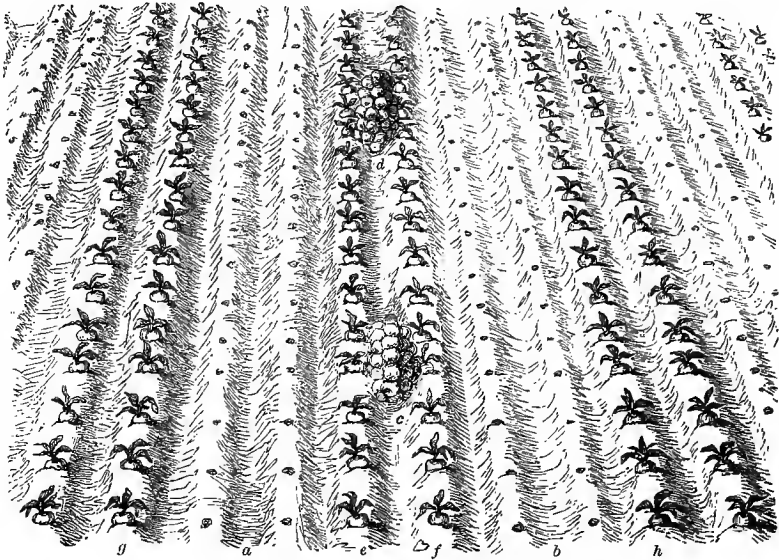


Fig. 60.—Method of pulling turnips in preparation for storing them.

a and b 2 pulled drills.

e and f 2 drills left with turnips.

c and d 2 heaps of prepared turnips.

by giving one lot of calves turnip-tops and another bulbs without tops, when the latter will show a superiority in a short time, both in bone and flesh. No doubt the large quantity of watery juice the tops contain at this season makes young cattle devour them with eagerness on coming off perhaps a bare pasture; and indeed any cattle will eat the tops before the turnips, when both are presented. But experience favours the condition that the time in consuming turnip-tops is worse than thrown away, inasmuch as tops, in their cleanest state, are apt to produce looseness in the bowels, partly, perhaps, from the sudden change of food from grass to a very succulent vegetable, and partly from the

dirty, wetted, or frosty state in which tops are often given to beasts. Looseness never fails to bring down the condition of cattle in so considerable a degree, that great part of the winter may pass away before they recover from the shock their system receives.

Sheep are not so easily injured by turnip-tops as cattle, on account, perhaps, of their costive habit; but in the spring it is dangerous to let sheep consume them freely, as fatal results have often followed.

Turnip-tops as Manure.—Tops are not thrown away when spread upon the ground—indeed, as already stated, they are more valuable as manure than as food, and should therefore, as a rule,

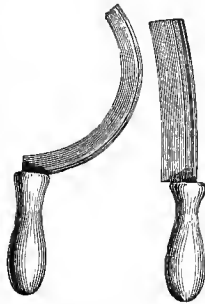
be left to be ploughed in on the field. Mr Grey of Dilston found that in one instance 2 bushels, and in another 3 bushels, per acre more of wheat was obtained when the turnip-shaws were ploughed down than when they were carried off the field.

Turnip-lifting Appliances.—The tops and tails of turnips are easily removed by means of very simple implements. Figs. 61 and 62 represent these in their simplest form, fig. 61 being an old scythe reaping-hook, with the point broken off. This makes a light instrument, and answers the purpose pretty well; but fig. 62 is better. It is made of a worn-out patent scythe, the point being broken off, and the iron back to which the blade is riveted driven into a helve protected by a ferrule. This is rather heavier than the other, and on that account removes the top more easily.

A superior implement to either is seen in fig. 63. The necessity for another implement of the kind arises from the fact, that when the top of a turnip has dwindled into a comparatively small size, it affords an inadequate hold for pulling the turnip from the ground; and when the attempt is found by the worker likely to fail, she naturally strikes the point of the instrument into the bulb to assist her, and the consequence is, that a deep gash is made in the turnip, which,

being stored for months, suffers by premature decay arising in the wounded part. If the turnip requires any effort to draw it, the claw *c* is inserted gently *under* the bulb, and the lifting is easily effected with certainty.

The mode of using these implements in removing tops and tails from turnips is this: When 2 drills are pulled and 2 left, the field-worker moves along between the 2 drills of turnips to be pulled, at *a*, fig. 60, and pulling a turnip with the left hand by the top from either drill, holds the bulb in a horizontal direction, as in fig. 64, over and between the



Figs. 61, 62.—Implements for topping and tailing turnips.

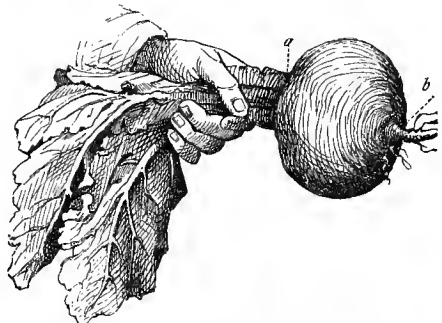


Fig. 64.—Mode of topping and tailing turnips.
b root, first cut off. *a* top, where cut off.

drills *e* and *f*, fig. 60, and with the knife first takes off the root with a smart stroke, and then cuts off the top between the turnip and the hand with a sharper one, on which the turnip falls into the heaps *c* or *d*, the tops being thrown down on the cleared ground. Thus, pulling one or two turnips from one drill, and then as many from the other, the two drills are cleared from end to end. Another field-worker is a companion by going up *b*, pulling the turnips from the drills on either side of her, and dropping them, topped and tailed, into the same heap as her companion.

Checking Turnip-growth in Spring.

—It frequently happens, especially in spring, when the second growth of the turnips requires to be checked, that the ordinary method of pulling and cleaning the turnips cannot be quickly enough performed to prevent the crop becoming useless. More speedy means must therefore be adopted. The old style of slashing the tops off with a scythe or hook

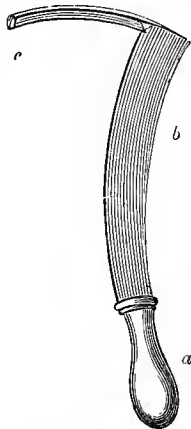


Fig. 63.—Turnip trimming-knife.

a Handle.
b Cutting edge.
c Claw welded to the extremity of the back.

does not overcome the difficulty. Mr George Brown, Watten Mains, Caithness, has for some years pursued the following plan with a fair amount of success. A common scuffler is taken, and after the cutting part of the hoes is extended to about 12 inches, the hoes are reversed—that is, change the side, so that the cutting part is turned out instead of inwards. Operations may then be commenced, after fixing the body of the implement to the required breadth between the drills. The hoes cut the tap-root beneath the surface without disturbing the bulb, which remains in the position it grew. The growth is thus completely checked, and the bulb will remain fresh, as there is a sufficient number of the small roots left to provide the moisture lost by evaporation, but not enough for continued growth.

Many farmers run the chain-harrows across the rows, which leaves the crop lying on the surface, ready to store; but the bulbs require to be cleaned and partly trimmed before being used.

Turnip-lifters.—An implement known as the “Turnip-lifter,” which tops and tails the turnips, was brought out some years ago. This implement would come into more general use if it were made to do the work throughout the season. When the shaws are strong and plentiful, these seem to clog the parts of the machine which tops the turnips, and on this account the usual workers have, as a rule, to be kept on the farm. Yet good work is in many cases done with this ingenious implement. A very useful machine of this kind, made by T. Hunter, Maybole, is represented in fig. 65.

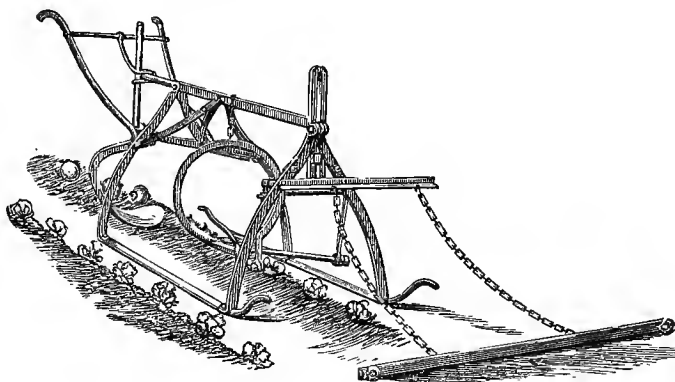


Fig. 65.—Turnip-lifter.

Further Hints to Turnip-lifters.

—Due care is taken, on removing tops and tails, that none of the bulb be cut by the instrument, as the juice of the turnip will exude through the incision. When turnips are consumed immediately, an incision does no harm; but slicing off a portion, and hacking the bulb, indicates carelessness, which, if persevered in, will be confirmed into an injurious habit, when turnips are to be stored.

When two-thirds of the turnips are pulled at *b*, fig. 60, and one-third left at *f*, the field-worker goes up *b*, and, pulling the 2 drills there, drops the prepared turnips between *c* and *d*.

When three-fourths are pulled, at

a, *e*, and one-fourth left at *f*, the turnips may still be dropped in the same place between *c* and *d*, the field-worker pulling the three drills on *a* and *e*, and the horse walking along *a* on taking them away.

When 6 drills are pulled at a time, 3 women work abreast, each pulling 2 drills: 2 of these workers drop the turnips into the centre drill of the 4 rows they are pulling. The other worker drops the turnips of the remaining 2 rows in the drill, next the growing crop, and on the return journey the turnips from the 2 rows next the drill are dropped along with them, the other 2 workers going on as formerly. The turnips are thus put into lines containing

4 drills each, and carting may be proceeded with as already described.

When the field is to be entirely cleared of turnips, the clearance is begun at the side nearest the gate; and if the workers move abreast, as directed just above, the carting on the land will be the least.

A Sheltered Spot for Sheep.—A field is begun to be stripped for sheep before the pastures are bare, and that part should be chosen which will afford them best shelter whenever the weather becomes stormy. A plantation, a good hedge, a bank sloping to the south, or one in a direction opposite to that from which high winds prevail in the locality, or a marked inequality in the form of the ground, will each afford shelter to sheep in case of necessity. On the sheep clearing the turnips from this part first, it will always be ready as a place of refuge against a storm.

Carting Turnips.—On removing prepared turnips from the ground, the carts are filled by the field-workers, as many being employed as will keep the carts agoing,—that is, to have one cart filled by the time another approaches the place of work in the field. If there are more field-workers than are required to do this, they should be employed in topping and tailing. The topped and tailed turnips are thrown into the cart by the hand, and not with forks or grips, which would puncture them. The cart is driven between the rows or lines of turnips, fillers being placed on each side. The carter manages the horses and assists in the filling, until the turnips rise as high in the cart as to require trimming, to prevent falling off in the journey.

Lifters one Yoking ahead of Carters.—As it is scarcely probable that there will be as many field-workers as to top and tail turnips and assist in filling carts at the same time, as to keep all the carts agoing, it will be necessary for the toppers and tailers to begin as much sooner—whether a yoking or more—as to keep the carts agoing when they begin to drive away; for it implies bad management to make horses wait longer in the field than the time occupied in filling a cart. The driving away should not commence at all until a sufficient

quantity of turnips is prepared to employ from four to eight carts one yoking; nor should more turnips than will employ that number of carts for that time be allowed to lie upon the ground before being carried away, in case frost or rain prevent the carts entering the field for a time.

Some employ one or two carts in an afternoon's yoking, to bring as many turnips as will serve the cattle for two or three days at most, and these are brought with the tops on, after much time has been spent in the field in waiting for their pulling and tailing. This is a slovenly and dirty mode of providing this valuable provender for cattle.

Dry Weather best for Turnip-storing.—Dry weather should be chosen for pulling turnips, not merely for preserving them clean and dry, but that the land may not be poached. When so poached, sheep have an uncomfortable lair, ruts forming receptacles for water not soon emptied; for let land be ever so well drained, its nature cannot be entirely changed—clay will always have a tendency to retain water on its surface, and loam will rise in large masses with the wheels. No turnips should therefore be led off fields during or just after rain; nor should they be pulled at all until the ground has become consolidated. They should not be pulled in frost, and if they are urgently required from the field in frost or rain, a want of foresight is manifested by either the farmer or his manager, or by both.

On the weather proving unfavourable at the commencement of stripping, or an important operation intervening—as wheat-seed—no more turnips should be pulled and carried off than will suffice for the daily consumption of the cattle in the steading; but whenever the ground is dry at top and firm, and the air fresh, no opportunity should be neglected of storing a large quantity.

Importance of Storing Roots.—To store turnips in the best state, should be regarded a work of the first importance in winter; and it can be done only by storing a considerable quantity in good weather, to be used when bad weather comes. When a store is prepared, the mind remains at ease as to the state of the weather, and having a store does

not prevent taking supplies from the field as long as the weather permits the ground to be carted upon with impunity, to be immediately consumed, or to augment the store. No farmer would dissent from this truth; yet many violate it in practice! The excuse most readily offered is want of time when the potato-land should be ploughed and sown with wheat; or when the beasts are doing well enough upon the pasture; or when the turnips are continuing to grow. The potato-land should be sown when ready; but the growing state of the turnips has no force when adduced against reducing

the condition of cattle; nor is the plea of the pasture being yet good enough for cattle tenable, for rough pasture is more useful to ewes in winter than to cattle in late autumn.

Methods of Storing Turnips.—The storing of turnips is well done in this manner. Choose a piece of lea ground, convenient to access of carts, near the steading, on a 15-foot ridge, running N. and S., for the site of the store. Fig. 66 gives the form of a turnip-store. The cart with topped and tailed turnips is backed to the spot of the ridge chosen to begin the store, and there emptied of

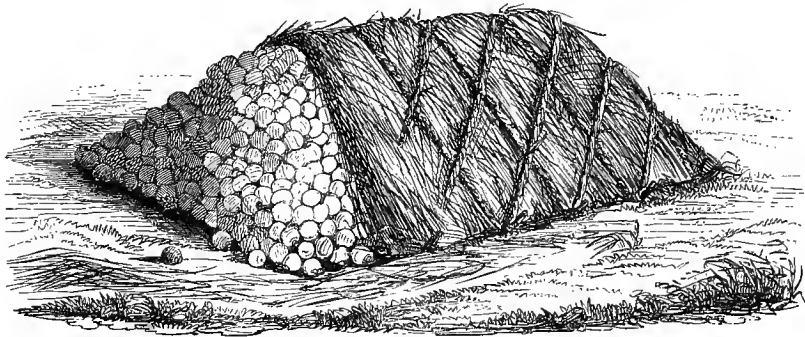


Fig. 66.—*Triangular turnip-store.*

its contents. The ridge being 15 feet wide, the store should not exceed 10 feet in width at the bottom, to allow a space of at least $2\frac{1}{2}$ feet on each side towards the open furrow of the ridge, to carry off surplus water. The turnips are piled by hand up to the height of 4 feet, but will not pile to 5 feet on that width of base. The store may thus be formed of any length; but it is more desirable to make two or three stores on adjoining ridges, than a very long one on the same ridge, as its farthest end may be too far off to use a wheelbarrow to remove the stored turnips.

There are various ways of thatching turnips. In some cases straw drawn out lengthwise is put 6 inches thick above the turnips and kept down by means of straw ropes arranged lozenge-shaped, and fastened to pegs driven in a slanting direction into the ground, along the base of the straw. Or a spading of earth, taken from the furrow, may be placed upon the ends of the ropes to

keep them down. The straw is not intended to keep out either rain or air—for both preserve turnips fresh—but to protect them from frost, which causes rotteness, and from drought, which shrivels them. Others merely cover the roots with a layer of earth about 8 inches deep, and if care is exercised to see that the roots are quite dry before being covered, this system suits very well. To avoid frost, the end and not the side of the store should be presented to the N., which is generally the quarter for frost. If the ground is flat, and the open furrows nearly on a level with the ridges, so that a fall of rain might overrun the bottom of the store, a furrow-slice should be taken out of the open furrows by the plough, and laid over to keep down the ropes, and the furrow cleared out as a gaw-cut with the spade.

Turnips may be heaped about 3 feet in height, flat on the top, and covered with loose straw; and though rain pass

through them readily, they will keep very fresh.

Pits in the Field.—In very many cases turnips are speedily and effectually stored by being thrown into small heaps on the land, with one or two loads in each heap, and covered with earth. Heaps of one load are most convenient, as they can be most easily thrown together. This method is called pitting, and is done without the aid of horses and carts. It is useful to place a tuft of straw in the apex of each pit as a ventilator.

Taking Roots from the Store.—

When turnips are to be used from the store in hard frost, the straw on the S. end is removed, as seen in fig. 66, and a cart, or the cattle-man's capacious light wheelbarrow, backed to it; and after the requisite quantity for the day has been removed, the straw is replaced over the turnips.

Storing in Furrows.—One plan of storing is to pull the roots from the field in which they have grown, and set them upright with their tops in a furrow made with the plough, and cover the bulbs with the next furrow-slice, while another plough is making a furrow 6 drills apart. This plan, with slight alterations, has been followed in many parts of Scotland. Instead of leaving the tops, the bulbs are both topped and tailed. The plough returns in the furrow, opening up both sides as deeply as possible, and into this furrow the turnips from the drills at each side are thrown, the plough then covering up the whole. Turnips stored in this manner cannot be left long before using. It is a speedy but not very effective method.

Temporary Storing on Lea.—Another still more temporary method of storing is to pull the turnips and carry them to a bare or lea field, and set them upright beside one another, as close as they can stand, with tops and roots on. This plan cannot save turnips from hares or rabbits. A turnip-field can be bared in this way for a succeeding crop. An area of 1 acre will thus contain the growth of 4 or 5 acres of the field. But turnips cannot be so secure from frost here as in a pit or store; and after the trouble of lift-

ing and carrying them has been incurred, it is much better to take them to a store at once, where they would always be at hand.

Storing in Houses Objectionable.

—Defective as these temporary plans are, compared to triangular or flat-topped stores, they are better than storing turnips in houses, where they engender heat and sprout on the top, and seldom fail to rot.

Storing in Hurdle Enclosures.—

The following method is frequently adopted for a temporary store. Ordinary hurdles are taken, and the spaces between the bars wattled up with the old straw ropes that have been used for thatching. These hurdles, when thus finished, are set with stays 9 or 10 feet apart, one of the ends being closed by a hurdle being placed across. Into the enclosed space the turnips are backed in the carts and tilted, after which they are trimmed until about 4 feet high. The store may be made any length by adding hurdles; the whole being finished, by throwing over the top old thatch, straw ropes, &c. Rain and air which permeate through the mass do no injury, but rather the opposite, as their tendency is to keep the turnips fresh and sappy.

Earthing-up Turnips.—The double mould-board plough is frequently employed to place earth upon the turnips in the drills, as a mode of temporary storing. The extra time required in pulling turnips after this process involves some loss, but the earthing-up protects the roots from damage by game and frost.

Preparing for a Storm.—Although storing is the proper method of securing turnips for a storm of rain or snow, when the turnip-field should not be entered by a cart, yet, as a storm may suddenly arise, food should be provided for the cattle. Rain, snow, and frost, give prognostics of their approach; and when they announce themselves, some farmers send all the field-workers and ploughmen to the turnip-field, and pull the turnips in the manner described in fig. 60, removing only the tails, and throwing the turnips with tops into heaps of from 3 to 6 cart-loads each, according to the bulk of the crop, tak-

ing care to finish each heap by placing the tops of the outward turnips around the outside, as a protection to the bulbs from the frost, should that be unaccompanied with snow. But if sharp frost set in, this plan cannot be adopted, as the heaps become miniature ice-houses, and the bulbs freeze more quickly and harder than if they had been left growing. A very slight covering of snow prevents the bulbs freezing to any great extent, if they are left alone; and if a farmer be placed in this position, the better plan is to pick the turnips out of the rows daily until fresh weather sets in.

Pulling Mangels.—In *pulling* mangel-wurzel, care should be taken to do no injury to the roots. Cleansing with the knife should on no account be permitted; rather leave some earth on the root. The drier the weather is, the better for storing the crop. The roots are best prepared for the store by twisting off the top with the hand, as a mode of preventing every risk of injuring the root. Mangel-wurzel not being able to withstand severe frost, should be entirely cleared from the field before its occurrence.

The best way of pulling them is in the order indicated in fig. 60, at *a*, where two drills are pulled by one worker, and the adjoining two drills by another; and the prepared roots placed in heaps in the hollow intermediate to the four drills, the leaves being also thrown into heaps between the roots. "The leaves thus treated, when intended to be fed either by sheep folded on land, or carted off and thrown on pastures for cattle or sheep, are always clean and fit food for stock, which they are not when thrown over the land and trampled on. Mangel-wurzel standing on the ground, and protected by the broad leaves, will stand frost (if not very severe) without injury; but a very slight frost will damage those roots which are pulled, therefore it is wise to cart the roots away." If the leaves are not desired to be used as food, they may be scattered over the ground. Mangel-leaves do not affect and injure young cattle as turnip-leaves do.

Carting Roots.—On removing any kind of roots, the cart goes up between

two rows of pulled roots, and thereby clears a space at once of the breadth of eight drills. In this manner the work proceeds expeditiously, and with little injury to the land by trampling. To save the land still further, and also to lessen the draught to the horses, the carts should be driven up and down the drills and not across them, whether going with a load or returning empty.

Cost of Pulling and Carting Mangels.—The pulling and driving a crop of 20 tons of mangel-wurzel is stated to cost from 9d. to 1s. per ton, and a bad crop will cost considerably more. From 25 to 45 tons per acre of mangel have been obtained in France, and 42 tons in Ireland.

Storing Mangels.—As to *storing* mangels, Mr Baker, of Writtle, recommends "stacking the roots upon a base not exceeding 3 yards in width, but from 6 to 7 feet is better. The roots should be packed with the crowns outward, in the form of a roof, diminishing upwards until they arrive at a narrow ridge at top, rising from the base from 6 to 8 feet in height. If a wider base is selected, it will be necessary to introduce a fagot upright, in the middle of the heap, at about every 6 feet apart, so as to carry off the heat; for should fermentation set in—which in some seasons it is apt to do, unless due precaution is taken to prevent it—the results would be to spoil the roots. When the clamp or row is completed, it should be well covered over with straw, about 6 inches in thickness, and then with the soil dug up immediately around to the thickness of about 8 inches, leaving an opening over each fagot secured at first partially from frost by a wisp of straw only. It is, however, thought advisable by some cultivators to defer earthing the heaps to the top for about 2 feet downwards until a later period, and all hazard of fermentation is over."

Mangels Stored in Houses.—Mr Baker says: "When it is stored in a building made secure from the frost for the purpose, but little further care is necessary, as I have never known an instance of its being injured by fermentation, *provided the top of the heap remain uncovered*. In my storing-house I frequently cart in from 400 to 500 tons in

one heap of 20 feet in width. The walls are formed of the earth excavated; a roof with a thick coating of thatch covers the whole, and the carts enter by folding-doors at one end. It may be safely packed to any thickness and height, if afterwards protected only with straw. For this purpose barley-straw answers best."

A Suffolk farmer has stored his mangel-wurzel in a boarded barn, the inside of which is first lined with barley-straw 18 inches thick, to protect them from frost, *leaving the top uncovered*. Then lay 12 feet deep, 18 feet wide, by 30 feet long. He has pursued this plan several years, and it has preserved them admirably up to March, or even longer. He never knew them to heat, or take more harm than by the common method of earthing them up. He should not be the least afraid of putting them in a brick barn, taking care to leave the top doors open during the day.

Another farmer says: "Respecting the storing of mangel-wurzel, it is quite safe in placing 100 tons together in a barn, if done when the roots are dry and the green removed, by allowing air from a window for the first week or ten days, afterwards *covering well up with straw* to prevent the frost from penetrating. In this manner I have kept the roots quite sound until the month of June following."

Cover with Dry Straw.—Opposite opinions are thus expressed as to covering. Upon the whole, it might be safest to cover with dry straw. A farmer gives this warning in regard to the state of straw: "In storing mangel for winter, my straw was carried to the spot in order to thatch the mangel before the covering of mould was put on. Some of this straw laid out and got thoroughly wet. Where the wet straw was used the mangels are rotten; where the dry straw, they are safe and sound."¹

Storing Cabbages.—Cabbages are generally consumed direct from the ground in a green state. They are not so easily stored for future use as are turnips or mangels; still there are some methods by either of which they may be safely preserved for several months.

The mistaken idea that cabbages cannot be successfully stored or protected from frost except in a barn or other building specially prepared for them has, no doubt, prevented the more extensive cultivation of this most useful crop.

Amongst the various methods of storing cabbages which have been practised and recommended are the following: Taking them up and replanting them in a sloping manner, and covering them with straw; pitting them; hanging them up in a barn; turning them head downwards, and covering them with earth, leaving the roots sticking up in the air. But every one of these plans is attended with great labour, and some of them forbid the hope of being able to preserve any considerable quantity.

The most successful plan is this: Throw up a sort of land or ridge with the plough, and make it pretty hard on top. Upon this land lay some straw. Then take the cabbages, turn them upside down, and, after taking off any decayed leaves, place them, about six abreast, upon the straw. Then cover them, not very thickly, with straw, or leaves raked up in the woods, throwing here and there a spadeful of earth on the top, to keep the covering from being blown off by the wind. Only put on enough of straw or leaves to hide all the green, leaving the cabbage-roots sticking up through the covering.

Stored in this way, cabbages of all sorts will be found to keep well through the winter. And not only do they keep better in this than any other way, but they are at all times ready for use. They are never locked up by frost, as often happens with those pitted in the earth; and they are never found rotting, as is often the case with those stored with their heads upwards and their roots in the ground.

The bulk of this crop is so large, that storing in buildings of any sort is not to be thought of. Besides, the cabbages so put together in large masses would heat, and rot quickly. In some gardens, indeed, cabbages are put into houses, where they are hung up by the roots; but they wither in this state, or soon putrefy.

By adopting the mode of storing recommended above, however, all these in-

¹ *Bell's Week. Messen.*, March 8, 1858.

conveniences are avoided. Any quantity may be so stored, in the field or elsewhere, at a very trifling expense compared with the bulk of the crop.¹

Lifting Cabbages.—Some recommend the cabbages to be pulled up by the roots; others prefer cutting the stem close to the ground and leaving the root in the ground, which will throw up a fresh growth of leaf early next spring. Mr Charles Howard, Biddenham, Bedford, says he has found these sprouts most valuable for ewes in early spring. Where the sprouts are not desired for food, the better plan is to pull up the roots along with the cabbages, as the spring growth tends to exhaust the soil.

Utilising Cabbage-stalks.—In regard to cabbage-stalks, after cutting off the cabbages, a farmer says: "I do not get these 'out of the way as quickly as possible,' by shooting them into a ditch to rot and wash away, as is too often the case. I lay them thin to dry, and then clamp and char them for absorbing urine, and drilling with a compost drill, or broad-casting, where most likely to be advantageous."

Storing Belgian Carrots.—*Belgian* carrots, which are white, will stand the winter without harm. By the first week in December they will have attained their greatest growth.

Storing Red Carrots.—Common *red* carrots are taken up before the frost appears, and stored for winter use. They are best taken out of the ground with a three-pronged fork when sown on flat ground; but on drills the plough, without the coulter, answers the purpose nearly as well, and executes the work much more quickly, though the extremities of the longest carrots may be broken off. On being taken up in either way, the tops are wrenched off by the hand, and may be given to cattle, or strewn over the ground to be ploughed in.

Carrots, not being so easily affected by frost as mangel-wurzel, may be stored in an outhouse mixed with dry sand, or in a triangular heap, and covered with straw, or with straw and earth.

Storing Parsnips.—The *parsnip* may

be taken up from the flat or the drill, and stored in precisely the same manner as carrots. They are not much affected by frost, and will keep fresh in the store till April. Care, however, should be taken that none of the leaves remain attached to the roots.

Parsnip-leaves as Food for Cows.—"In October, the *leaves* of parsnip, as they *begin* to decay, should be cut off, and given, when dry, to cows: it is important to see that they be dry, as, when moist from rain or dew, they are apt to inflame the udder. The leaves come in as a convenient auxiliary to grass at this period; and, if given *moderately*, a good armful per day to each cow will impart as much richness to the milk as the parsnip itself."²

Storing Kohl-rabi.—Of *kohl-rabi*, Mr Green, Stratford-on-Avon, says: "The bulbs may be taken up and stored the same as swedes, or remain on the field, according to the farmer's convenience: 20 tons an acre may be considered a good crop."

VARIETIES OF TURNIPS.

The varieties of turnips cultivated in this country are very numerous. They are divided mainly into swedes, yellow turnips, and white turnips, the names of the two latter being derived from the colour of the flesh. One kind from each of these classes is generally cultivated on every farm, although the yellow is omitted in some districts, and the swede in others. Where the swede is known, its culture is seldom relinquished, and its area is extending.

Order of Using Turnips.—White varieties come earliest into use, and will always be esteemed on account of their rapid growth and early maturity; and though unable to withstand severe frost, their abundance of leaf serves greatly to protect the roots from the effects of cold. Being ready for use as soon as pasture fails, they afford the earliest support to both cattle and sheep; and only such a quantity should be stored of them as will last to the end of the year.

Yellows then follow, and usually last for about two or three months.

¹ *Farming World*, 317, October 28, 1887.

² *Lawson's Agric. Man.*, 237, and *Suppl.*, 49.

Swedes finish the course, and should last until the grass is able to support young cattle at the end of May or beginning of June, to which period they will continue fresh in store, if stored in the manner recommended in fig. 66, or any of the other effective methods.

Time for Storing Swedes.—It has been contended that the best time for storing swedes is before vegetation makes its appearance, in March or April, when they are heaviest. By experiments made in England, it was found in weighing swedes on the 16th of November 1858, and again on the 16th of February 1859 from the same field, that the crop had

increased in weight in that time no less than $2\frac{1}{2}$ tons per acre. This experiment corroborates what has already been stated in the table of specific gravities, that swedes attain weight until vegetation recommences in April. If there were no danger of damage by frost, it would therefore be prudent to delay storing swedes until the end of February. There is, however, great risk of damage from frost, and it is safer to store the roots early in winter before severe frosts set in.

White Varieties.—Of all the varieties of white turnips, the white globe (*Brassica rapa, depressa, alba*, of De Candolle), *a*, fig. 67, is one of the best for early

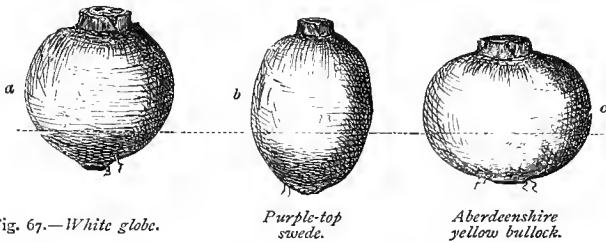


Fig. 67.—White globe.

Purple-top
swede.

Aberdeenshire
yellow bullock.

maturity, sweetness, juiciness, size of root, weight of crop, and elegance of form. Its form is nearly globular, as its name indicates; skin smooth, somewhat oily, fine, and perfectly white; neck of top and tap-root small; leaves long (frequently 18 inches), upright, and luxuriant. Though the root does not feel particularly heavy in the hand, it does not emit a hollow sound when struck, as the white tankard-turnip does; its flesh is somewhat firm, fine-grained, though distinctly exhibiting fibres radiating from the centre, the juice easily exuding, and the rind thin. Its specific gravity was determined by Dr Skene Keith at 0.840.

Besides this white there are the light green-topped white, which is good and beautiful, and the red-topped white, which seems coarse, though perhaps hardy.

Yield per acre of White Turnips.—Our crops of white-globe turnip must ordinarily consist of middle-sized bulbs, or contain many blanks. Taking the distance between the turnips at 9 inches—being that to which white turnips are usually thinned out—and the usual dis-

tance between the drills at 27 inches, an area of 243 square inches of ground is allowed to each turnip. Hence there should be 25,813 turnips per imperial acre; and taking 20 tons per acre as a fair crop, each turnip should only weigh 1 lb. 8 oz.! Now, suppose each turnip should weigh 6 lb., the crop will be 69 tons 1 cwt., instead of 20 tons per acre. The inevitable conclusion is, either that blanks occur to the enormous extent of 9445 turnips, or the average distance between the turnips must be 20 inches instead of 9; but as we are sure that turnips are not at 20 inches asunder, we must go to the other alternative that there are only 9445 turnips to the acre, which should make each turnip only 4 lb. 6 oz. When actual results fall so very far short of expectation, the inquiry is, Whether the deficiency is occasioned by the death of plants after singling? or the average weight of each turnip is much less than we imagine? or the distance left by the singling is greater than we desire?—or from all these causes combined? From whichever cause, singly or combined, it is worthy of serious investigation by the farmer, whether or not the fate of the

crop really depends more on occult circumstances than mode of culture? Let us examine this a little:—

Weights and Sizes of White Turnips.—Weights and sizes of white turnips have been ascertained with sufficient accuracy. White globes exhibited at the show of the Highland and Agricultural Society at Inverness in October 1839 gave a girth varying from $28\frac{1}{2}$ to 34 inches, and a weight varying still more—from 8 lb. to $15\frac{1}{2}$ lb. each root; and 3rd roots of the same girth of $30\frac{1}{2}$ inches weighed respectively 8 lb., $9\frac{3}{4}$ lb., and $14\frac{1}{2}$ lb.¹ After such a statement, it is evident that crops of the same bulk weigh very differently; turnips from the same field exhibit different feeding properties, and different localities produce turnips of different bulk and weight. Whence arise those various results? The above weights are not the utmost to which this turnip attains, examples occurring from 18 lb. to 23 lb.;² and we have pulled one from among swedes weighing 29 lb., including the top. And yet from 30 to 40 tons per imperial acre are regarded a very great crop of this kind of turnip.

Greystone Turnips.—The greystone white turnip has a purplish top, and being of the form of the white globe, may have been derived from it. It attained at Yester in 1863 a crop of 40 tons per imperial acre, with $6\frac{1}{2}$ cwt. guano and guano phosphate, half and half, along with farm-dung. It is extending in culture. There are several other white varieties in use which are found very suitable for providing early food when pasture runs short.

Yellow Varieties.—Of yellow turnip, perhaps the most general favourite is the green-top Aberdeen Yellow Bullock (*Brassica rapa, depressa, flavescens*, of De Candolle). This is a good turnip, of the form of an oblate spheroid (c, fig. 67); the colour of the skin below ground, as well as of the flesh, is a deep yellow orange, and that above ground bright green. The leaves are about 1 foot long, dark green, rather soft, spreading radiantly over the bulb, and collected into

a small girth at the top of the turnip; the tap-root is small. Its specific gravity, as determined by Dr Keith, is 0.940. This root feels firm and heavy in the hand, with a smooth fine skin, the flesh crisp, but not so juicy nor the rind so thin as in the case of the globe. There are several other very useful varieties, such as the purple-top yellow, and various hybrids.

Yield of Yellow Turnips.—Selected specimens exhibit a circumference of from 27 to 30 inches, with a weight varying from 6 lb. to $8\frac{1}{2}$ lb., but specimens may be found weighing from 9 lb. to 11 lb. with the same diameter, showing a difference of 2 lb. in weight. Yellow turnips seldom yield so heavy a crop as either the globe or swede, 30 tons the imperial acre being a great crop; but their nutritive property is greater than that of the white. In the northern parts of the kingdom, where light soils predominate, they are grown in preference to the swede; but with proper culture the swede will exceed the yellow in weight and nutrition on most soils and localities. Occasionally as much as 33 tons per acre of purple-top yellows are raised.

Varieties of Swedes.—Of the varieties of the swede, the Purple-top (*Brassica campestris, napo-brassica, rutabaga*, of De Candolle) has obtained the preference; and for weight of crop, nutritive property, and durability of substance, it is an excellent turnip. It is of an oblong form (b, fig. 67), having the colour under ground and of the flesh a deep yellow orange, and the part above the ground a dusky purple. The leaves are about 1 foot long, standing nearly upright, of a bluish-green colour, and growing out of a firm conical crown, which forms the neck of the bulb. The skin is somewhat rough, the rind thicker than in either the white or yellow turnip, and the flesh very crisp. This turnip feels heavy and hard in the hand. According to Dr Keith, the specific gravity of the orange swede is 1.035, and of the white 1.022. Dr Keith found the swede heaviest in April, at the shooting out of the new leaves; and after its flower-stem was fairly shot in June, the specific gravity of the root decreased to 0.94—that of the yellow turnip. This differential fact indicates

¹ *Jour. Agric.*, x. 456.

² *Lawson's Agricul. Man.*, 253, 254.

the comparative values of those turnips. In recent years many valuable new varieties of swedes, as of other roots, have, with great benefit to farmers, been brought into use by leading seedsmen.

Yield of Swedes.—Picked specimens of swedes have exhibited a girth of from 25 to 28 inches, varying in weight from 7 lb. to 9½ lb.; but the weight varies in a different proportion to the bulk, as one of 25 inches gave 9½ lb., whilst another of 26 inches only weighed 7 lb. It is no uncommon thing to see swedes from 10 lb. to 12½ lb. A crop of 16 or 20 tons may be obtained by ordinary culture, but on first-class well-managed land from 28 to 34 tons per imperial acre are occasionally obtained. In 1863, 41½ tons per acre of purple-top swedes were raised on the Nether Mains of Pitfour in the Carse of Gowrie. A crop of 50 acres of swedes within the policy of Wedderburn, Berwickshire, was in 1815 let to be consumed by cattle and sheep, the wethers to pay 6d. a-head per week, and it realised no less than £21 per imperial acre! The crop, unfortunately, was not weighed, but it was estimated at over 58 tons per acre. Take the calculation in another form, and see the result of £21 at 6d. a-head per week, which implies the support of 32 sheep to the acre; and take Mr Curwen's estimate of a sheep eating 24 lb. a-day for 180 days, or 26 weeks,¹ and we find the crop should have weighed 61 tons 12 cwt.

Quantity of Turnips eaten by Sheep.—The quantity of turnips eaten by sheep is, however, variously stated. Sir John Sinclair gives a consumption of 21 acres of 44 tons each, by 300 sheep in 180 days, or nearly 38 lb. a-day for each sheep.² If we take the usual allowance of 16 young sheep to an ordinary acre of 30 tons, which is 23⅓ lb. a-day to each, or ten old sheep, which is 37⅓ lb. to each, both respectively are near the results given by Mr Curwen and Sir John Sinclair, the difference between them being exactly that consumed by old and young sheep. Whether we take 24 lb. or 38 lb. as the daily consumption of turnips by sheep, there is no doubt

whatever of the £21 per acre having, in the case referred to, been received for their keep.

Proportion of Leaf and Root.—The proportion the top bears in weight to the root is little in the swede, as evinced in the experiments of Mr Isaac Everett, South Creak, Norfolk, on a crop of 17 tons 9 cwt. Grown at 18 inches apart, and 27 inches between the drills, it was 3 tons 3 cwt. of tops, on the 15th December, after which they were not worth weighing; and, what is remarkable, the tops are lighter in a crop raised on drills than on the flat surface—that is, whilst 28 tons 8 cwt. of topped and tailed turnips afforded only 5 tons 10 cwt. of tops from drilled land, a crop of 28 tons 16 cwt. from the flat surface yielded 6 tons 16 cwt. of tops.³ Sir John Bennett Lawes and Dr Gilbert have determined, in the Rothamsted experiments, that common turnips, such as Norfolk whites, yield a much higher proportion of leaf to root than swedes; and if the leaf be unduly developed, there may even be more nitrogen, and more total mineral matter, remaining in the leaf to serve only as manure again, than accumulated in the root to be used as food. In the case of swedes, however, not only is the proportion of leaf to root very much less under equal conditions of growth, but the amount of dry matter, of nitrogen, and of mineral matter, remaining in the leaf, is very much less than in the root. In one case, with a highly nitrogenous manure, whilst there was with an average of 10¼ tons of white turnip roots nearly 6¼ tons of leaves, there was with swedes, with more than 12 tons of roots, not quite one ton of leaf. In a series of experiments, moreover, with different manures, whilst white turnips gave from 300 to 600 parts of leaf to 1000 of root, the highest proportion by weight of leaf to root in the case of swedes was 78½ to 1000. Whilst in yellow or white turnips a very large amount of the matter grown is accumulated in the leaf and only serves as manure again, in swedes a comparatively small amount of the produce is useless as food for stock.

Keeping Properties of Turnips.—

¹ Curwen's *Agricul. Hints*, 39.

² Sinclair's *Husband. Scot.*, ii., Appendix, 47.

³ *Jour. Eng. Agric. Soc.*, ii. 279.

The yellow turnip will continue fresh in the store until late in spring, but the swede has a superiority in this respect to all others. A remarkable instance of the swede keeping in the store, in a fresh state, was observed in Berwickshire, where a field of 25 acres was pulled, rooted, and topped, and stored in the manner as in fig. 66, in fine dry weather in November, to have the field sown with wheat. The store was opened in February, and the cattle continued on them until the middle of June, when they were sold fat, the turnips being then only a little sprouted, and somewhat shrivelled, but sweet to the taste.

Large Swedes best.—One property possessed by the swede stamps a great value upon it for feeding stock; the larger it grows the larger proportion of nutritive matter it contains, affording a sufficient stimulus to the farmer to raise this valuable root to the largest size attainable.

With yellow and white varieties the experience on this point has been different.

Specific Gravity of Turnips.—All turnips, except swedes, are lighter than water. This is remarkable, because all the ingredients composing turnips—sugar, gum, proteine compounds, fibre, &c.—are heavier than water; the conclusion is, that all turnips except swedes contain a large proportion of air.

Composition of Heavy and Light Turnips.—The comparative composition of heavy and light turnips is as follows:—

Swede, specific gravity 1.015.	
Pectic acid and lignine	247.0
Proteine compounds	19.0
Ash	12.0
Total fibre	278.0
Water	9,101.0
Proteine compounds	58.0
Sugar, gum, &c.	563.0
Total juice	9,722.0
Ash	50.000
Phosphates	10.000
Phosphoric acid in alkaline salts	0.300
Nitrogen in fibre	3.200
Nitrogen in juice	9.280
Specific gravity of juice	1.037
Dry matter in 100 parts of juice	7.480

Tweeddale purple-top yellow, specific gravity 0.782.	
Pectic acid and lignine	283.5
Proteine compounds	16.9
Ash	22.6
Total fibre	323.0
Water	9,313.0
Proteine compounds	33.3
Sugar, gum, &c.	330.7
Total juice	9,677.0
Ash	72.000
Phosphates	12.000
Phosphoric acids in alkaline salts	0.500
Nitrogen in fibre	2.700
Nitrogen in juice	5.300
Specific gravity of juice	1.028
Dry matter in 100 parts of juice	8.870
Total nitrogen in swede	12.300
Total nitrogen in purple-top	8.000
Total fibre in swede	278.000
Total fibre in purple-top	323.000

Ash of Swedes.—Messrs Way and Ogston found the ash of a crop of Skirling's swede, of 20 tons per acre, to contain these ingredients:—

		Mineral matter removed by an acre of crop. lb.
Silica	2.69	9.4
Phosphoric acid	9.31	31.3
Sulphuric acid	16.13	54.2
Carbonic acid	10.74	36.2
Lime	11.82	39.7
Magnesia	3.28	11.0
Peroxide of iron	0.47	1.6
Potash	23.70	79.6
Soda	14.75	49.6
Chloride of sodium	7.05	23.7
	99.94	336.3 ¹

Ash of Yellow Turnips.—The composition of the ash of the yellow turnip was this:—

	Leaves.	Roots.
Peroxide of iron	2.67	1.37
Lime	6.76	12.12
Magnesia	13.73	4.97
Potash	15.47	28.03
Soda . . . . .	...	6.82
Chloride of sodium	17.81	9.61
Phosphoric acid	11.32	10.16
Sulphuric acid	13.93	13.07
Carbonic acid	14.73	10.74
Silicic acid	3.58	3.11
	100.00	100.00

¹ *Jour. Eng. Agric. Soc.*, viii. 144.

Actual quantities of these substances in the ash in an imperial acre:—

	Leaves. lb.	Roots. lb.
Peroxide of iron . . .	5.60	10.08
Lime	14.24	88.92
Magnesia	28.92	36.44
Potash	32.60	205.64
Soda . . . . .	...	50.04
Chloride of sodium	37.52	70.48
Phosphoric acid . . .	23.84	74.52
Sulphuric acid . . .	29.36	95.84
Carbonic acid . . .	30.04	78.76
Silicic acid	7.52	22.80
	209.64	733.52

Ash of Green-tops.—The analysis of the ash of the green-top white turnip is thus given by Messrs Way and Ogston:—

	Mineral matter removed by an acre of crop. lb.	
Silica	0.96	2.6
Phosphoric acid . . .	7.65	20.5
Sulphuric acid . . .	12.86	34.5
Carbonic acid . . .	14.82	39.7
Lime	6.73	18.0
Magnesia	2.26	6.1
Peroxide of iron . . .	0.66	1.8
Potash	48.56	130.0
Chloride of sodium	5.44	14.6
	99.94	267.8

Ash of Greystone Turnips.—The composition of the ash of the greystone turnip—after deduction of carbonic acid, sand, and charcoal—was, on clay and sandy soils, thus found by Dr Ander-

	Clay.	Sandy.
Peroxide of iron . . .	2.74	2.85
Lime	15.90	13.24
Magnesia	1.61	2.46
Potash	45.01	44.86
Soda	3.15	3.20
Chloride of sodium	9.72	9.69
Phosphoric acid . . .	18.03	18.94
Sulphuric acid . . .	3.02	3.62
Soluble silica	0.82	1.14
	100.00	100.00

The proportion of bulb to top in turnips has been ascertained by Messrs Way and Ogston in these ratios; in 100 of root, the top bore these proportions:—

	Per cent.
Swedes	10.05
Yellows	16.09
White	22.18

Thus swedes yield more root in proportion to their tops than white turnips, in

the ratio of 10.5 to 22.18 per cent.¹ Compare with this what is said on this subject in a preceding paragraph under heading of "Proportion of Leaf and Root."

Ash of Yellow-globe Mangels.—Messrs Way and Ogston found the ash of the yellow-globe mangel to consist of these ingredients in a crop of 22 tons per acre:—

	Mineral matter removed by the crop in an acre. lb.	
Silica	2.22	11.1
Phosphoric acid . . .	4.49	22.5
Sulphuric acid . . .	3.68	18.5
Carbonic acid . . .	18.14	91.0
Lime	1.78	8.9
Magnesia	1.75	8.8
Peroxide of iron . . .	0.74	3.7
Potash	23.54	118.2
Soda	19.08	95.7
Chloride of sodium	24.58	123.3
	100.00	501.7

Ash of Long Red Mangels.—They found the ash of the long red mangel to consist of these constituents in a crop of 24 tons per acre:—

	Mineral matter removed by an acre of crop. lb.	
Silica	1.40	4.8
Phosphoric acid . . .	1.65	5.7
Sulphuric acid . . .	3.14	10.7
Carbonic acid . . .	15.23	52.3
Lime	1.90	6.5
Magnesia	1.79	6.1
Peroxide of iron . . .	0.52	1.8
Potash	21.68	74.3
Soda	3.13	10.7
Chloride of sodium . .	49.51	169.8
	99.95	342.7

Ash of Cabbage.—Dr Anderson gives the composition of the ash of cabbages thus:—

	Outer leaves.	Heart.
Potash	14.96	38.74
Soda . . . . .	...	1.05
Chloride of potassium	8.71	...
Chloride of sodium . .	9.16	5.73
Lime	24.68	11.64
Magnesia	3.22	2.91
Oxide of iron . . .	1.89	0.43
Sulphuric acid . . .	16.56	13.99
Phosphoric acid . . .	2.95	5.47
Carbonic acid . . .	15.10	19.21
Silica	2.77	0.83
	100.00	100.00

¹ *Jour. Eng. Agric. Soc.*, viii. 171.

Ash of Carrots.—Messrs Way and Ogston ascertained the ash of the white Belgian carrot, in a crop of 27 tons per acre, to contain :—

		Mineral matter removed by an acre of crop. lb.
Silica	1.10	5.5
Phosphoric acid . .	7.86	39.0
Sulphuric acid . .	6.95	34.5
Carbonic acid . .	17.72	88.1
Lime	8.26	41.0
Magnesia	3.20	15.9
Peroxide of iron . .	1.66	8.3
Potash	28.00	139.2
Soda	17.53	87.2
Chloride of sodium .	7.65	38.0
	99.93	496.7

Comparative Mineral Ingredients of Turnips, Mangels, and Carrots.—It is interesting and instructive to be made acquainted with the composition of individual crops, but it is still more instructive to have a comparison of the mineral matters contained in a given weight of different crops. Here is a comparative view per cent of the mineral matters contained in *one ton* of turnip, mangel, and carrot, by Messrs Way and Ogston :—

	Turnip.	Mangel.	Carrot.
Silica	0.34	0.54	0.24
Phosphoric acid .	1.77	0.66	1.73
Sulphuric acid . .	2.33	0.65	1.31
Lime	1.76	0.41	1.77
Magnesia	0.47	0.43	0.80
Peroxide of iron .	0.07	0.12	0.22
Potash	6.07	4.99	6.59
Soda	1.46	3.02	2.71
Chloride of sodium	1.49	5.29	1.42
	15.76	16.11	16.79

Ash of Parsnips.—Dr Richardson determined the composition of the ash of the parsnip to be this :—

Potash	36.12
Soda	3.11
Lime	11.43
Magnesia	9.94
Phosphoric acid .	18.66
Sulphuric acid . .	6.50
Phosphate of iron .	3.71
Silica	4.10
Chloride of sodium	5.54
Loss, &c. . . .	0.89

100.00¹

Ash of Kohl-rabi.—Messrs Way and

Ogston found the composition of the ash of kohl-rabi to be this :—

Potash	36.27
Soda	2.84
Lime	10.20
Magnesia	2.36
Peroxide of iron .	0.38
Phosphoric acid .	13.46
Sulphuric acid . .	11.43
Carbonic acid . .	10.24
Chloride of sodium .	11.90
	99.08

For further analysis of roots of all kinds, see "Foods."

Nutritive Matter in different kinds of Roots.—A white-globe turnip of 7 inches in diameter affords 72½ grains, whereas one of 4 inches yields 80 grains of nutritive matter, the smaller being the more nutritive.

A large swede contains 110 grains, and a small one only 99 grains of nutritive matter, the larger swede being the more nutritive.

Nutritive Matter in an Acre of Roots.—The nutritive matter contained in an imperial acre of turnips is great. In a crop of 20 tons, or 45,000 lb., there are 900 lb. of woody fibre; 4000 lb. of starch, sugar, gum; 670 lb. of gluten; 130 lb. of fat or oil; and 300 lb. of saline matter. Turnips contain a very large proportion of water, and this, enhancing the cost of transport, makes it desirable to have them consumed on the spot where they are grown.

Keeping Properties and Feeding Value of Swedes.—Mr Gilbert Murray, Elvaston, Derby, ascertained by experiment that "determination of the specific gravity of the entire bulb of the swede turnip gives its *keeping* properties; and the specific gravity of the expressed juice indicates at once the real *feeding* value of the specimen examined;" and the following are the specific gravities of the bulb and juice of six specimens of swedes, raised on purpose :—

Specific gravity, bulb.	Specific gravity, juice.
1.003	0.099
0.991	0.984
1.101	0.947
	1.018
	1.016
	1.018 ²

Ill-shaped Turnips.—In a, fig. 68, is shown an ill-formed turnip, as also one,

¹ Wilson, *Our Farm Crops*, 12, Part VII.

² *Jour. Eng. Agric. Soc.*, xxiii. 361.

b, which stands so much out of the ground, represented by the dotted line, as to be liable to injury from frost. The turnip *a* is ill-formed, inasmuch as the part around the top is hollow, where rain or snow may lodge, and find their

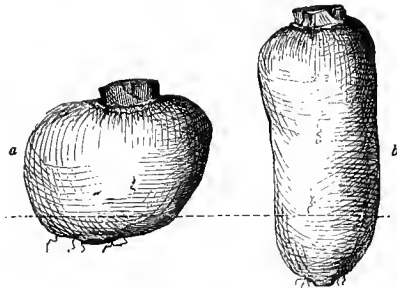


Fig. 68.—*Ill-shaped turnip.* *Tankard-turnip.*

way into the heart, and corrupt it, as is actually found to take place.

When to Store White Turnips.—

All white turnips, when allowed to remain on the ground after they have attained maturity, become soft, spongy, and susceptible of rapid putrefaction, which reduces them to a saponaceous pulp. This affords a good motive to store white turnips when they come to maturity, which is indicated by the leaves losing their green colour.

There are some sorts of white turnips always spongy in the heart, and among these may be classed the tankard, *b*, fig. 68; as also a flat red-topped white and a small flat white, both cultivated by small farmers; because, being small, they require little manure to bring them to maturity.

Number of Turnips per Acre.—It may be useful to give a tabular view of the number of turnips there should be on an imperial acre at given distances between the drills, and between the plants in the drills, and of the weight of the crop at specified weights of each turnip, to compare actual receipts with defined data, and to ascertain whether differences in the crop arise from deficiency of weight in the turnip itself, or in the plants being too much thinned out. The distance between the drills is the usual 27 inches; the distance between the plants is what is allowed to the different sorts of turnips. As the

imperial acre contains 6,272,640 square inches, it is easy to calculate what the crop should be at wider and narrower intervals between the drills:—

Usual distance between the drills.	Usual distances between the plants.	Area occupied by each plant.	Number of turnips there should be per imperial acre.	Weight of each turnip.	Weight which the crop should be per imperial acre.
Inches.	Inches.	Square inches.		lb.	tons. ewt.
27	9 between the plants of white turnips.	243	25,813	1	11 10½
				2	23 1
				3	34 11½
				4	46 2
				5	57 12½
				6	69 3
				7	80 13½
				8	92 4
27	10 between the plants of yellow turnips.	270	23,232	1	10 7
				2	20 14
				3	31 1
				4	41 8
				5	51 15
				6	62 2
				7	72 9
				8	82 16
27	11	297	21,120	1	9 8
				2	18 18½
				3	28 5
				4	37 14½
				5	47 2
				6	55 11½
				7	65 19
				8	75 8½
27	12 between the plants of swedes.	324	19,360	1	8 12¾
				2	17
				3	25 17½
				4	34 11
				5	43 3½
				6	51 16½
				7	60 9¾
				8	69 2

Careful and Careless Thinning of Roots.—On comparing a common crop of 20 tons of swedes with these data, and keeping in view the distance of 12 inches between the plants, the inevitable conclusion is, that the average weight of turnips must be less than 3 lb., or the distance between them greater than 12 inches. In the one case, skill in raising a crop is almost rendered nugatory; and in the other, negligence in wasting space in the thinning out appears conspicuous. An amendment in both particulars is therefore required, and fortunately attainable; for as a slight difference in either makes a great difference in the

weight of a crop, the turnip should be heavy, and the distance invariable. For example, 5-lb. turnips, at 9 inches asunder, give a crop of 57 tons $12\frac{1}{2}$ cwt.; whereas the same weight of turnip at 11 inches apart gives only a little more than 47 tons. Now, how easy is it for careless workers to thin out the plants to 11 instead of 9 inches! and yet, by so doing, $10\frac{1}{2}$ tons of turnips are sacrificed. Again, a difference of only 1 lb. on the turnip—from 5 lb. to 4 lb.—at 9 inches asunder, makes a difference of $11\frac{1}{2}$ tons per acre. So that a difference of only 1 lb. in each turnip, and 2 inches in the distance between them, makes the united sacrifice of 22 tons per acre, from what might be obtained! Who will deny after this, that minutiae require the most careful attention of the farmer?

Errors in Estimating Weight of Roots.—It is quite possible for great errors to be committed in measuring a crop of turnips as it stands, instead of topping and tailing a whole field, and weighing every cart-load separately. For example: Suppose 1 yard is measured from a turnip along a drill, 1 yard will embrace 5 turnips of white and 4 of swedes; but if the measurement is taken from between two turnips, 1 yard will only embrace 4 turnips of white and 3 of swedes, making, in the white, a difference of 1 turnip in 5, and in the swedes 1 in 4; and if the weight of an acre is calculated on such data, the crop, in the case of the white will be $\frac{1}{5}$, and in that of the swedes $\frac{1}{4}$, beyond or below the truth. Again, if the yard be placed across two drills, their produce will be included within the yard, the distance between the drills being only 27 inches; but if the yard be placed across one drill only, then its produce alone will be included, as the yard will not reach to the drill on either side; and if the produce of the whole field is calculated on such data, the result, in the second mode of measurement, will just give half the amount of the first. These ways of estimating a crop, when thus plainly stated, appear ridiculous; but they may be causes of error by persons who are not aware of the powers of numbers when squared. A part of a field measured may give a different result from

the whole, or from another part, as a crop on a rising knoll, compared with that in a hollow, where it may be twice as much as the other. Filling one cart-load and weighing it, and filling other loads to a similar bulk, without weighing them, is fallacious, when it is known that turnips grown on the same field differ much in weight. There is, therefore, no certain mode of estimating the weight of turnips in a field but by weighing every cart-load taken from it.

HISTORY OF THE TURNIP.

The history of the turnip, like that of most other cultivated plants, is obscure. According to the name given to the swede in this country, it is a native of Sweden; the Italian name *Navoni de Laponia* intimates an origin in Lapland; and the French names *Chou de Lapone*, *Chou de Suède*, indicate different origins. Sir John Sinclair says: "I am informed that the swedes were first introduced into Scotland anno 1781-2, on the recommendation of Mr Knox, a native of East Lothian, who had settled at Gottenburg, whence he sent some of the seeds to Dr Hamilton."¹ There is no doubt the plant was first introduced into Scotland from Sweden, but its introduction would seem to have been prior to the date mentioned by Sir John Sinclair. The late Mr Airth, Mains of Dunn, Forfarshire, stated that his father was the first farmer who cultivated swedes in Scotland, from seeds sent him by his eldest son, settled in Gottenburg. Whatever may be the date of introduction, Mr Airth cultivated them in 1777; and the date may be taken as corroborated by the silence of Mr Wight regarding its culture by Mr Airth's father when he undertook the survey of the state of husbandry in Scotland, in 1773, at the request of the Commissioners of the Annexed Estates. He would not have failed to report so remarkable a circumstance as the culture of so useful a plant, so we may infer that its culture was unknown prior to, and in, 1773. Mr Airth sowed the first portion of seed he received in beds in the garden, and transplanted the plants in rows in the

¹ Sinclair's *Hus. Scot.*, i. 278, note.

field, and succeeded in raising good crops for some years, before sowing the seed directly in the fields.

It is probable that the yellow turnip originated, as supposed by Professor Low, in a cross between a white and the swede,¹ and, as its name implies, the cross may have been effected in Aberdeenshire. The origin of the yellow turnip must therefore, on this supposition, have been subsequent to the introduction of the swede.

It is rather remarkable that no turnips should have been raised in this country in the fields until the end of the 17th century, when it was lauded as a field-root as long ago as the time of Columella, and even then the Gauls fed their cattle on them in winter. The Romans were so well acquainted with turnips, that Pliny mentions having raised them 40 lb. weight.² Turnips were cultivated in the gardens in England in the time of Henry VIII.³

SHEEP IN WINTER.

SHEEP ON TURNIPS IN WINTER.

Room having been prepared on turnips for sheep to be fed upon them, by removing half the crop in the manner described in fig. 59, the first thing to be done is to carry the articles on carts to the field to construct a temporary enclosure of a given space. It is the duty of the shepherd to erect the enclosure, and he requires in any case but little assistance from other labourers.

Enclosing Sheep on Turnips.—There are two ways of enclosing sheep

upon turnips ; with *hurdles* made of wood, and *nets* made of twine. Since the introduction of nets, the older method of enclosing with wooden hurdles has become exceptional, and is now seldom adopted unless where the enclosure or division is to stand for a considerable time, or for temporary fanks for sorting sheep. Still it may be useful to explain how the enclosures are formed of these wooden hurdles.

Wooden Hurdles.—Fig. 69 represents 2 Scotch hurdles set as they should be, and the mode of setting them is:

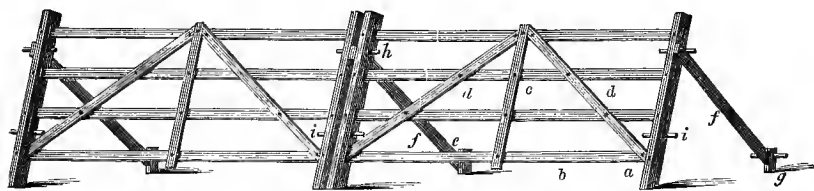


Fig. 69.—*Wooden hurdles or flakes set for confining sheep on turnips.*

The shepherd requires the assistance of another person for this purpose. The hurdles are set down in the line of the intended fence. The first hurdle is raised by its upper rail, and the ends of its side-posts *a* are sunk a little into the ground with a spade, to give them a firm hold. The second hurdle is let into the ground in the same manner, both being held in that position by the assistant. One end of a stay *f* is then placed between the

hurdles near the tops of the heads, and the stay and hurdles are fastened together by the wooden pin *h* passing through holes in both side-posts and stays. Another pin *i* is passed through a lower part of the side-posts. The hurdles are then inclined away from the ground fenced, until the upper rail shall stand 3 feet 9 inches above the ground. A short stob *e* is driven into the ground

¹ Low's *Ele. Agric.*, 290.

² Dickson's *Hus. Anc.*, ii. 250-4.

³ Phillips's *Hist. Cult. Veg.*, ii. 365.

by the hardwood mallet, fig. 70, at a point where the stay *f* gives the hurdles the above inclination, and a pin fastens the stob and stay together, as seen at *g*. After the first two hurdles are thus set, the operation is easier for the next, as one hurdle is raised after another, and fastened to the last, until the entire line



Fig. 70.—Shepherd's hardwood mallet.

is completed. The other component parts of a hurdle are *b* long rails, *c* stay-rail, *d d* diagonals.

Objections are made against this kind of hurdle, as being inconvenient to carry from one part of a field to another in carts—their liability to be broken in consequence—the shepherd being unable to set them without assistance—the time they consume in setting—being easily upset by a high wind blowing from behind them—and the constant repair they require in replacing pins, stays, and stobs. When carefully laid aside at the end of the season, these hurdles will last several years. They are best made of larch, and the separate parts are now prepared by machinery, and can be purchased and put together anywhere at small cost.

English Wooden Hurdles.—A very common hurdle used in England is shown in fig. 71. It is formed of any sort of

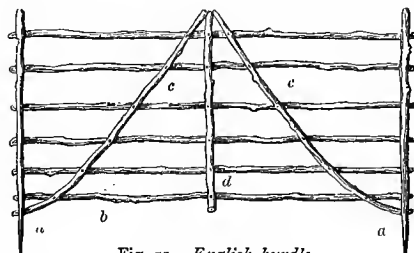


Fig. 71.—English hurdle.

willow or hardwood, as oak-copse, ash-saplings, or hazel. It consists of 2 heads *a a*, 6 slots *b*, 2 stay-rails *c c*, and an upright slot *d*. The slots are mortised into

the heads and nailed with flattened fine-drawn nails, which admit of being very firmly riveted, upon which the strength of the hurdle mainly depends. Although the horizontal slots are cut 9 feet long, the hurdle, when finished, is only somewhat more than 8 feet, the slot ends going through the heads 1 or 2 inches: 2 hurdles to 1 rod of 16 feet, or 8 to 1 chain of 22 yards, are the usual allowance.

Erecting Hurdles.—The hurdles being carted to the field, they are laid down flat, end to end, with their heads next to, but clear of, the line in which they are to be set. A right-handed man generally works with the row of hurdles on his left. Having made a hole in the line of hurdles, for the foot of the first hurdle, with the *fold-pitcher*, fig. 72, which is an iron dibber, 4 feet long, having a well-pointed flattened bit,



Fig. 72.—*Fold-pitcher in hurdle-setting.*

in shape similar to the feet of the hurdles, he marks on the ground the place where the other foot is to be inserted, and there with his dibber he makes the second hole, which, like all the others, is made 9 inches deep. With the left hand the hurdle is put into its place, and held upright while lightly pressed down by the left foot on the lowest slot. This being done, the third hole is made opposite to, and about 6 inches from, the last. The dibber is then put out of hand by being stuck in the ground near where the next hole is to be made; the second hurdle is next placed in position, one foot on the open hole, and the other foot marks the place for the next hole, and so on throughout the whole row. When the place of the second foot of a hurdle is marked on the ground, the hurdle itself is moved out of the way by the left hand, while the hole is made by both hands. When the whole row is set, it is usual to go back over it, giving each head a slight tap with the dibber, to regulate their height and give them a firmer hold of the ground.

To secure the hurdles steady against the rubbing of sheep, couplings are put over the heads of each pair where they meet, which is a sufficient security.

These couplings are made of the twigs of willow, holly, beech, or any other tough shoots of trees, wound in a wreath of about 5 inches diameter.

Nets for Enclosing Sheep.—Nets, made of twine of the requisite strength, form a superior enclosure for sheep; and, to constitute them into a fence, they are supported by stakes driven into the ground.

The *stakes* are best formed of thinnings of ash-trees which have been planted thick together, and grown tall and small, 3 inches in diameter and 4 feet 9 inches long—allowing 9 inches of a hold in the ground, 3 inches between the ground and the bottom of the net, and 3 inches from the top of the net to the top of the stake; or they may be made of larch weedings, 4 inches in diameter and 4 feet 9 inches long; but every kind of wood they are made of should be seasoned with the bark on before being cut into stakes. They are pointed at one end with the axe, and that end should be the lowest one when growing as a tree, as the bark is then in the most natural position for repelling rain.

Setting Sheep-nets.—A net is set in this manner: If the ground is in its usual soft state, the stakes may simply be driven into the ground with the hardwood *mallet*, fig. 70, in the line fixed on for setting the net, at distances of 3 paces asunder. The wood of the apple-tree makes the best mallet, as not being apt to split. Should the soil be thin and the subsoil moderately hard, a hole sufficiently large for a stake may be made in the subsoil with the tramp-pick used in draining; but should it be very hard and a larger hole be required than can be easily formed by the tramp-pick, or should the ground be so dry and hard as to require the use of any instrument at all, the most efficient one for the purpose is the *driver*, fig. 73, formed of a piece of pointed hardwood, strongly shod with iron, with its upper end protected by a strong ferrule of iron to prevent its splitting by the strokes of the mallet. The stakes are driven in until their tops may not be less than 4 feet high, along as many sides of the



Fig. 73.—*Driver for stakes.*

enclosure as are required at the place to form a complete fence.

The net is set in this manner: Being in a bundle, having been rolled up when not required, the spare ends of the top and bottom ropes, after the stake is run through the outer mesh of the net, are tied to the top and bottom of a stake driven close to the fence, and the net is run out loose in hand towards the right as far as it will extend on the side of the stakes next the turnips. On coming back to the second stake from the fence, with your face to the turnips, the bottom rope first gets a turn to the left round the stake, then the top rope a similar turn round the same stake, so as to keep the meshes of the net straight. The bottom rope is then fastened under the shepherd's knot to this stake, 3 inches from the ground, and the top rope with a similar knot near the top of the stake, adjusting the net along and upwards; and so on, with one stake after another, until the whole net is *set up*, care being taken to have the top of the net parallel with the surface of the ground throughout its entire length.

Shepherd's Knot.—The shepherd's knot is made in this way: Let *a*, fig. 74, be the continuation of the rope fastened to the first stake; then, standing on the opposite side of the stake from the net, press the second stake with the left hand towards *a*, and at the same time tighten the turn of the rope round the stake with the right hand by taking

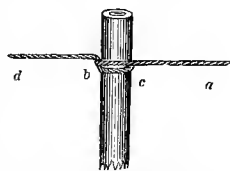


Fig. 74.—*Shepherd's knot, in fastening a net to a stake.*

a hold of the loose end of the rope *d*, and putting it between *a* and the stake at *c*, twist it tight round the stake till it comes to *b*, where it is pulled up under *a*, as seen at *b*, and there its elastic force will secure it tight when the stake is let go. The bottom rope is fastened first, to keep the net at the proper distance from the ground, and then the top rope is fastened to the same stake in the same manner, at the width the net admits, at stake after stake. If both the cord and stake are dry, the knot may slip as soon as made; but the part of the stake at *b* where the

knot is fastened on being wetted, the rope will keep its hold until the cord has acquired the set of the knot. It is difficult to make a new greasy rope retain its hold on a smooth stake even with the assistance of water, but a little earth rubbed on the stake will neutralise the greasy effect. A net may be set up either towards the right or the left as the starting-point may be situate, but in proceeding in either direction the top and bottom ropes should be wound round the stakes, so as the rope shall be uppermost towards the direction in which the net is to be set up. Thus, in fig. 74, the end of the rope *d* is above the rope at *a*, and continues uppermost until it reaches the next stake to the left, when it becomes undermost as *a* is here.

Precautions in Setting Nets.—Some precautions are required in setting a net. If the net is new, it may be set tight, because all the cords will stretch considerably; but if old, the least damp or rain will so tighten them as to cause them to break. If the net is damp, it may be

set tight, because rain cannot make it tighter; and if not then set tight, dry weather will loosen all the knots, and cause the cords to slip down the stakes; and although it be not slackened to that degree, it will shake about with the wind, and bag down and touch the ground. This, however, may be remedied by taking a turn or two of the upper rope over a few of the stakes at regular intervals. In wet weather, shepherds take the opportunity of a dry moment for setting a dry net in anticipation along a new break of turnips, and they also hang up wet nets to dry on the stakes drawn along another break. Nets should never be wound up in a wet state, even for a short time, as they will soon contract mould and rot.

On connecting the setting of one net to another, its top and bottom ropes are fastened to those of the last net, and the ends of the nets themselves are brought together by lacing the meshes of both with a part of the twine left there for the purpose, as at *a*, fig. 75, or by lacing the

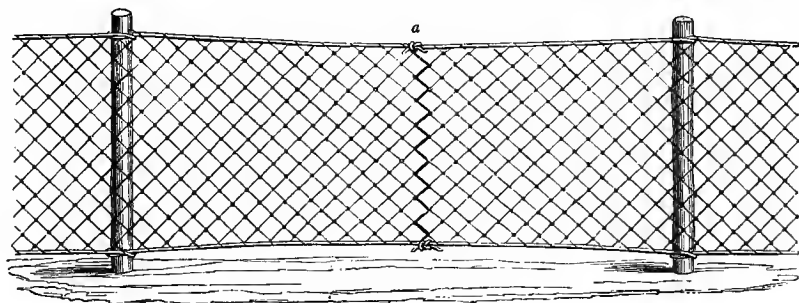


Fig. 75.—Net set for confining sheep.

meshes themselves. The spare end of one of the ropes is also often used for this purpose. One net is set after another, until the whole area is enclosed. Where there is a turn in the line of nets in going from one side of the enclosure to another, if a large piece of the net is still left at the turn, it may be brought down the next side; and the stake at the corner should be driven very securely, to resist the strain upon it by the nets pulling from different directions, and such a strain will be the most powerful in damp weather. But a safer and better plan is to take a fresh net at the turn, set it up by fastening it to

a stake for itself, and coil up the end of the first net along the tops of its own stakes. All surplus ends of nets, when wet, should be hung upon the backs of the stakes to dry. Part of the nets will cross ridges, and part run along them. Where they cross flat ridges, the bottom of the nets will be nearly close to the open furrows. Where they cross high ridges, a stake should be driven at the side of the open furrow, and another at the crown of the ridge, and the bottom rope made parallel to the surface of the ground. Some sheep acquire the habit of creeping under the net where they find an opening.

In setting nets, each side of the enclosure should be in a straight line, the surface of the nets perpendicular, and any two sides should meet at right angles, so that every break of turnips should either be within a rectangle or a square: the strain will thus be equalised over the entire length of the cords and the stakes of each side, no undue pressure being exerted on any one stake. A shepherd who pays attention to these particulars, will preserve the nets and stakes much longer in a serviceable state than one ignorant or careless of them.

The shepherd should be provided with net-twine to mend any holes that may break out in the nets.

Begin on High Ground.—The method in which the nets and hurdles are set has now been made clear. A commencement is generally made on the upper corner of the field. The turnips have been stripped in the proportion, say, of taking eight and leaving four drills, as the greater the space for the first break, the better for the sheep. The first net is set parallel to the drills enclosing four stripes, and this net may be extended to any length, at any time. Another net is set at right angles to the preceding one, cutting off a portion of about 25 yards in length.

Extent of Roots given at a time.—We have, then, an enclosure ready for the reception of from 200 to 250 sheep. Next day about 12 yards is given, and a like amount the following day, after which the sheep will begin to eat the bulbs, and fall back on the partially consumed breaks. Where sheep are fully learned, breaks which will serve a couple of days, or three at most, are given, but this will altogether depend on the weather.

In frosty weather or snow, turnips sufficient for the day only should be given, otherwise the shells will become hard frozen in a very short time, and the sheep are unable to eat them, so that when a fresh sets in these rot. A good plan is to allow the sheep to work on the ground given during the forenoon, and set pickers on in the afternoon, and pick up all the shells for the sheep, no more ground being given than will serve the sheep for the day.

Carting Turnips to Lea Land in

Wet Weather.—When the weather becomes wet, and the sheep cannot comfortably consume the roots upon the black earth, then carts are sent to work, and the turnips, after being tailed, are taken from the field and spread or sparted on old lea or pasture, and the sheep taken from the turnip-breaks until better weather sets in.

Another plan has been adopted by Mr George Brown, Watten Mains, Caithness, with a lot of 700 hogs. After the sheep are properly learned to eat the turnips, they are driven off the break every afternoon at 3 o'clock to a lea field, in which are placed boxes containing a mixture of chaffed hay and light oats. The sheep are left there until next morning, when they are returned to the turnip-break, to come off again at the same time. This plan not only saves turnips, but is also more conducive to the good health and rapid progress of the sheep than the system of keeping the sheep day and night on the turnip-break.

Still another plan—that of pulping turnips for sheep—is pursued by some with great success, and is described on p. 198 by Mr D. Buttar, Corston.

Begin Turnip-feeding Early.—The turnip-break should be made ready for the sheep before the grass fails, so that the feeding sheep may not lose any of the condition they have acquired on grass; for it should be borne in mind that it is easier and better for animals to progress in improvement than to regain lost condition. Much rather leave pastures in a rough state than lose condition in sheep for want of turnips. Rough pasture will never be wasted, but will be serviceable in winter to ewes in lamb and to aged tups. Feeding sheep, therefore, should be put on turnips as early as will maintain the condition they have acquired on grass; and this can be the more certainly attained, that cattle requiring turnips before sheep, the land will be the earlier cleared for the sheep.

Begin cautiously with Turnips.—It is considered advisable to avoid putting sheep on turnips for the first time in the early part of the day when they are hungry. Danger may be apprehended from luxuriant tops at all times, but when they are wetted by rain, snow, or half-melted rime, they are sure to do

harm. The afternoon, when the sheep are full of grass, should be chosen to put them first on turnips; and although they will immediately commence eating the tops, they will not have time to hurt themselves.

Turnips risky for Ewes.—Sheep for turnips are selected for the purpose. Ewes being at this season with young, are seldom, in Scotland, put on turnips in the early part of the winter, but continue to occupy the pastures, part of which should be left on purpose for them in a good state, to support them as long as the ground is free of snow. As the lambing-time approaches, and the pastures begin to get bare, a few turnips are often given daily to in-lamb ewes, generally on a pasture-field, and along with a little hay and cake. But care should be taken never to give frozen roots to in-lamb ewes, as this has often been blamed for causing abortion. Many farmers also avoid giving turnips to in-lamb ewes, in the belief that they are liable to cause inflammation at lambing.

Tups on Turnips.—Aged tups are frequently put on turnips, and young tups always, but not in the same part of the field as the feeding sheep, having a snug corner to themselves, or the turnips led to them in a sheltered part of a grass field.

Draft Ewes on Turnips.—Every year a certain number of old ewes, unfit for further breeding, from want of teeth or a supply of milk, are drafted out of the flock to make room for the same number of young females, and are fattened upon turnips.

Young Sheep on Turnips.—It sometimes happens that the hogs—the castrated male lambs of last year—instead of being sold, have been grazed during the summer, and are fattened the second season on turnips. “The usual plan of feeding turnips out of doors is to give them whole until the hoggets begin to lose their teeth; after that the cutter must be employed. In feeding sheep on turnips, whether hoggets or old sheep, it is important to begin early, say about the middle of September, or at all events before the first of October. Sheep will feed faster netted on the turnip-land than when the turnips are laid on the grass. The turnips may, however, be

given on fresh pasture the first fortnight or three weeks, after which the sheep should be folded. When this is done, it is a great point not to give too large a break at once, but shift the nets or hurdles often.”

Turnip-tops for Sheep.—“Care should be taken, however, not to shift the sheep or give them a fresh break when the turnip-tops are covered with white or hoar frost, as numbers of deaths happen from this cause. In fact, farmers put too much value on turnip-tops; if hoggs, fat sheep, or other feeding animals were never to taste them, they would fatten much faster. If the tops are cut off a day or two before the fold is shifted, and scattered over the ground, they wither before the hoggs get at them, and much loss is avoided.

“A supply of stored turnips should always be at hand to give the sheep in case of hard frost.”¹

Lambs on Turnips.—In this age of precocity, a great proportion of the wether and part of the ewe lambs are fed and sent to the butcher before they are twelve months old. Even with the mountain breeds, such as Blackfaces and Cheviots, this practice is now pursued extensively, and in these cases the lambs are freely fed on turnips.

Mixed Sheep on Turnips.—With the exception of the tups, all these classes of sheep, of different ages, may together occupy the same break of turnips. It is seldom that the lambs of last year are kept on to the second year, but draft ewes are fed along with young sheep, and prove useful in breaking the turnips and eating the picked shells. A mixture of old and young sheep is less useful when turnips are cut by machines.

Nomenclature of Sheep.—In thus speaking of all the classes of sheep, here is a favourable opportunity of recognising those classes by acquiring their technical names in accordance with age and sex. A new-born sheep is a *lamb*, and retains the name until weaned from its mother. The generic name is altered according to the sex and state of the animal: when a female, it is a *ewe-lamb*; when a male, a *tup-lamb*; and this last is changed to *hogg-lamb* after it has undergone castration.

¹ *Farming World*, 1887, 317.

After a lamb has been weaned, until the first fleece is shorn, it is a *hogg*, which is modified according to sex and state, a female being a *ewe-hogg*, a male a *tup-hogg*, and a castrated male a *wether-hogg*. Hogg is said to be derived from the Celtic *og*, young, whence *ogan*, a young man, and *oigie*, a virgin.¹

After the first fleece has been shorn, another change is made in the nomenclature: a *ewe-hogg* then becomes a *gimmer* or *shearling-ewe*, a *tup-hogg* a *shearling-tup*, and the *wether-hogg* a *dinmont*.

After the second shearing another change is effected in all the names: a *gimmer* is then a *ewe*, if *in lamb*; if not in lamb, a *barren gimmer* or *yeld ewe*, and if never put to the ram, a *yeld gimmer*. A *shearling-tup* is then a *2-shear tup*, and a *dinmont* a *wether*, but more correctly a *2-shear wether*.

A *ewe* three times shorn is a *twinter ewe* (two-winter ewe); a *tup*, a *3-shear tup*; and a *wether* still a *wether*, or more correctly a *3-shear wether*.

A *ewe* four times shorn is a *three-winter ewe* or *aged ewe*; a *tup*, an *aged tup*, a name he retains ever after; and the *wether* is now a *wether* properly so called.

A *tup* and *ram* are synonymous terms, applied to entire males.

A *ewe* that has borne a lamb and fails to be with lamb again is a *tup yeld* or *barren ewe*. After a *ewe* has ceased to give milk she is a *yeld ewe*.

A *ewe* when removed from the breeding flock is a *draft ewe*; *gimmers* unfit for breeding from are *draft gimmers*; and lambs, *dinmonts*, or *wethers*, when drafted, are *sheddings*, *tails*, or *drafts*.

In many parts of England a somewhat different nomenclature prevails. Sheep bear the name of *lamb* until 8 months old, after which they are *ewe* and *wether teggs* until once clipped. *Gimmers* are *theaves* or "two tooths" until they bear the first lamb, when they are *ewes* of 4-teeth, next year *ewes* of 6-teeth, and the year after *full-mouthed ewes*. *Dinmonts* are *shear hoggets* until shorn of the fleece, when they are *2-shear wethers*, and ever after are *wethers*.

Dry Food with Turnips.—When sheep are on turnips, they should always

be supplied with dry fodder, hay or straw; that is, where they cannot have a daily run of some rough dry pasture. Clover-hay is the best and most nutritious, but fresh oat-straw answers the purpose very well. The best way of supplying dry food is to chaff the hay or straw and place it in the boxes which are required for the cut turnips later in the season. About $\frac{1}{4}$ lb. oats per sheep per day, mixed along with the chaff, gives excellent results; many of the sheep will be ready for the butcher without further feeding. The fodder may also be given in racks, which are of various forms: some are so elevated that sheep can with difficulty

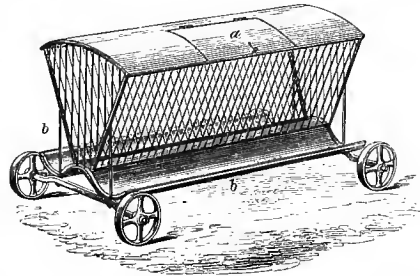


Fig. 76.—Kirkwood's wire sheep-fodder rack.

Rack of wirework 6 feet long, 2 feet 9 inches wide at top, 8 inches wide at bottom, and 2 feet $3\frac{1}{2}$ inches deep.

a Curved cover of sheet-iron with a hatch.

b b Sheet-iron troughs to contain corn, &c.

reach the fodder; and others are mounted on too high wheels. An elegant, strong, and useful fodder-rack for sheep, fit for grass or tares in summer, or turnips in winter, is shown in fig. 76. It was invented by Mr Kirkwood of Tranent. The troughs are provided with a hole at each end to allow the rain to drain off, and might be used in dry weather for holding salt or oilcake for the day. The rack is mounted on axles and 4 wheels, to be moved anywhere.

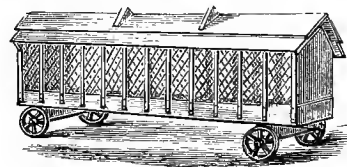


Fig. 77.—Elder's sheep-fodder rack.

Another very useful rack, made by Mr W. Elder, Berwick-on-Tweed, is shown

¹ Notes and Quer., 1st ser., ii. 461.

in fig. 77. It is made chiefly of wood and wire, and is useful also as affording shelter.

Substitutes for Racks.—Another plan often adopted by farmers is to hang a net on a double row of stakes, the middle of the net forming a receptacle for the hay. Wire-netting with mesh of about $1\frac{3}{4}$ inch, hung on stakes, has also been found a very cheap and durable means of giving hay to sheep.

Supplying Fodder.—Two racks or more are required, according to the number of sheep. It is the shepherd's duty to fill them with fodder, and is easily done by carrying a small bundle of fodder every time he visits the sheep. When carts are removing turnips from the field, carry out the bundles, the shepherd having prepared them in the straw-barn or hay-house. Though only for

shelter, the racks should be kept full of fodder. Fodder is consumed more at one time than another; in keen sharp weather the sheep eat it greedily, and when turnips are frozen they have recourse to it. In rainy or soft muggy weather it is eaten with little relish; but it has been observed that sheep eat it steadily and late, and seek shelter near the racks, prior to a storm; while in fine weather they select a lair in the open part of the break.

A combined rack and trough, specially designed to prevent waste in fodder, has been patented by Mr James A. Gordon of Arabella. It is brought out in various forms for holding cake and grain as well as fodder, and is sometimes made so that by its being turned upside down, the food is protected from damage by snow or rain. Fig. 78 shows Mr Gor-

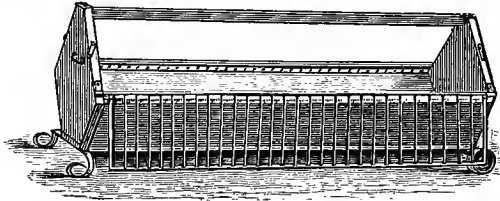


Fig. 78.—Gordon's "Economiser."

don's "economiser," as applied to an ordinary wooden trough. The trough, or box, is 12 feet long, 9 inches broad at bottom and 11 inches at top, and 9 inches deep. The ends are made of wood $1\frac{1}{4}$ inch thick, the sides and bottom being $\frac{3}{4}$ inch, the top rail $1\frac{1}{2}$ inch by $2\frac{1}{2}$. The cut turnips, as well as cake, grain, or hay or straw, may in turn be given in this combined rack and trough.

Fig. 79 is a simple and convenient form of trough for oats or other feeding-



Fig. 79.—Trough for turnip sheep-feeding.

stuffs. A convenient length is 8 feet, its form acute at the bottom.

Picking out Turnips-shells.—Until of late years, sheep helped themselves to turnips, and when the bulbs were scooped out to the ground, their *shells*

were raised with a *picker*, the mode of using which is seen in fig. 80. By this mode of action, the tap-root of the turnip is cut through and the shell separated

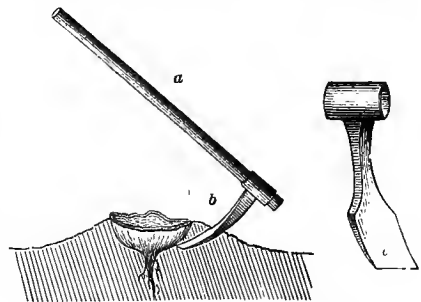


Fig. 80.—Best form of turnip-picker.

a Handle 4 feet long.

b Blade 10 inches long, including eye for handle.

c Breadth of blade 2 inches.

from the ground at one stroke. The tap-root contains an acrid juice detrimental to the stomach of sheep, and should be left in the ground.

Only half the ground occupied by shells should be picked up at once, so that the sheep may take up a larger space of ground while consuming them. When the ground is dry, the shells should, on the score of economy, be nearly eaten up before a new break of turnips is given; and if any shells are left, the sheep will come over the ground again and eat them.

Cutting Turnips for Sheep.—The feeding of sheep on uncut turnips can be satisfactorily carried out until their teeth becomes defective: this occurs from the constant eating of hard roots, often in a semi-frozen state, which loosens the front teeth. The farmer can readily judge when other measures become necessary by the appearance of the bulbs, which have their outer skin peeled off by the sheep, and so left.

To meet this difficulty, the turnip-cutter comes into requisition. A most efficient machine is Samuelson's improved Gardner's cylinder turnip-cutter, fig. 81,

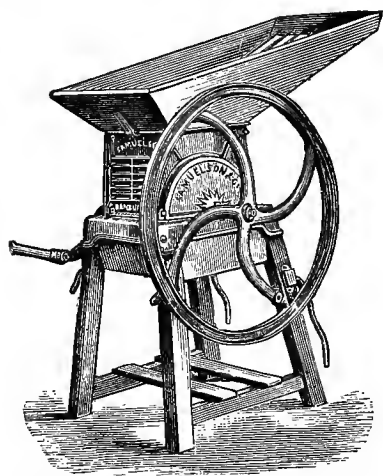


Fig. 81.—Samuelson's Gardner's cylindrical turnip-cutter.

which cuts the turnips into finger-pieces. In this form they are readily eaten by the sheep. The plan adopted, if the turnips are to be eaten on the land where grown, is to cast them into heaps alongside the net, a sufficient quantity for one or two days in each heap. The turnip-cutter is sometimes fitted up with boards, which enclose the framing be-

neath on three sides and bottom, the open side being opposite the driving-wheel; and a box $4\frac{1}{2}$ feet long, $2\frac{1}{2}$ feet deep, and of sufficient breadth to fit the open side of the cutter, is provided, and put on to catch the cut turnips. This arrangement prevents the cut turnips falling to the ground, and allows the work to be done in a satisfactory manner. The cut turnips are then given to the sheep in the troughs or boxes (fig. 82), 7 boxes being sufficient for 100 sheep.

The heaps being laid down at intervals allows the troughs or boxes to be changed to fresh ground daily, so that the land is equally manured all over the field. One worker can in this manner feed 300 sheep.

Feeding Cut Turnips on Lea.—In very wet weather, or late in the season, the sheep may require to be changed to lea or pasture, when the same plan can be adopted, or the sheep allowed their liberty over the whole field. In such a case the boxes or troughs are placed in line along the top of the ridge at one side of the field, and daily changed from ridge to ridge across the field until the other side is reached.

Force required.—All that is requisite to feed 500 to 1000 sheep is pony-gearing to drive the cutter, and a small cart with scoop to carry the cut turnips. The boy or man first attaches the pony to the arm of the driving-gearing, cuts the boxful of turnips, then yokes the pony in the cart and loads up, going from box to box down the ridge. The scoop takes sufficient turnips from the cart at each turn to make expeditious work.

A good method of placing the boxes is described on p. 199 by Mr D. Buttar.

Ploughing Land manured by Sheep.—A large field, that contains sheep for a considerable part of the season, is ploughed as each stretch of breaks is cleared, to preserve the manure. In ploughing, however, with this intent, the sheep should not be deprived of any natural shelter, which should be secured to them as long as practicable, by arranging the breaks so as to make the first at the most sheltered part of the field, that the sheep might resort to the bottom of the break they are occupying, after the first breadth of breaks had been given up and ploughed from the bottom

to the top of the field. Such an arrangement requires some consideration at first, as its oversight may create much inconvenience to sheep in want of shelter, or delay in ploughing. Shelter to sheep on turnips does not merely imply protection from a blast for a night or two, but also preservation of the fleece, and comfort to the flock through the winter.

The Cutter Cart.—The old-fashioned method of cutting turnips by means of

the lever slicer has now been superseded by the cutter cart, or cylinder cutter. The cutter cart is preferable for a small lot of ewes or tup hogs. This implement may be briefly described as follows: A cart 7 feet long by $3\frac{1}{2}$ feet broad, and 18 inches deep, is provided; $1\frac{1}{2}$ foot of the hind part of the cart is boarded off from the main portion. In this division is a slip-door leading into a miniature cutter or slicer head, which is fitted up in the

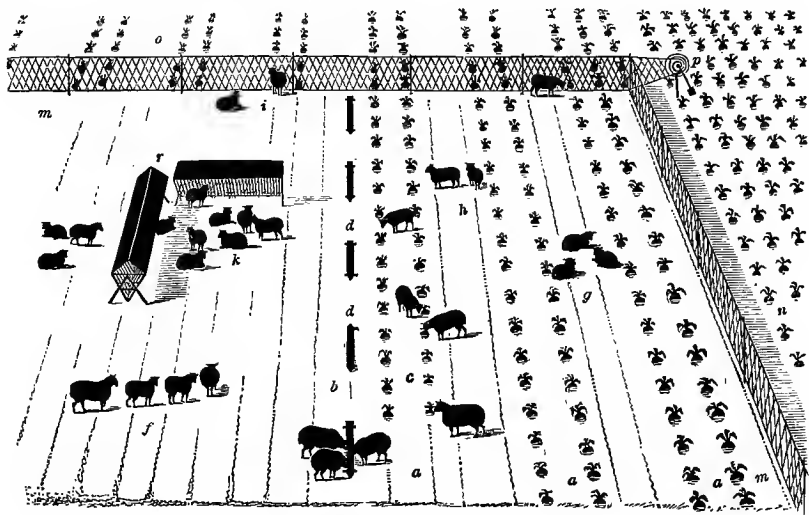


Fig. 82.—Mode of occupying turnips with feeding sheep.

portion cut off behind. Under this head is placed an ordinary cutter barrel, with tooth gearing and clutch. The power is taken from the wheel of the cart by means of a chain which revolves upon a couple of pulleys attached to the nave and axle of barrel respectively. A lever being connected with the clutch, the machine can readily be thrown in or out of gearing. The slip-door being shut, the fore part of the cart is loaded up with turnips, and the cart taken to the field where the sheep are being fed. The machine is then thrown into gearing, the slip-door drawn, and the horse started down the centre of the ridge. The finger-pieces fall regularly to the ground, and the sheep eat them cleanly and thrive well.

This plan has been pursued for years with very satisfactory results by Mr George Brown, Watten, Caithness, in

feeding a flock of 50 Border Leicester rams.

Cake or Corn for Sheep on Turnips.—Sheep while on turnips may receive either oilcake or corn, or a mixture of both. These concentrated foods are best served in a covered trough, to protect them from the weather. Mr James A. Gordon's patent combined rack and trough is shown in fig. 83, as it is used for holding cake or corn for sheep.

In fig. 84 is represented a very useful combined feeding-trough and corn-bin made by E. Thomas & Co., Oswestry. A supply of corn may be locked into the corn-bin and withdrawn and placed in the trough by the shepherd as desired.

Oilcake or corn, or both, may be served in these troughs to sheep on grass in winter as their entire food. Oilcake renders the dung of sheep moist. It is given them in a bruised

form, partly in powder and partly in pieces, as it falls from the oilcake-breaker. There is no use measuring the quantity of oilcake to sheep when on turnips, as they will eat it when

inclined, and some sheep eat it more heartily than others, but 1 lb. to each sheep a-day is the usual allowance, as is also of corn.

Oats and Hay for Hogs.—Refer-

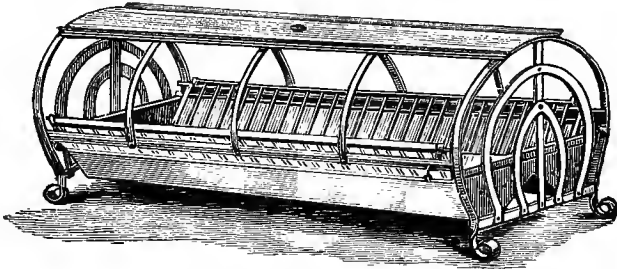


Fig. 83.—Gordon's combined rack and trough.

ring to the wintering of hogs, a writer in the *Farming World* says: "Some prefer to put them wholly on turnips. My plan is to give them not more than two or three hours daily on the turnips,

giving them the remainder of the time the run of a dry pasture-field, where they get $\frac{1}{2}$ lb. of oats per head daily, and a handful of hay when the weather is hard. After the New Year the turnips



Fig. 84.—Combined trough and corn-bin.

must be cut for them; so from that date any turnips that are going are given in boxes on the pasture."

Some useful information was brought out by the following query in the same journal from an East Lothian farmer:

"I have still a lot of hoggets to finish off, and have no roots and no hay to spare for them, but plenty of oats and oat-straw. How shall I feed them?" One correspondent advised him to "chop fine the oat-straw and mix with rolled

or ground oats, and say $\frac{1}{2}$ lb. best oilcake per day for each sheep. Add a little salt to the mixture, or have some rock-salt convenient to the feeding-troughs, and plenty of pure water." A little bran would improve this mixture. Another said: "East Lothian had better take turnips for his hogs in his own neighbourhood; for oat-straw and oats would be very unsuitable food for them without turnips, or their equivalent in green soft food."¹

Ensilage for Tup Hogs.—Mr W. Oliver, Howpasley, Hawick, says: "My tup hogs were wintered on silage instead of roots, with the same quantity of Indian corn as they usually get, $\frac{1}{2}$ lb. each per day. They did as well as on turnips, and certainly they never came out better as regards both health and condition; they preferred the silage to turnips."

Cake-breaker.—In fig. 85 is a representation of a first-class oilcake-

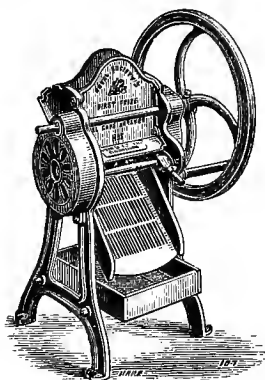


Fig. 85.—Oilcake-breaker.

breaker made by Barford & Perkins, Peterborough. The oilcake is put into the hopper, the mouth of which is open upwards. The two rollers bruise it to any degree of smallness, by means of pinching-screws. The bruised cake falls down the spout into any vessel below.

Salt for Sheep.—Salt is frequently given to sheep on turnips, and conveniently in a covered box, or in fig. 83, in the form of rock. The eagerness with which sheep at first follow the

shepherd when he lays down a small quantity, here and there, upon flat stones, and the relish they manifest, are very remarkable; but the relish lasts a very short time, and by-and-by they will be found to eat very little of it. Sheep should have access to water when using salt. Perhaps the cultivator who advocated the use of salt to animals most perseveringly was Mr Curwen, of Workington Hall, Cumberland, who gave from 2 to 4 ounces per week to each sheep when on dry pastures, and on turnips or rape it was supplied without stint. Salt is said to prevent rot in sheep, and some have even gone the length of averring that it will cure rot, which is certainly erroneous.

Removing Sheep from Turnip Land in Heavy Rains.—There are certain inconveniences attending sheep on turnips *in winter*. A heavy rain falling for days will render the ground soft and poachy, though thorough-drained, or even naturally dry. Until the rain disappears, the removal of the sheep for a day or two to an old grass field where turnips can be carted to them will give the land sufficient time to resume its firmness.

A heavy rain may fall in a day, and inundate the lower end of the field with water, which may take some days to subside. The best way of keeping the sheep from any wet part of a field is to fence it off with a net.

Sheep on Turnips during Snow.—A fall of snow, driven by the wind, may cover the sheltered part of the field, and leave the turnips bare only in the most exposed places. In this case the sheep must feed in the exposed parts, and the racks should be so placed there as to afford shelter.

But the snow may fall heavily, and lie deep over the whole field, and cover every turnip out of reach. Two expedients only present themselves in such a case; one is to cast the snow from the drills containing the turnips, and pile it upon those which have been stripped. This cannot be done by the shepherd himself, or by female field-workers. The ploughmen must clear away the snow; and in doing so in severe frost, as many turnips only should be exposed as will serve the sheep for the day. When the

¹ *Farming World*, 1888.

snow does not lie to a great depth on the ground, the simpler plan is for the workers to start along the rows with ordinary pickers, and pull out a sufficiency of roots for the day. This plan is frequently adopted to provide turnips for both cattle and sheep.

The best plan to pursue at first, when a heavy snowfall takes place, is the other expedient,—to give the sheep oilcake and hay in their troughs and racks, in a sheltered place of the field for a time, until it is seen whether the snow is likely soon to disappear; and should it remain long, the snow may be cleared away, and its disadvantages submitted to. Yet it should always be borne in mind that sudden changes in food are undesirable for all kinds of stock, and have therefore to be avoided as much as possible.

Unripe Turnips dangerous.—In the winter of 1887 great mortality occurred in Perthshire, Dumfriesshire, and other parts of Scotland, amongst young sheep and ewes being fed on turnips. The death-rate in several cases was as high as 25 per cent, in one or two cases still higher. A form of “braxy” was generally believed to be the fatal ailment, and there seemed to be good reason to suspect that the cause of the disease was too exclusive feeding upon unripe unusually watery turnips. A *post-mortem* examination of some of the sheep which thus died, showed that their kidneys had been completely over-taxed in endeavouring to discharge the excessive amount of water consumed in the ill-balanced unripe food.

Commenting upon these fatalities, the *Farming World* (Dec. 16, 1887, p. 437) says: “It is more than likely that the unripe condition of the turnips is the primary cause of the present mischief; but any ill effects from unripe roots, it is well to know, may be completely counteracted by pulling the roots two or three days before the sheep are allowed to feed upon them. The present experience recalls the old saying that ‘a good turnip year is never a good sheep year.’

“The fact is, that the Scotch method of turnip-feeding sheep is faulty to a degree and wasteful in the extreme. Were all the turnips pulled and cut before feeding them, one-half the present acreage grown would suffice, and as many

animals would be fed, while they would thrive better.”

Avoid sudden Changes in Feeding.—Writing in the *Farming World* as to the injurious influence of sudden changes in methods of feeding sheep, an experienced sheep-farmer says: “The plan which I would recommend, and have practised with great success, is to make inquiry when the sheep are bought as to their previous bill of fare, and feed accordingly. For instance, if the sheep had been on a good pasture, and getting just a bite of hand-feeding in the form of cake, I should not hesitate to commence cake-feeding at once, with a small allowance, of course. On the other hand, if the sheep came off a bleak exposed pasture, and had never been hand-fed, it would be madness to start them on cake. Better, far better, wait a little till they become acclimatised and accustomed to the place and richer pasture. Then commence with good hay, and after a bit give a small allowance of cake and corn when on the turnip-break.

“If the feed is gradually increased in this way, the sheep will be healthier and pay better than if the excessive forcing process were pursued. I have known hogs bought off a poor place, and when brought home immediately given cake, and within a week were getting above 1 lb. per day. Small wonder, I say, that many died, and were lost altogether, because in a case of this kind the dead ones are usually found cold in the morning. That flock did not pay. A very few deaths take all the profit out of a lot of sheep nowadays. Yet feeding sheep does pay if properly done.

“I have been writing more especially of young half and three-quarter bred hogs, but my remarks apply with equal if not more force to blackfaced stock. ‘Hasten slowly,’ and ‘More hurry the less speed,’ are very good mottoes to keep in mind.”¹

Fattening Wethers.—Mr S. Robinson, Lynhales, Hereford, states that the wethers which he fattens for slaughter are treated as follows: “They are weaned the last week in June, when they are put on a fresh pasture, and are drawn in two lots. They are allowed $\frac{1}{4}$

¹ *Farming World*, 1887.

lb. of linseed-cake, mixed with a few uncrushed oats and cut hay. In November they are put on common turnips, and the allowance then is $\frac{1}{4}$ lb. of linseed-cake, $\frac{1}{4}$ lb. decorticated cotton-cake, and a pint of crushed oats per sheep. This allowance is continued until after Christmas, when the sheep are put on to swedes, when $\frac{1}{2}$ pint of peas is added to the above."¹

Feeding Ewes in Lamb in Winter.

—Whilst young sheep and tups are provided with turnips in winter, the *ewes in lamb* find food on the older grass, which, for their sakes, should not be eaten too bare in autumn. When pastures are bare, or snow covers the ground, they should have cut turnips in troughs, or, what is better, clover-hay in a sheltered spot. The best hay for sheep is the red clover, and next, meadow-hay; but much rather give them turnips than hay in a wet or moulded state, as such hay has an injurious influence on the health of the sheep; and as regards ewes in lamb, in particular, it is apt to produce abortion.

If turnips cannot be had, and the hay bad, give them sheaves of oats, or oats in troughs, or oilcake; but whatever extraneous food is given, do not supply it in such quantity as to fatten the ewes, but only to keep them in fair condition.

Ration for Breeding Ewes.—"A daily ration for each ewe of 1 lb. bran and $\frac{3}{4}$ lb. crushed oats, mixed with $2\frac{1}{2}$ lb. of straw-chaff, has been found very useful in the case of a large flock when given from the 1st of January, where no roots, &c., could be given. Pulped roots mixed with straw-chaff also make a very good feed for ewes, where straw has to be substituted for hay."²

As to substitutes for hay and roots, in wintering ewes, Professor Wrightson says: "Rough cotton-cake given at the rate of about $\frac{1}{2}$ to 1 lb. per head, according to the state of the weather, together with oat-straw or pea-haulm, would answer very well. It costs very little over $\frac{1}{2}$ d. per lb., and would cost from 2d. to 4d. per week. I find a good many farmers now rely a good deal upon pea-chaff, or the outer husk of peas. Also

malt-combs mixed with chopped straw is a good substitute for hay, say $\frac{1}{4}$ to $\frac{1}{2}$ lb. each per day, well turned over, and mixed with the chopped straw. There must be some bulky material, such as straw, together with a concentrated food, to keep sheep healthy."

Blackfaced Sheep in Winter.—"It is always safe policy in stormy weather to supplement the natural food with hay. Blackfaces being naturally very hardy, they require less artificial feeding in winter than almost any other breed of mountain-sheep; yet in excessively severe winters the prudent manager does not leave his sheep to forage for themselves until it is too late to help them. So long as the snow does not get too deep, or is not frozen hard, they take little harm. Blackfaced sheep are excellent workers in the snow, and will toil bravely for a sustenance under the most trying circumstances. Hand-feeding is only resorted to when it cannot be longer avoided; and in that case the sheep are either removed to a lower district or fed on hay at home."³

Hay-silage and Corn for Hill Sheep.—"Hay is still considered the best of winter foods for hill sheep; but silage is likely to take its place very largely in the damp regions of the Western Highlands, where hay-making is frequently seriously interrupted by wet or misty weather. Corn is only fed to blackfaced sheep in winter, when hay would be ineffectual in maintaining ewes in a condition fit to rear their lambs. Those so treated, however, are usually drafted the following autumn."⁴

When to begin Hand-feeding.—The proper time to begin the hand-feeding of hill sheep in a storm is a point of vital importance, and not easy to determine. "When to commence to feed, is a question that has created more discussion, more disagreement, and more loss of sheep than any other in the whole range of the subject of wintering sheep. . . . When the sheep once acquire a taste for hay or other food, they never settle afterwards so well to their natural fare; and even in fresh weather they continue to languish for food they don't re-

¹ *Live Stock Jour.*, 1886, p. 549.

² *Farming World*, 1887.

³ *Blackfaced Sheep*, by J. and C. Scott, 109.

⁴ *Ibid.*

quire, and which it will not pay to allow them. Rather than disturb their equanimity in this way, it is maintained, and rightly, by many good stockmen, that it is better for the sheep not to commence feeding them until it can be no longer avoided. Where the evil arises, however, is in putting off the inevitable for too long. The point which the stockowner has to decide is whether the loss of condition [in the sheep], or the harm done by feeding in the event of a storm of short duration, is the greater evil. When the storm ultimately proves to be protracted, and lasts for perhaps a month or six weeks, then the earlier the feeding is commenced the better; but on the other hand, when a thaw shortly ensues, much damage may be the result. To rightly decide what to do, is not at all times an easy matter. . . . There is one rule, however, which may be given as nearly correct as it is possible to make it under the circumstances, and it is this: when feeding becomes necessary, it should be begun early, and not discontinued until there is plenty of grass."¹

Dangers of putting Sheep in a Wood in a Snowstorm.—During a severe snowstorm we put ewes into an old Scots-fir plantation, into which only a small quantity of snow had penetrated, and supplied them there with hay upon the snow round the roots of the trees. A precaution is requisite in using a Scots-fir plantation in snow for sheep: its evergreen branches intercepting the snow are apt to be broken by its weight, and fall upon the sheep and kill them; and in this case, a ewe was killed on the spot by this cause the first night. Heavily loaded branches should therefore be cleared partly of their snow where the sheep are to lodge.

In driving ewes heavy with lamb through deep snow to a place of shelter, ample time should be given them to wade through it, in case they overreach themselves and bring on abortion.

Rape for Sheep.—In the south of Scotland, and more generally in England, rape is grown for sheep. The rape (*Brassica rapa oleifera* of De Candolle) culti-

vated in this country is distinguished from the colsat of the Continent by the smoothness of its leaves. It has been cultivated for feeding sheep in winter from time immemorial. The green leaves, as food for sheep, are scarcely surpassed by any other vegetable, in so far as respects their nutritious properties; but as a crop it cannot cope with turnips or cabbages. Its haulm may be used as hay as readily as cut straw.² The consumption of rape by sheep is conducted by breaks in exactly the same manner as that of turnips; but rape is never stripped or pulled, the entire crop being consumed on the ground.

In England, the rape intended for sheep is sown broadcast and very thick, in which state it grows very suitable for them. In Scotland, it is often raised in drills like turnips; and although not so conveniently placed for sheep as the broadcast, the top leaves being somewhat beyond their reach from the bottom of the drill, yet the drills permit the land being well cleaned in summer, which renders the rape an ameliorating crop for the land. It is acknowledged on all hands that, for oil, the drill form of culture is far the best.

Standing and Floating Flocks.—Every kind of sheep kept in the low country should be treated in winter in the way described above, though the remarks are meant to apply chiefly where a *standing flock* is kept. But on Lowland farms, in certain districts, no flock of ewes is kept for breeding, and sheep to be fattened on turnips are bought in, and are thus known as *floating* or *flying* flocks. For this purpose some farmers purchase wethers, others old ewes, dinmonts, or lambs. Sheep are thus easily obtained for turnips at fairs in autumn; but where certain mountain stocks have acquired a good name, purchasers go to the spot and buy them direct from the breeders.

Shelter for Sheep on Turnips.—Sheep on turnips have little shelter but what the fences of the field afford, or plantations. In some cases this is quite sufficient, but in others it is inadequate. Of late years the subject of shelter has attracted much attention, and artificial

¹ *Blackfaced Sheep*, by J. and C. Scott, p. 109.

² Don's *Dict. Bot.*, i. 245.

means have been suggested, consisting of various devices, involving different degrees of cost, to afford shelter not merely against sudden outbreaks of weather, but with the view of gradually improving the condition of sheep, both in carcass and wool. It is a natural expectation that a fat carcass should produce the most wool, and constant shelter preserve its quality.

An excellent temporary shelter for sheep on turnips may be made by the erection of a double line of hurdles or nets, the space between the lines being filled up with straw. A curve or angle can be introduced, and thus shelter can be provided for every quarter from which storms may come.

Ewes in lamb are very apt to catch cold, and when exposed to wet and cold weather, or kept in a wet lair, are liable to abort.

Littering the Turnip-break for Sheep.—Mr Hunter of Tynefield, in East Lothian, tried littering of the break occupied by sheep with straw, and supplied them with turnips upon it. He littered 300 sheep upon 17 acres of turnips with wheat-straw, at 26 cwt. per acre. The sheep thus treated for 5 months fetched 2s. a-head more than those treated in the usual manner. This increase of price is small, and not commensurate to the trouble of carting, at intervals, 22 tons of straw to the field—of carting the same, as manure, from that field to another.

When turnips are laid upon straw, sheep cannot bite them easily, from their rolling away; and this is an objection to laying whole turnips on grass, instead of cutting them with a turnip-cutter. Amongst damp litter sheep invariably contract foot-rot; and of Mr Hunter's flock many became lame, and some died.¹

Feeding Sheep in Sheds.—In former times the feeding of sheep in sheds was strongly commended by a few who had experimented upon it with satisfactory results. Others, however, were less successful, and while it may be useful for small flocks, it is not likely to come into extensive practice where large flocks are kept. Shed-feeding has been tried by one or

two enthusiasts in modern times, but has rarely been successful, as if attempted for any lengthened period, the sheep were almost invariably foundered, or attacked with foot-rot. The practice, if it could be called such, has indeed been entirely discontinued.

There can be no doubt that the better plan to adopt with our domestic animals, especially sheep, is to keep them as nearly as possible in their natural condition. The only improvement which can safely be introduced is to increase their comfort, but not at the expense of exercise, fresh air, and the health-giving influences of temperature; otherwise we must weaken the constitution, deteriorate the quality of the mutton, and diminish growth.

In the most northern county of Scotland, which has been famed for its breed of sheep, shed-feeding, when thoroughly tried, proved an utter failure, and is now never attempted, except where Leicester rams are early clipped, and even then it has been modified, as the rams have the run of a field during the day.

Feeding sheep in boxes, and tied up in stalls like cattle, has also been tried by enthusiasts, but neither system can be said to come within the range of practical stock-rearing.

"Shed and Yard" Feeding.—A much better method than attempting to feed in sheds is what is known as "shed and yard" feeding. In reference to this system the *Farming World* (October 28, 1887, p. 317) says: "Shed or yard feeding is now much practised, and with considerable advantage when extra feeding is to be given; for a sheep put up to fatten does not require exercise any more than a steer or a pig; but the system requires a great deal of attention. For the accommodation of 100 sheep, a shed 60 feet long and 8 feet wide, with a yard at least twice that size, must be provided. The yard and sheds should be divided by a railing 4 feet high, into five compartments, so as to separate the sheep into lots of twenty. Troughs for turnips should be placed in the yards, and boxes and racks for corn, cake, and hay should be fitted up around the inside of the sheds, and the floors of the sheds should be kept well

¹ Sinclair's *Husb. Scot.*, ii. App., 47.

bedded with dry peat-litter or cut straw.

"A flock of 100 feeding sheep in the yard will nearly occupy a lad's whole time, as the turnips must be all cut and carried to the troughs. The sheep should only get as many turnips as they will eat up clean, and no more. As soon as they have done feeding, the troughs should be swept out and kept fresh for the next feeding-time. The food should always be given at stated hours. The allowance of grain or oilcake may vary from $\frac{3}{4}$ to $1\frac{1}{2}$ lb. per head per day—half the quantity to be given in the morning; and while they are eating it, the keeper should be filling the troughs with cut turnips, and during the time they are eating these, he should clean out the sheds. When the turnips are eaten the troughs should be cleaned and a little hay put into the racks, after which the yard should be immediately shut up, and the animals left in quietness till next feeding-time, which should be about twelve o'clock. The second allowance of cake or corn should now be given, and turnips to follow—adopting the

same process as in the morning. They should be again fed at four o'clock with turnips, and a little good hay given them in the racks; after this last meal of turnips, the yard should be closed for the night. Each yard should have a close-boarded door, in order that the sheep may not at any time be disturbed from the outside; in fact, no person should be allowed to go near them, except the keeper and master. The keeper on no account to have a dog. Quiet and rest are the two grand requisites in yard-feeding, with regularity and cleanliness."

Shed for Sheep.—A very good shed for sheep can be made with a tight roof, and west, north, and east parts covered up tight, leaving the south side open. Let the roof slope to the north and extend far enough over the sides, so that a good gutter will carry off the water. If the dirt taken out of the gutter is banked up against the side, it will assist in keeping it dry. Having a dry place to stand is fully as important as a good roof, and in planning the sheep-yard take some pains to build the shed where good drainage can be readily se-

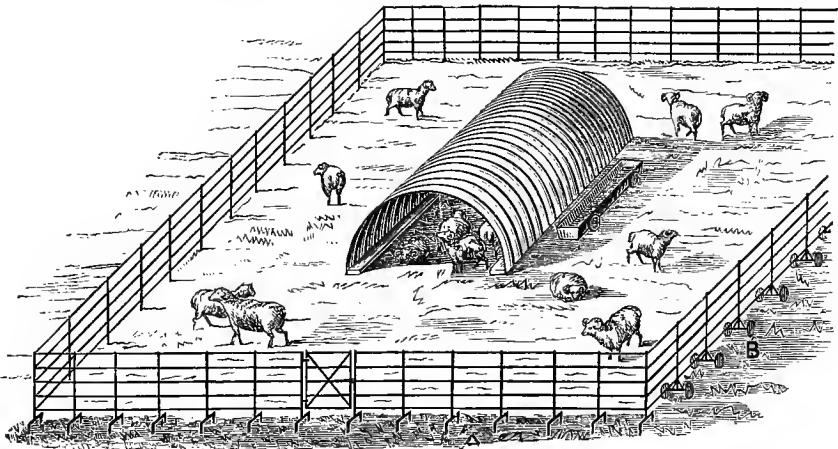


Fig. 86.—*Sheep-yard and shelter.*

cured. Fig. 86 represents a very useful form of yard and shed for sheep, made by T. Pearson & Co., Midland Iron Works, Wolverhampton. The important feature here is the simple, durable, and efficient form of the "shed," which is constructed of galvanised iron, corru-

gated and covered, and resting upon a wooden bearer. In exposed situations, a close fence for the yard would be preferable.

White Turnips v. Swedes for Sheep.

—Some curious and interesting results were brought out by experiments made

by Mr Pawlett in feeding sheep on *different kinds of turnips*, and in *washing* these. A lot of lambs were put on white turnips in October, and another lot on swedes, and in the course of the month the lot on white turnips had gained each $10\frac{3}{4}$ lb., while that on swedes only gained $4\frac{3}{4}$ lb. each, showing a gain of 6 lb. in the month. Other experiments for the same purpose produced similar results. "Since these experiments," observes Mr Pawlett, "I have invariably used white turnips for lambs in the autumn, and find they are excellent food if not sown too early in the season, and are not too old at the time, and preferable to swedes during the months of September and October, equal to them in November or until the latter part of that month, and very inferior to them in December, or when the weather becomes cold and frosty. Lambs are not naturally fond of white turnips, and will take to swedes much sooner."

A turnip-cutter will bring sheep to like any turnip sooner than any other expedient.

Washing Roots for Sheep.—"Being aware," writes Mr Pawlett, "that it was the custom of some sheep-breeders to *wash* the food—such as turnips, carrots, and other roots—for their sheep, I was induced also to try the system; and as I usually act cautiously in adopting any new scheme, generally bringing it down to the true standard of experience, I selected for the trial two lots of lambs. One lot was fed, in the usual manner, on carrots and swedes *unwashed*; the other lot was fed exactly on the same kinds of food, but the carrots and swedes were *washed* very clean every day: they were weighed before trial, on the 2d December, and again on the 30th December, 1835. The lambs fed with the unwashed food gained each $7\frac{1}{2}$ lb., and those on the washed gained $4\frac{3}{4}$ lb. each; which shows that those lambs which were fed in the usual way, without having their food washed, gained the most weight in a month by $2\frac{3}{4}$ lb. each lamb. There appears to me no advantage in this method of management—indeed animals are fond of licking the earth, particularly if fresh turned up; and a little of it taken into the stomach with the food must be conducive to their health, or

nature would not lead them to take it."¹ The earth would act as an alkaline tonic.

Linseed-cake for Sheep.—To test the value of *linseed-cake* as food for sheep, Mr James Bruce, Waughton, East Lothian, took two lots of sheep of 60 each from two flocks. A part of two fields of swedes, which had a uniform soil and crop, was carefully divided into equal portions, each of which was occupied by 20 sheep.

One lot of 60 consisted of half-bred dinmonds of good quality, 20 of which *a* were put on turnips alone, 20 *b* on home cake, and 20 *c* on foreign cake. On the 1st January *a* weighed 2803 lb., *b* 2768 lb., and *c* 2739 lb. On the 7th February, *a* having consumed its portion of turnips, was reweighed, and found to be 2880 lb.; on the 1st of March, having also consumed theirs, *b* weighed 3054 lb., and *c* 2966 lb. The quantity of cake consumed by each division was 1182 lb., being nearly 16 oz. each day per sheep.

The other lot of 60 consisted of Cheviot dinmonds of inferior quality, 20 of which *d* were put on turnips alone, 20 *e* on home cake, and 20 *f* on foreign cake. On the 9th January, the weight of *d* was 2031 lb., of *e* 2082 lb., and of *f* 2001 lb. On the 15th of February, *d*, having finished their turnips, were reweighed and gave 2097 lb.; and on the 2d of March, having also finished theirs, *e* weighed 2315 lb., and *f* 2274 lb.; *e* and *f* on the cake consuming the same quantity of turnips. The management of this lot was exactly similar to that of the other, described above; but the sheep would take no more than 13 oz. each of cake each day.

The results of both these experiments are given in the following table:—

Lots of Sheep.	Live weight at first.	Live weight at last.	Incr.	Incr. from cake.	Cake eaten.	Of cake to produce 1 lb. mutton.
	lb.	lb.	lb.	lb.	lb.	lb. oz.
60 {	20 <i>a</i> 2803	2880	77	..	..	.. ..
	20 <i>b</i> 2768	3054	286	209	1182	5 3
	20 <i>c</i> 2739	2966	227	150	1182	7 14
60 {	20 <i>d</i> 2031	2097	66	..	..	.. ..
	20 <i>e</i> 2082	2315	233	167	880	5 4
	20 <i>f</i> 2001	2274	273	207	880	4 4

The remarks which the perusal of this table suggests are—that as regards in-

¹ *Jour. Royal Agric. Soc. Eng.*, vi. 368-370.

crease of live weight, the offal of sheep remaining comparatively the same, whatever weight is gained is of intrinsic value; that the improvement on turnips alone is below the average; that the improvement experienced by *b* and *e* on the home cake, in the one field, was reversed by *c* and *f* on the foreign in the other field—a circumstance quite unaccountable. The average quantity of cake to produce 1 lb. of mutton was 5 lb. 10 oz.

Linseed, Beans, and Turnips for Sheep.—In another experiment, Mr

Bruce put 15 sheep *a* upon linseed, 20 *b* upon linseed-cake, 20 *c* upon a mixture of beans and linseed for three weeks, and afterwards upon poppy-cake, 20 *d* upon beans, and 20 *e* upon a mixture of beans and linseed. The results will be understood by the contents of the next table. An explanation is given for the use of beans with linseed to the sheep in *a*; the linseed, lying in a ground state, had acquired a musty smell, and the beans were added to induce the sheep to eat it.

Lots of sheep of 20 each.	Weighed at first.		Incr.	Eaten by each sheep per week.		Incr. of each sheep per week.	Quantity of ingredients to produce 1 lb. mutton.		Total consumption.
	lb.	lb.		lb. oz.			lb. oz.		
<i>a</i>	1839	2008	169	{ 3 8½ Beans & linseed	1 4	2 14½ Linseed	{ 477 Linseed		
<i>b</i>	2401	2603	202	{ 4½ Beans	1 2	6 5 Linseed-cake	{ 36 Beans		
<i>c</i>	2382	2479	97	{ 5 15½ Beans & linseed	1 9¾	4 11 Beans & linseed	{ 1275 Linseed-cake		
...	2479	2657	178	{ 9 13½ Poppy-cake	1 7¾	6 10 Poppy-cake	{ 310 Beans		
<i>d</i>	2404	2557	153	{ 7 1½ Beans	1 13½	8 5½ Beans	{ 48 Linseed		
<i>e</i>	2417	2736	319	6 4 Beans & linseed	1 12½	3 8½ Beans & linseed	{ 1180 Poppy-cake		
							{ 1275 Beans		
							{ 702 Beans		
							{ 422 Linseed		

Linseed-cake saving Roots.—In order to ascertain whether those substances would economise the consumption of turnips, Mr Bruce put all the sheep on a full allowance of white turnips, with abundance of the materials enumerated above, and the results were—that the saving of turnips effected by linseed-cake is very great, and secures a larger proportion than the cake used in the former experiment realised; but much of these results must depend on the size and condition of the sheep, as the lower the condition the greater quantity of food will be consumed. It may be safely held, says Mr Bruce, that an allowance of 1 lb. of good linseed-cake to a sheep of 9 stones weight imperial, every day, will effect a saving in the consumption of turnips of 33 per cent, and at the same time improve its health so as to diminish the chances of death by upwards of 50 per cent. This last result is well worth remembering.

Increase in Tallow.—Whether or not the use of these extraneous ingredients increases the tallow in sheep, is a reasonable inquiry; and Mr Bruce made experiments to ascertain this point

also, by taking 5 average ewes from each division of the experiment, first weighing them, and in two days afterwards killing them after being driven 23 miles. The results are detailed in the following table:—

Lots of Sheep of 5 each.	Fed upon.	Live weight, Dec. 23.		Weight of carcass, Dec. 25.	Weight of tallow.	Weight of skin.
		lb.	lb.			
<i>a</i>	Linseed and beans	666	344	55	52	
<i>b</i>	Linseed-cake	647	335	57	57	
<i>c</i>	Beans and linseed	654	338	57	57	
<i>d</i>	and poppy-cake	641	327	49	52	
<i>e</i>	Beans	688	347	61	50	
	Beans and linseed					

Advantageous to use Rich Foods with Turnips.—The conclusion Mr Bruce draws from these experiments is, that “they clearly establish the fact, that mutton can be produced at a lower rate per lb. upon a liberal use of such ingredients along with turnips than upon turnips alone, taking, of course, the increased value of the manure into account; and that of the articles used, linseed is the most valuable, and beans the least so, but that a mixture of the two forms the

most nutritious food.”¹ This last result is also worth remembering.

In the section on Foods, information is given as to feeding sheep with malt, barley, wheat, peas, &c.

Wheat-meal v. Linseed-cake.—In a comparative trial between the nutritive property of wheat-meal and linseed-cake, Mr P. H. Frere obtained the following results from December 26 to February 20 :—

<i>Linseed-cake.</i>		lb.
5 Down shearlings gain	.	99
5 East-down hoggets gain	.	108
<i>Wheat-meal.</i>		
5 Down shearlings gain	.	100½
5 East-down hoggets gain	.	106½

All four lots are put on swedes ; the shearlings eat 6 stone per pen per day ; the hoggets 4 stone.

Cabbages v. Swedes.—Mr John M'Laren, farm-manager to Lord Kincaid, Rossie Priory, Perthshire, made an experiment to ascertain the comparative values of cabbage and swedes in feeding sheep. He selected 10 Leicester wethers bred on the farm for each kind of food, and placed them in a well-sheltered lea field with a division between them, and supplied the food in troughs, with abundance of hay. The particulars of the following table will at once show the results :—

No. of Sheep.	Kind of food.	Weight of 10 sheep, 1st Dec. 1855.		Weight of 10 sheep, 1st Mar. 1856.		Gain of weight.		Value of gain at 6d. per lb.			Weight of food consumed.		Weight of crop per acre.		Value of crop per acre.			
		st.	lb.	st.	lb.	st.	lb.	£.	s.	d.	tons	cwt.	lb.	tons	cwt.	£.	s.	d.
10	Cabbage	90	10	101	5	10	9	3	14	6	8	13	47	42	14	18	6	6
10	Swedes	89	3	100	7	11	4	3	19	0	8	10	7	26	12	12	6	7¼

Mr M'Laren offers these remarks : That both lots were sold in Edinburgh at the same price, 5s. 6d. ; that each lot consumed about the same quantity of food, 21½ lb. cabbage per day each sheep, and 20½ lb. swedes ; that swedes gave a return of 11 st. 4 lb. of weight, and cabbage 10 st. 9 lb. ; that 3 cwt. 40 lb. less of swedes were consumed ; that taking mutton at 6d. per lb., swedes were worth 9s. ¾d. per ton, and cabbage 8s. 7d. per ton ; that the extra cost of raising cabbage was £4. 10s. 11d. per acre, and of swedes 7s. per acre ; but that the great additional weight of crop gave a balance in favour of cabbage, at the above prices, of £1. 15s. 11¾d. per acre.²

Mangels for Lambs and Sheep.—It is feared by some that mangel-wurzel is dangerous food for lambs, and not without reason, at an early period of winter, because it is well known that unmatured roots of all kinds act powerfully upon the bowels. Even swedes may produce black scour on hoggs before November. But Mr Thomas Staggs, Grafton Manor Farm, Wilts, believes in

no such accusation against mangel. He has had 600 or 700 sheep and lambs on it for 15 years. His treatment of lambs with mangel is this : “The quantity I commence with giving lambs is about 10 bushels of cut roots to a hundred lambs per day ; this quantity I increase gradually as the season advances, and as the lambs grow, and require more food. Of course, large animals would require more than small.”

No doubt, when hoggets are first placed on roots, we must be careful not to overfeed, especially if the animals' condition is low. In such cases black scour sets in, and mortality is great. Hence a little artificial food given at this time will keep lambs in thriving condition. When first put on turnips, ½ lb. of oilcake, with chopped hay or fresh oat-straw, will be sufficient.

Reluctance to give Hay to Hill Sheep.—In his prize report on wintering a flock of sheep, Mr Thomas Carruthers refers to the prejudice which he says exists among some stock farmers against feeding hill sheep in winter, and adds : “That such should be the case at this time of day, and that any rational being can expect sheep or any other animal to

¹ *Trans. High. Soc.*, July 1849, 376-381.

² *Ibid.*, October 1858.

live without food, surpasses my comprehension. I hold that whenever winter sets in with severity the sheep should be foddered, and when hay fails they should be fed with locust-beans or something else. Were this more attended to, thousands of sheep might be saved which now perish from hunger."¹

Consumption of Food and Increase of Weight.

Sir John Bennett Lawes states that "fattening sheep, fed liberally upon good food, composed of a moderate proportion of cake or corn, some hay or straw-chaff, with roots or other succulent food, and well managed, will on the average consume about 15 lb. per week, and should yield over a considerable period of time one part of increase in live weight for about nine parts of the dry substance of their food. If the food be of good quality, sheep may give a maximum amount of increase for a given amount of total dry substance of food, even provided the latter contains as much as five parts of total non-nitrogenous to one of nitrogenous compounds."

Canadian Experiments on Sheep-feeding.—Many important experiments on the feeding of live stock have been carried out by Professor Brown at the Ontario College of Agriculture and Experimental Farm, Guelph, Ontario, Canada. The following summarised results of a series of experiments conducted by him on the feeding of sheep may be perused with interest and advantage:—

Oats and Hay with Turnips.

Results per head per day with four head for fifteen weeks, beginning 10th November: The sheep in this test and

all the others hereto noted are Oxford Downs and Shrops grade wether lambs, dropped on an average in March, and with the exception of the high and low feeding, were alternated to the different foods in pens, as described.

The average wether lamb receiving $1\frac{3}{4}$ lb. oats, $2\frac{2}{3}$ lb. of clover-hay, and $1\frac{1}{3}$ lb. of turnips, gave a daily increase of fully $\frac{1}{3}$ lb., at a cost of 9 cents ($4\frac{1}{2}$ d.) per lb. to the added weight of the animal.

Peas and Hay with Turnips.

In this experiment the average wether lamb consumed fully $1\frac{1}{2}$ lb. of peas, nearly $2\frac{1}{2}$ lb. of hay, $2\frac{1}{8}$ lb. turnips per day, and increased in live weight at the rate of $\frac{1}{4}$ lb. per day—cost, 12 cents (6d.) per lb. of added weight.

Beans and Hay with Turnips.

The daily consumption of this ration was $1\frac{1}{8}$ lb. beans, $2\frac{1}{10}$ lb. hay, and $1\frac{1}{4}$ lb. turnips, and the increase to live weight scarcely 1 lb. per week, which makes a cost of 19 cents ($9\frac{1}{2}$ d.) to produce every pound added to the live weight of the average wether lamb.

Low Feeding of Sheep.

Upon a daily ration of $2\frac{1}{2}$ lb. of clover-hay, 1 lb. pea-straw, and 4 lb. of turnips, the average wether lamb increased in weight at the rate of nearly $\frac{2}{3}$ lb. per week, and the cost of producing 1 lb. to live weight amounted in this case to 22 cents (11d.)

High Feeding of Sheep.

Results per day with four wether lambs for 15 weeks:—

FOOD CONSUMED.								Daily increase.	Weekly increase.	Weight of average animal at finish.
Oats.	Peas.	Beans.	Bran.	Hay.	Roots.	Oilcake.	Thorley.			
lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
.507	.354	.101	.601	1.992	1.269	.27	.2	.2	1.4	125

The food above enumerated is the daily ration as consumed by the average

wether lamb, upon which it increased in weight at the rate of $\frac{1}{5}$ lb. per day; cost of production $12\frac{1}{2}$ cents ($6\frac{1}{4}$ d.) per lb.

¹ *Farming World*, 1888, 507.

Comparative results in Feeding Wether Lambs.

	Weekly increase per head.	Weight at finish.	Cost of increase per lb.
	lb.	lb.	cents.
Oats and hay with turnips	2.60	143	9
Peas and hay with turnips	1.75	124	12
Beans and hay with turnips	.95	117	19
Low feeding	.63	112	22
High feeding	1.40	125	12½

Analysis.

The rapid and cheap production of mutton in winter has here been attained best by the use of oats and hay; and second, by peas and hay. This places six wether lambs as equivalent to one two-year-old steer. The average of these two only distinct ordinary forms of feeding sheep in this test equals $\frac{1}{3}$ lb. per head per day, and 10½ cents for the added 10 lb. in weight.

Beans do not seem to be as profitable food for sheep as peas, as the rate of growth of the average wether lamb is little over half, and the cost of production is double that of peas.

That poor feeding is expensive feeding is well illustrated here: not one-third the ordinary rate of progress, and twice the cost of production, must be very much the position of those who practise such economy as this.

Cross-bred v. Pure-bred Sheep.—It accords with experience that cross-bred sheep return a larger quantity of mutton in the same food and time than pure-bred sheep. Half-breds somehow consume more food than pure-breds. Perhaps an analogy might be found in the human race. A raw-boned middle-class consumes more food than a high-bred upper-class, and acquires a heavier weight in a given time than the more refined individual, who will maintain his condition on a smaller allowance of food.

This is an interesting proposition in the comparative economy of the farm.

Mr Bird has endeavoured to solve it. He selected 4 lots of 5 matured wethers in each, consisting of Leicesters Twice-

crossed, pure-bred Cheviots, and Half-breds. The Half-breds were a cross between Leicester and Cheviots, and the Twice-crossed were between the Half-breds and Leicester tups. The enclosures within which they were confined were hurdles and straw, open above, in the same fold against a stone wall, and were 15 yards in length and 9 broad. Their food consisted of swedes cut with a Gardner's slicer in troughs, and oats for the last 5 weeks of the experiment, which lasted from 13th November to 16th March. This table furnishes the particulars of the experiment:—

Kind of Sheep.	Weight, 13th Nov. 1898.	Weight, 16th March 1899.	Gain on weight.	Turnips consumed.	Oats consumed.
	st. lb.	st. lb.	st. lb.	sq. yds.	lb.
Leicesters	51 9½	55 10½	4 1½	1220	128
Twice-crossed	50 6½	57 3½	6 11	1295	128
Cheviots	50 1½	56 9½	6 8	1300	128
Half-breds	50 0½	60 10½	10 10	1417	128

The Half-breds having thus gained 4 stones more weight than any of the others, in return for little more than 100 square yards more turnips consumed, undoubtedly must be awarded to them the superiority of acquiring an increase of weight. It must be observed that the Leicesters did not eat so plentifully as the others, and were for several weeks before the close getting discontented both with food and confinement, two of them having literally lost weight of 1 st. 1 lb. This experiment corroborates the common idea that half-breds pay better for food than pure-breds—that is, where the latter are, like the former, kept for direct mutton production, and where they have no special value in the raising of young stock to be sold for breeding purposes.

Sheep on Carse-farms.—Sheep are not fed on turnips on every kind of farm. Carse-farms are unsuited to this kind of stock, and where turnips are raised on them, cattle would be more conveniently fed on them. And even where there are no turnips, it would be better on carse-farms where straw is plentiful to keep cattle than sheep, and feed the former upon the straw, cake, and grain.

Sheep near Towns.—On farms in the neighbourhood of *large* towns, whence a supply of manure is obtained at all times, turnips are not eaten off with sheep. The turnips in this case will usually bring more money by being sold to cow-feeders. Near small towns sheep are fed on turnips to manure the land. They are bought in for the purpose, and consist of wethers, hogs, or draft ewes: the ewes, if young, feed more quickly than wethers of the same age.

Sheep on Dairy-farms.—On dairy-farms there is as little use for sheep as near towns, except a few to eat off any surplus turnips.

Attention to Details.—Mr John Coleman well observes: "Fatting sheep should be kept in rather close quarters, and placed in small lots about 40 in each pen; fresh ground given each day if practicable, and great regularity in feeding observed. During the short days of winter, the routine of operations should consist in supplying corn and cut straw the first thing in the morning; and whilst this is being consumed, the troughs should be filled with roots—the swedes having been carefully cleaned, and also the troughs: success depends upon attention to details. The sheep feed until replete, and at about ten to eleven lie down to ruminate. The fresh fold may now be pitched, and the animals left undisturbed until about two; feeding then recommences. More corn and cut straw (either then, or, which is better, the last thing at night), and the root-troughs filled. A teg (or hogg) will consume from 18 to 20 lb. of roots, and $\frac{3}{4}$ to 1 lb. of cut straw, with corn, daily. As the spring advances, the sheep must be attended to betimes in the morning and late at night, and the roots supplied three times a-day. Water should be given, and boxes with rock-salt should never be absent."

DETAILS OF MANAGEMENT IN TYPICAL FLOCKS.

Although it is with the winter management that we are in the meantime chiefly concerned, it may be convenient to present here in a connected form the outstanding features in the systems pur-

sued throughout the year in a few leading flocks.

Mr T. H. Hutchinson's Leicesters.

Mr T. H. Hutchinson, Manor House, Catterick, Yorkshire, has long maintained a very celebrated flock of the genuine old English Leicesters. In response to a request for information as to his system of management, he writes:—

"I keep a flock of pure-bred Leicesters, which I find to answer my purpose better than any other breed. My aim is to produce as much wool and mutton as possible from the produce of my farm, and to keep the land in a very high state of cultivation.

"I annually put 100 ewes to the ram, and generally average about $1\frac{1}{2}$ lambs to a ewe. The ewes are put to the ram last week in September.

"Besides the lambs I breed, I buy from 150 to 250 to 'turnip' during the winter. As I cannot buy pure Leicesters, I generally buy 'north' lambs—that is, lambs bred from Cheviot ewes with three crosses of the Border Leicester. These do remarkably well on turnips, and go off fat in February and March, weighing from 16 lb. to 22 lb. per quarter.

Feeding of Ewes.—"The ewes run on the grass in autumn, and have roots with cut oat-sheaves given in addition before lambing, also hay if I can spare it. After lambing, the ewes get roots with a mixture of malt-combs, linseed-cake, bran, oats, and cut hay, until the pastures are good enough to keep them going.

Feeding Lambs.—"The lambs are weaned in July either on to some after-grass or good old pastures, until cabbages or thousand-headed kale are ready. After that they go on to Fosterton Hybrid turnips, then finish on the swedes. As soon as the lambs go upon cabbage, &c., they are allowed a mixture of crushed tail corn, linseed-cake, malt-combs, bran, &c., made into a kind of lamb food. I prefer a mixture to cake alone. When put upon turnips the roots are all cut, the turnips all being stored in October and early part of November in small pieces. Hay and straw are also given. I find nothing like plenty of dry food for sheep on turnips.

"A piece of rock-salt should always

be kept in a trough, for the sheep to go to when they like.

"The lambs and ewes are all dipped after clipping, and again in autumn.

"The rams for show purposes are kept as well as possible, and get the best of everything likely to do them good.

"You ask me what quantity of turnips or other food should be consumed per day. I am sorry to say I cannot tell you. I always let the sheep have plenty to go to, and fancy they are better judges than I am as to the quantity they require; at any rate, I leave it to them to decide."

Glenbuck Blackfaces.

Age of Draft Ewes.—The valuable flock of highly improved Blackfaced sheep belonging to Mr Charles Howatson of Glenbuck is managed in a very systematic and skilful manner. Mr Howatson takes only four crops of lambs from his ewes before parting with them, as he finds that better and stronger lambs are bred from robust young ewes than from exhausted old ewes, and that, as a matter of course, five-year-old draft ewes sell better than ewes a year older. The draft ewes are sold early in October, and the whole remaining flock is then dipped, the dipping being repeated in January if the weather permits.

Early Lambs.—Mr Howatson lets out his rams about the first week of November, which is about a week earlier than the general custom. The best lot of rams go first, and then in about three weeks the remainder of the rams are put amongst the ewes, so as to pick up those not already served.

Ram Lambs.—Mr Howatson has so much improved his flock, that he finds a ready demand for all his ram lambs for breeding purposes, so that none of them are castrated. He retains a few of the choicest of the ram lambs for his own flock, and the remainder, with the spare ewe lambs, are sold at the Glenbuck ram sale in September, which is now one of the principal events of the year in blackfaced circles. The system of selling ram lambs, so successfully inaugurated by Mr Howatson about 1870, is growing in favour, as thereby the purchaser gets possession of the young sire before he can be spoiled by over-feeding, as is sometimes

the case with rams sold as shearlings in September.

Ewe Lambs.—The Glenbuck ewe lambs are weaned in August. The selection of ewe lambs to be retained in the flock are dipped and sent back to the hill till the second week in October, when they are despatched to the low country, where they are wintered at a cost of from 7s. to 8s. per head.

Clipping.—Clipping begins in the second week of June with the ewe hoggs. At this time care is taken to mark for sale any of the ewe hoggs which may not in every respect be satisfactory for breeding purposes, special attention being given to the fleece, in the improvement of which Mr Howatson has been very successful. Mr Howatson thinks it advantageous to delay clipping ewes until the new wool is well raised, and the clipping of them is therefore postponed till the latter part of July.

Cheviot Flocks.

Mr John Robson, Newton, Bellingham, whose valuable and old-established flock of Cheviots has for several years taken the leading position in showyards, has favoured us with some notes relating to the management of his own and other similar flocks. His flock is entirely home bred. He casts ewes at 5 or 6 years old, according to the ground they go on. Almost all West-country ewes are sold at 6; further east or on the Cheviot range, at 5 years old.

Selling Young.—Wether lambs used to be hogged on the farm, and kept till 3 or 4 years old, then sold fat—or in plentiful turnip years, for turning. Now, on account of bad seasons, increase of sickness, and low price of wool, they are mostly sold as lambs, to go to better land to be fed off as shearlings; or if kept on hill farms, they are sold at 2 years old.

Weights.—Ewes weigh when sold probably 60 lb., Wethers, 72 lb.; but, of course, when very fat they greatly exceed these weights.

Hirsels.—On the Cheviot Hills a farm is generally divided into two hirsels. On large farms the number of hirsels is of course multiplied indefinitely. But take a sixty-score farm—the ewe hirsle will contain three ages of ten scores of

ewes each, 3, 4, and 5 years old; the hogg hirsels, two ages of fourteen or fifteen scores each of 1 and 2 years old sheep. At clipping time the 2 years old ewes or "young ewes" are brought from their "hogging" and put amongst the ewes, their ground being hained till the end of July, when the ewe lambs are weaned and taken to it.

Land "tired of Hogging."—Thus lambs never follow lambs, the ground always getting a year's rest from lambs, as they are allowed to remain till 2 years old. If lambs follow lambs too often, the land is apt to get "tired of hogging," which, if continued, means that the hogs either die freely of sickness or of poverty.

Age for Breeding.—When farms are managed on this system, the gimmers are not, except on the very best low-lying farms, expected to bring lambs; only a few of the strongest are put to the tup, to provide lambs for setting on.

West-country System.—The other or West-country system is to allow the ewe lambs to follow their mothers—none but those on the draft ewes being weaned, and those only for ten days, when they are put back to their mothers. Here the gimmers in good seasons are expected to bring lambs, all but a few of the worst get the chance of the tup, and the ewes are generally sold at 6 years old.

On land addicted to louping-ill this is much the best way, as there is less change; but on the healthy and stormy Cheviot Hills the former plan has this advantage, that it provides a stock for the harder and higher ground which would not keep ewes, and also allows of the hogs being better looked after in a storm.

Feeding in a Snowstorm.—The only difference between winter feeding and summer is, that if a snowstorm comes which blocks up the ground so thoroughly that little or no natural food can be got, the sheep are given hay. About one pound each is the usual quantity once a-day, as early in the morning as possible. Great care should be taken to keep sheep in as small "cuts" as possible—100 is about the best number, and every farm should have a stell for every cut of sheep.

Hand-feed judiciously.—Hay should only be given to prevent hunger, as on some land sheep which have been heavily

hayed do not thrive next summer so satisfactorily as those which have not been so much pampered. Corn or cake has also the same tendency, and ewes which have been hand-fed one winter always look for the same indulgence afterwards.

Wethers on Turnips.—Wethers are mostly kept on turnips about 20 weeks the first winter, and 6 or 8 weeks the next.

Extra Food with Turnips.—As a rule, no additional food is given to sheep on turnips, but sometimes when turnips are taken by the week they get hay or straw; feeding-stuff is rarely given. If a hill-farmer has turnips of his own, he is generally a generous feeder, giving cake or corn and hay to fattening sheep, and hay or straw to hogs. In a storm all sheep get hay, but seldom corn or cake.

Dressing.—The sheep are dipped either in October after the surplus stock is cleared off, or in the spring. The latter is the best time for killing vermin, but in bad springs it is often difficult to get suitable weather for dipping. Usually some of the well-advertised sheep-dips are used; but since money became scarcer many farmers have begun to use preparations of their own, which are often quite as efficacious and cost much less.

Rams.—The rams are usually kept amongst the other sheep during summer. In winter they get turnips, and when being prepared for sale a little cotton-cake.

Price and Quantity of Turnips.—Turnips for wethers cost this year (1887) 5d. or 6d. per week; for hogs, 3d. And as an acre of fair turnips is said to winter a score of hogs, it may be supposed that the same quantity will keep 20 wethers 10 weeks. Probably an acre and a half will be required to feed 20 wethers.

Winchendon Oxford Downs.

Mr John Treadwell, Upper Winchendon, Aylesbury, Bucks, favours us with the following notes as to the management of his famous prize flock of Oxford Downs: "This flock being entirely devoted to ram-breeding, is in many respects managed differently from an ordinary flock kept for mutton producing.

Management of Ewes.—"About the middle of August the ewes are separated into lots, according to their suitability to the different rams to be used; and as many of the sires used are home-bred ones, care has to be taken as to the different pedigrees, as well as to size, wool, and symmetry. This adapting the rams to the different ewes is considered the most important factor in the whole matter of breeding.

"This farm containing a large proportion of grass-land—two-thirds—enables the ewes to be placed in lots as they are drawn in the different pastures, excepting what are served by the *show sheep*. These latter ewes are generally put on to a piece of old seeds or stubbles, and probably come on to a piece of cabbage or some other green food at night, having a 'teazer' with them; and the ewes as they come into use are taken up and served by these heavy sheep on a stage, or what we term *hand-tupping*.

"About the beginning of November when the ewes are all served they are put together, and clear up mangel-tops, stubbles, seeds, or anything there is for them. When this is done they are again drafted into smaller lots about the pastures, until they come up to the lambing-pen for lambing. They are sometimes dipped in November at the veterinary surgeon's dipping-yard, but not always.

"Rather a large number of rams are used, as some have only a very few ewes and others have a fair number, varying from 10 to 70 to a ram.

"When the ewes come up to the lambing-pen they get a little hay or straw, according to the weather and their condition; and they run on pastures by day. As soon as they have lambed they return to the pastures, and have about 2 pints of oats each, and hay if they require it. The oats are continued until April, when they are gradually taken off, as the grass comes on.

"They are shorn about the end of May, and the lambs are generally weaned in June—the ewes being put to vetches or clover, or a rough pasture, or anywhere where they can be kept cheaper until tupping-time.

"The draft ewes get better treatment at this time. They are fed on the pas-

tures, sometimes getting some cake and corn until they are sold off fat or put to roots or cabbage to finish. These get to very heavy weights if put on roots and brought out in January. They will average about 16 to 18 stone when well finished. Sometimes some of the best of them are sold to breeders to keep on another year or two.

Treatment of Lambs and Rams.—

"The lambs when weaned are separated, the ram lambs getting a little cake and corn at once. The ewe lambs do not get anything with the grass, as a rule.

"The ram lambs have their cake and corn increased slightly as the season advances, but do not get much attention until after the shearling rams are sold in August, when they are got on to the arable land as soon as some rape or turnips or something can be got for them. They then follow on to swedes and mangels until about the beginning of April, when, if the weather permits, they are shorn, kept in for a few nights, and out in the day, but kept out entirely as soon as possible. They get on to kale, then to rye, and then to vetches, with which they get some mangels until the cabbages come, when these take the place of mangels.

"These rams grow very fast and get big by the 1st Wednesday in August, when about 60 of the best of them are annually sold by auction at home, when buyers from almost every county in England and from many distant countries attend, and every sheep offered is always sold—the rest of the rams having been generally sold previously by private bargain to foreign buyers, chiefly Germans.

"The show rams are managed differently, being selected from the rest in October, shorn, and fed in the sheds—of course getting more fare.

"The ewe lambs generally go off the pastures on to rape in October, and then on to turnips, with which they get a little cotton-cake. In the spring about half are selected for the flock, and they are fed on vetches or seeds or pasture until turned into the ewe flock, when the rams are put amongst them. The draft ones are put into the pastures, and sold during the summer for stock or to the butchers, the majority now going to the United States for breeding purposes.

"The stock rams, except those for showing, are not highly fed."

Nocton Heath Lincolns.

Mr Wright, Nocton Heath, Lincoln, keeps his well-known flock of well-bred Lincoln sheep in a liberal but natural and rent-paying condition.

Ewes.—The ewes are wintered on turnips and grass. A short time before lambing commences, they get cut straw or wheat-chaff, with a little linseed and cotton-cake and oats. No extra food on the grass in summer.

Lambs.—Lambs are wintered on turnips, with a liberal supply of cake and mixed corn, and cut straw and fodder. On the grass in summer they generally have a little cake and oats.

Rams.—The young rams have a liberal supply of cake and corn on the pasture in summer, as well as with the roots in winter. Stock rams have cabbage taken to them on the pasture, and receive cake and corn night and morning.

Littlecote Hampshires.

Mr F. R. Moore, Littlecote, Upavon, Wilts, has, like several other leading breeders of Hampshire Downs, given great attention to the breeding and rearing of ram lambs for sale in the autumn of the year in which they are dropped. He breeds about 200 ram lambs every year, and sells them in August and September for use as sires that same year. The stock ewes are kept on the Downs during summer. Before lambing, they get roots sparingly; after lambing, plenty of roots—that is, if any are grown—with cake, hay, and perhaps a little malt-dust. All the hay is cut into chaff, and if it is not plentiful, a quantity of cut straw is mixed with it.

The bulk of the ram lambs get corn and cake moderately when young, with rye, barley, mangels, and vetches, with rape, cabbage, &c., to follow in course. Show animals are fed more liberally.

Biddenham Oxford Downs.

Mr Charles Howard's valuable flock of Oxford Downs at Biddenham, Bedford, usually consists of about 400 ewes, from which he rears about 450 lambs.

Management of Ewes.—The ewes

are generally put to the rams about the second week in August, and are from that time, with the run of the stubbles, the scavengers of the farm. Some white peas are grown for the use of the rams; immediately these are harvested, the stubble is either ploughed or dragged, and mustard sown, which is ready at the latter end of September, upon which the ewes are folded at night. After this is disposed of, they run the grasses, and are folded at night upon the land where the mangels have been drawn. A few kohlrabi are generally sown with the mangels, which are left for consumption by the ewes. After this they generally consume the cabbage-sprouts, and are then supplied with some dry food. Approaching lambing-time, they are placed in comfortable yards at night, and have a supply of chaff and straw, with some bran, oats, and mixed cake. Previous to lambing, they get as few roots as possible.

Treatment of Lambs.—The ewes, after lambing, run upon grass adjoining the yards, and when the lambs are strong enough, they are placed upon the roots, with lamb hurdles for the lambs to run forward on the tops, and have a supply of bran, oats, and cake crushed very small. Mr Howard thinks it desirable to get them out of the yards as soon as possible, which of course depends upon the weather and the strength of the lambs. After the turnips are consumed they are placed upon winter oats and tares or the grasses, until the clovers are ready, the ewes being plentifully supplied with mangels. The lambs are weaned in June, and are placed as soon as possible on the aftermaths of clovers and grasses, when a supply of cabbages is drawn to them, which generally lasts until September, when a few white turnips of an early variety are ready for them, upon which they are folded at night.

Feeding "Tegs."—The feeding tegs get permanently settled about the middle or latter end of October upon roots, which are sliced for them, and have a supply of clover chaff and $\frac{1}{2}$ to $\frac{3}{4}$ lb. mixed cake and split-peas, which is increased as the season advances to 1 lb., being then composed of mixed cake, split-peas, beans, peas, maize, and a little malt. The

ram tegs are somewhat more generously treated.

The breeding ewe tegs get a good supply of clover-chaff and about $\frac{1}{2}$ lb. of mixed corn and cake. The feeding tegs are ready for market between February and April, being between twelve and fourteen months old. Those sold in the former month are in the wool; those in April are shorn, and weigh from 10 to 12 stone, and as they are of excellent quality they command a good sale for the London market.

Feeding Flocks in Norfolk.

Mr Hubert V. Sheringham, South Creak, Fakenham, Norfolk, gives the following account of the Norfolk system: "I both breed and buy sheep for fattening, and that is the case with most Norfolk farmers, as few of them keep a large enough flock to breed as many sheep as they require to feed off their roots in the winter.

"As to feeding. The breeding ewes during lambing-time have a pen of turnips every day, and a mixture of cut hay and either malt-dust or bran, and some of the weaker ones get a little linseed-cake in addition to the other food. As soon as the lambs are able to eat they have a small allowance of Mackinder's lamb food, in troughs placed outside the fold (so that the ewes are not able to get it), and the quantity is increased as they are able to stand it. I usually take the lambs off the ewes about the end of May or beginning of June, and run them on trefoil and ryegrass until after the hays are off, when they are put on clover and sainfoin eddish, and I like, if possible, to have mangels to throw them until I have some turnips fit for use, about the middle or end of August. At this time the lamb food has been increased to about $\frac{1}{2}$ lb. each.

"About the 20th of September the lambs begin feeding off the early turnips, having a fresh fold every day, and cut hay and a small quantity of linseed-cake added to the lamb food. This method of feeding continues until the beginning of November, when the sheep go on to swedes, which are put through a turnip-cutter, and given them in troughs, they (the swedes) having

been previously thrown up into heaps; and the allowance of artificial food is increased to about $\frac{3}{4}$ lb. each until the last two months, when they get 1 lb. each of cake and corn. These sheep—cross-breds from Hampshire Down ewes and Cotswold rams—are fit for the butcher at a year old, and the best of them at that age will weigh from 84 lb. to 90 lb. each dead weight, and will clip a fleece of from 9 lb. to 10 lb. of wool."¹

Mr H. Dudding's Lincolns.

Mr H. Dudding, Riby Grange, Great Grimsby, has a large and valuable flock of pure-bred Lincoln sheep—350 ewes on a 650-acre farm. In reference to his system of management he says: "The greatest attention is paid to the lambs after taking them from the ewes in July. As a rule, they have all got to eat well from the troughs a mixture of linseed-cake, crushed oats, and locust-beans, a little bran, malt-combs, and a little cut clover, which make a most healthy mixture, at a cost of under £5 a ton. The most critical time is before getting them on turnips in October without a loss, especially the cough which is caused by the throat-worm, and in many cases shrinks them 10s. a-head. After the hoggs, as they are now termed, have got well hold of turnips, they improve rapidly without much loss."²

Montford Shropshires.

Mr T. S. Minton, Montford, Shrewsbury, whose well-known flock of Shropshire sheep has taken a high position, both in the show-yard and sale-ring, says: "The breed of sheep kept almost exclusively in this neighbourhood is the Shropshire. They are very hardy, prolific, and produce high-class mutton and wool. My custom is to breed my own, having the lambs February and March. During March, April, and May, the ewes and lambs are on seeds one and two years old, the ewes receiving mangels at first, and the lambs a few split-peas (in a pen made on purpose in centre of field) during the latter part.

Care of Lambs.—"In June the lambs are weaned and put on a sweet pasture,

¹ *Live Stock Jour.*, 1886, 549.

² *Ibid.*, 573.

receiving a small allowance (two or three ounces) of corn, where they remain until the clover aftermath is ready, which generally lasts them July and August. The last few years the custom has been to shear the lambs in June, as we consider they grow better, are not troubled much with the fly, and keep much cleaner when on the turnip land in winter.

"In September lambs go on to the young seeds on the cleared barley stubbles, still receiving their corn, and where they remain until the middle of October, when they are gradually moved on to white turnips, where in the course of a week they remain altogether, and now receive $\frac{1}{4}$ lb. of corn and some clover-hay in racks. The hurdles are moved daily, and they bite their own turnips for the first month, when the roots are then cut into fingers. White turnips generally last till Christmas, and we then commence swedes. The allowance of corn is then gradually increased to $\frac{1}{2}$ lb.

"The last few years I have sold mine in the wool, at from eleven to twelve months old, weighing about 80 lb. per sheep, and having from 8 to 8 $\frac{1}{2}$ lb. of wool to cut. When on turnips they receive their corn the first thing in the morning, then a feed of turnips. During the morning the clover is put in racks, and another feed of turnips in the afternoon."¹

Mr David Buttar's Flock.

Upon his arable farms of Corston and Baldinny, Coupar-Angus, Mr David Buttar maintains a large stock of sheep, and in response to our request he gives the following interesting notes as to his system of management: "The class of sheep principally kept by me are pure-bred Shropshires, but I also buy in a considerable number of other kinds of sheep for feeding during winter.

Shropshire Flock.—"My Shropshire flock consists of from 120 to 130 ewes, with 3 or 4 stock rams. The produce of these—numbering generally from 90 to 100 ram lambs, and the same number of ewe lambs—are all reared and sold in August and September of the year following for breeding purposes, with the

exception of a few shotts or culls which go to the fat market.

Feeding of Stock Ewes.—"The stock ewes during winter are fed principally on the foggage of the farm, with no extra keep whatever, except perhaps a little hay and a few turnips during the time of a snowstorm. About the beginning of February—a month or so before the lambing season—I commence to give them a few fresh yellow turnips (swedes strictly withheld at this time) twice a-day, with a little hay; and as there is a considerable drain on their constitution at this time—the most of the ewes having two lambs, and sometimes three, to support—I increase their daily allowance of turnips by degrees till they get about 20 lb. each.

"After the ewes have lambed, I give them, in addition, a little linseed-cake and oats (crushed), and some bran, twice a-day, increasing the feed by degrees till they have a daily allowance of from 1 to 1 $\frac{1}{2}$ lb. of this mixed food for each ewe with their lambs. I continue this till there is plenty of grass, when I stop giving the ewes any extraneous feeding, as they are apt to get too fat. But I continue to give the lambs about $\frac{1}{4}$ lb. each daily, which they get access to through hurdles made for the purpose.

"After weaning the lambs, which takes place about the middle of June or beginning of July, I put the ewes to the barest and worst pasture I have till September, when I again give them better keep to bring them into proper condition for the rams, which are generally put to the ewes about the first of October.

Feeding of Lambs.—"The lambs, on the other hand, after being weaned, are put on the very best pasture I have, with a continuance of their daily allowance of cake, bran, &c., which keeps them growing: once stint a lamb, and it will never do so well again, give it what you like. And when the pastures are getting bare towards the autumn, I supplement their feeding with an allowance of vetches, rape, cabbages, and such-like, which I have always growing for them, and which, I think, is better for them than an extra allowance of cake, &c.

"During winter, the ram and ewe

¹ *Live Stock Jour.*, 1886, 573.

lambs being drawn, are folded on separate fields, and both fed very much in the same way,—their principal food being a mixture of cut hay and pulped turnips, with a few blades of thousand-headed cabbage, which stand the winter better than any other variety, and which the sheep are very fond of. They have also at all times a quantity of rock-salt beside them.

Young Rams.—"In April month the young rams are generally shorn, and for a week or two at that time are taken under cover on account of the cold. They are let out to the fields again in May when the weather gets a little warmer, and there they are fed on early grass, winter vetches, &c., with a little cake and corn if thought necessary.

Dipping.—"For the prevention of scab and other skin-diseases, and the killing of ticks, &c., the lambs are generally dipped twice a-year—first, shortly after they are weaned, and again about the New Year. The ewes are dipped only once a-year, shortly before the rams are put amongst them.

Prevention of Foot-rot.—"With the object of preventing attacks of this destructive ailment, we pass the whole flock *twice* during the year through a solution of arsenic, prepared and carried out in the following manner:—

Solution for Foot-rot.

"Boil 2 lb. of arsenic with 2 lb. of potash (pearl-ash) in 1 gallon of water over a *slow* fire for half an hour; keep stirring, and when like to boil over, pour in a little cold water; then add 5 gallons of cold water.

"Put this solution to the depth of 1 to $1\frac{1}{4}$ inch, just sufficient to cover the hoofs of the sheep, in a trough 12 feet long, by 18 inches wide, and about 6 inches deep—the trough to be set *perfectly level* along the side of a wall or other fence in some place out of the way, with a good waterproof lid on it, and secured by a padlock to prevent danger from the poison which might be left in it. There should also be a wooden fence on the other side of the trough, carried out a little at one end to conduct the sheep into the trough, as indicated in fig. 87.

"Before the sheep are passed through

the trough their feet should be well pared; then walk them quietly through, and let them remain in the second pen twenty minutes or so before taking them back to their pastures.

"Before adopting this plan my sheep were scarcely ever free of foot-rot. Now they have not a single case of it, and

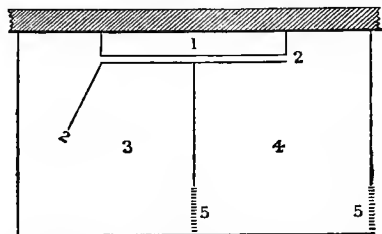


Fig. 87.—Trough and pens for foot-rot dressing.

1 Trough.

2 Fence.

3 First pen.

4 Second pen.

5 Gates.

have had none since I adopted the practice four years ago.

Feeding Sheep.—"The sheep I generally buy in for feeding purposes are two-year-old Blackfaced wethers.

Pulped Food for Sheep.—"They are all fed with pulped food, none ever seeing a turnip in the shape of a turnip. They are generally bought in about October or November; and as all the foggage on the farm is required for the breeding flock, the wethers are at once folded on a field of stubble on which I intend to have potatoes, or on any other suitable field, and commence to give them prepared food. At first I am very careful to feed them sparingly, till their stomachs are accustomed with such feeding; but after a few weeks the food is increased slightly from week to week till they get their full allowance, which is about 1 lb. cut hay and straw, 10 lb. pulped turnips, 1 lb. of cake and crushed grain, with a little salt. The cost of this full feeding per day is $1\frac{1}{2}$ d. for each sheep, or $10\frac{1}{2}$ d. per week; but from this must be deducted the value of the droppings on the land, which I value at not less than *one-third* of the whole cost, leaving a net cost for feeding of 7d. a-week, or say in round figures, 2s. 6d. a-month.

"In the autumn of 1877 I bought 400 two-years-old Blackfaced wethers, and on 9th November put them in two lots of 200 each on the pulped food.

On that day I drew out 10 average sheep of nearly equal size from each lot, and on weighing them, found they averaged 110 lb. each. I then weighed them regularly every month during the time I had them, and at the end of three months, when sold, they averaged 155 lb., being an average gain of 15 lb. each month, or about $8\frac{3}{4}$ lb. of mutton (allowing 58 per cent of the live weight for mutton). This, at $7\frac{1}{2}$ d. per lb., gave 5s. 6d. a-month for feeding, which cost only 2s. or so, as they did not get more than half the allowance of food for the first month."

Advantages of Pulped Food for Sheep.—"This system of feeding sheep, besides being much more profitable, has many advantages over the ordinary way of feeding in the fold. One very important advantage gained is that the sheep always get a clean warm feed instead of a bellyful of dirty cold frozen turnips, which is generally the case in the ordinary way. Besides this, the percentage of deaths is much less. In 1887, out of 800 sheep, I lost only one during the whole winter-feeding. Then, with me, the cost of labour in carrying out this system was no greater, as two men did the whole work of pulping and feeding, &c., for the 800 sheep; and they could have done no more had they been fed in the usual way. Without water-power for pulping, however (which I have), the cost would necessarily be a little more.

"By this system there is also a great economising of a costly and valuable root-crop, which is a very great advantage. In the usual way of feeding on the fold, an ordinary Blackfaced wether will consume not less than 20 lb. of turnips per day; whereas by this pulping system not more than 10 lb., the one-half, is required.

"The droppings of the sheep are also richer by this mode of feeding; and by careful attention to the shifting of the feeding-troughs, which should be done at least *once* every day, the whole field can be gone over and manured as equally as by the ordinary way of feeding off sheep.

Shifting Feeding-boxes.—"The following is the method I adopt in placing the feeding-boxes: Suppose there is a lot of 200 sheep to be fed; they require 20 feeding-troughs, of about 10 or 12 feet long, 6 inches wide at the bottom, 12

inches wide at the top, and 6 inches deep. These are put down in two rows, 5 yards or so apart, in the order below—



"A clear space of 12 feet or so (the supposed length of the troughs) is left between the ends of the troughs. By this means the sheep, and also the horse and waggon drawing out the pulped food, can freely pass round them in any way; and by removing the troughs forward about 5 or 6 yards every day, the whole field is thereby thoroughly and regularly gone over."

Sussex Flocks.

The first of three prizes offered (1888) by the *Farming World* for reports on the wintering of a flock of sheep was won by Mr H. Sessions, Truleigh Farm, Beeding, Sussex, from whose report we take the following extracts:—

"The farm lies on the north side of the South Downs, and has 300 acres below the hill, and 200 acres of down and hill arable.

Cropping.—"The hill arable is farmed almost exclusively for the sheep on a five years' system—corn, fallow crop, corn, and seeds for two years. Rape is almost invariably grown as the green crop, though cabbage sometimes is sown on a part of the fallow. Besides this rape on the hill we had eight acres just below, and ought to have had ten acres of swedes and turnips on the lower greensand for the ewes to eat during lambing, but the dry autumn prevented a plant being got, though the land was repeatedly worked and drilled, and had at last to be planted with winter oats, hoping they would come away in time for the ewes and lambs to run over in the spring. This, with five acres of rye and five of winter barley, constituted the available green food for the winter.

Stocking.—"The flock whose wintering I am describing is a well-bred South Down one, and consisted at the beginning of the winter of 262 ewes. There are 172 full-mouthed ones, the remainder being six-toothed. We put three rams with this flock on the 7th October, and kept them in until December 2d.

Winter Feeding.—"The ewes came

first into the rape under the hill, having a 'bait' twelve hurdles square in the middle of the day, running on the downs the remainder, and folding on a wheat stubble (where our mangels are now) during the night. The reason they did not go back to fold on the rape ground was the danger of having the present wheat crop too big and down, and also to help the mangel crop, a very important one on a heavily stocked farm.

"Just after Christmas the flock, having eaten their rape below, had to be sent on to the hill. To make a deadfold, protected from the winds, which come unchecked for miles, is very necessary. Fortunately we have a shed and walled yard, which, though not large enough to hold the flock, make a very useful base. To make it larger, straw stacks are put on the north and south sides, joining the east wall, in which is the gate. This leaves only the east side of the outer part unprotected, and we cut a number of furzes and built a wall against the hurdles to make that side also as snug as possible. The ewes lay here very comfortably; and even when the snow was three feet deep in their rapefold, and the cutting wind and frozen particles made it hard work to get to them, yet once there you were out of snow and wind.

"The ewes started the day with some mixed cotton and linseed cake, a bushel of each *per diem*, then on to the grattons till mid-day, back to a pitch of rape, then on the down until folding-time, when they went back to the fold from which they had eaten their rape, as long as the weather permitted. When it got colder and rougher they went to the deadfold at nights, following the same course during the days as long as they could. When the snow prevented their going out at all, they had three, and, as they got near lambing, five trusses of clover hay *per diem*, and unlimited oat-straw. This, with three bushels of linseed-cake, only just kept them in the same order—in fact, if either way, they rather lost flesh for a week or two.

"The end of February the ewes came down to the sheds and yards on the lower greensand. The feeding course now was—pea-haulm to start with, then three bushels of cake and five trusses of hay,

out into the meadows, and back to a liberal allowance of oat-straw.

Lambing-yard.—"While the ewes were out, the time was utilised in getting the yard ready for lambing. It was divided into three main parts by thatched and furzed hurdles, which could easily be repitched as the numbers in the divisions altered. The largest part was at first for the 'full ewes,' the next division, about thirty pens, being reserved for the single lambs, and the last part being occupied by the twins. The bay of a barn was reserved as a hospital, and the occupants of that and the twins had rather a larger allowance of cake and the pick of the hay.

"As soon as a ewe lambed she was put into one of the pens, and drafted into one of the larger lots—twins or singles—when another ewe wanted her pen. After lambing, and while in the yard, they had a mangel each *per diem*.

Scour in Lambs.—"Several of the lambs died of scour; and in the case of singles we parted the weakest twins, and put one to the mother of the dead lamb, using the dead lamb's skin as a coat for the stranger until the new mother took to it.

"There is no infallible remedy for scour; prevention is the great thing—keeping the ewes on proper food, and getting the lambs away from the crowded yards to the fields as soon as it can possibly be managed. When we saw a case of scour, the lamb had a dose of salts or oil, and sometimes the lamb died and sometimes it lived, whether through the salts and oil, or in spite of them, is hard to say.

Help in Lambing.—"When we had to help a ewe that was lambing, we used carbolic oil to dress the hands, and also as a salve for sore places, except on the udder, which, when inclined to garget, was dressed with fresh lard.

Late Spring.—"The late spring made it necessary for the ewes to stay round the yards much longer than was profitable or good for the sheep, but until the rye began to grow there was nothing for them elsewhere. They had their first fold of rye the second week in April, and ran the different meadows the rest of the day. When the meadows were eaten down they ran over the winter

oats, and after that the winter barley, which just lasted them until the grass on the downs began to grow, where they are now coming into a fold of trefoil at night. The lambs run into a fold that is pitched forward, and have a bushel and half of linseed-cake in their troughs, which they eat greedily. The ewes have two bushels before they go to the downs in the morning.

"Of the 262 ewes with which we commenced the winter 1 died, 7 were barren, and we have 254 running with 281 lambs."

A Roxburgh Flock.

In his prize report on the wintering of Mr David Pringle's flock on the farm of Hyndlee, Bonchester Bridge, Hawick, Thomas Carruthers says:—

"There are five hirsels upon the farm, which is from 1200 to 1800 feet above sea-level. Pretnest and Nedslaw are mostly bog-lea, and have little heather; and Jedhead and Ravenburn, the farthest out and highest hirsels, are mixed with lea, moss, and heather, there being little bog.

Shelter.—"There are on the farm 16 stone stells of the cipher shape, that hold from 160 to 200 sheep each; and 5 old fir plantations, into which the sheep are admitted. We greatly prefer the plantations for shelter, the sheep lying much warmer than in the stells, as the drift goes through the stone walls. It is to be regretted that generally there are so few plantations on hill-farms, the want of which is the cause of great loss in severe winters. They afford the best of shelter, and improve the climate, and this is a department of estate management which should be more attended to.

Stocking.—"The stocking of the farm on the 1st November 1887 consisted of 1841 Cheviot ewes (three, four, and five years old), 366 Cheviot gimmers, and 455 Cheviot ewe hogs; and 273 Blackfaced ewes (three, four, and five years old), 36 Blackfaced gimmers, and 125 Blackfaced hogs,—in all, 3096 head.

Losses.—"We have lost by death, or otherwise, 11 Cheviot ewes (5 from inflammation of the lungs, 2 drowned, 1 disease in the head, 1 hanged in the hay-heck, 1 pined, 1 sturdy); 2 Cheviot

gimmers (from sickness and sturdy); 9 Cheviot ewe hogs (5 from sickness, 2 drowned, and 2 sturdies); 1 Blackfaced gimmer (from pining); and 2 Blackfaced hogs (from sickness)—25 head in all.

Dipping.—"We bath with an oily dip, which we consider to be the best for sheeting the wool and keeping the sheep through winter.

Winter Feeding.—"Upon the hirsels where there is no heather, the Cheviot hogs are taken to where heather and moss abound, which is hained for ten days or so previous. Whenever snow covers the ground, it is the practice at once to fill the hecks with hay, by this means keeping the sheep in good condition; and all this winter and spring till now hay has been given during snow or frost.

"The cuts of sheep mostly remain on their own hefts, there being either plantations or stells for every cut, and the hay is carried to them by sleds or on horses' backs.

"We try to fodder the sheep in the morning with hay; for, as a cup of good tea is cheering to man, so is a lock of good hay to sheep. And it is a fact that sheep spread themselves over the ground for grass far better after a good morning's bite of hay than when they get none. After getting the hay the shepherds go round and put them quietly away to the hill.

"When the weather is fine we hain the low ground; and during cold and wet we turn them down for shelter.

"Though it is rather expensive to make so much hay, still, from long experience, it is found to pay well. Besides a meadow of 50 acres, we make as much hay as we can get among the sheep's feet. We use the latter first, and reserve the meadow-hay till the spring. Ewes nurse lambs fairly well on good hay. Cows give abundance of milk on hay alone, and so will a ewe."¹

Sheep on Pastoral Farms.

On pastoral farms, sheep are not fattened on turnips; but the treatment of sheep on them in winter possesses exciting interest. There are *two sorts of pastoral farms* for sheep, and a few re-

¹ *Farming World*, 1888, 507.

marks on their constitution and fitness for rearing sheep will be useful.

Want of Shelter.—The first thing that strikes any one on examining a pastoral country is the *entire want of artificial shelter*. After being accustomed to see the enclosed and protected fields of arable land, the winding valleys and round-backed hills of a pastoral country appear naked and bleak. One is not surprised to find bare mountain-tops and exposed slopes in an alpine country, because it is scarcely practicable for man to enclose and shelter elevated and peaked mountains with trees; but amongst green hills and narrow glens, where no natural obstacles to the formation of plantations seem to exist, but whose beautiful outlines rather indicate them as sites for clumps and belts of trees that would delight the eye, one would expect to see at least an attempt made to rear trees for the express purpose of procuring shelter and comfort to sheep; and should these be deemed too expensive for a whole farm, the farm-buildings might surely be protected by trees.

Fencing Plantations.—The chief difficulty of forming shelter on a large scale is the dreaded expense of enclosing plantations—for it is wisely concluded there is no use of planting trees unless they are protected from injury, and few animals injure young trees so much as sheep, by nibbling them with their teeth as well as rubbing against them with their fleece; and yet in a mountainous country there is no want of rock for building rough but substantial stone fences; labour is but required to remove and put them together, and it is surprising what a quantity of stones a couple of men will quarry from a hill-face, and a couple of single-horse carts convey, in the course of a summer. Carriage might always be sent down-hill, fresh rock being attainable at higher elevations as the fences proceed. Or, failing rock, turf, even peaty turf, makes a very good wall.

Suppose a hill-farm containing 4 square miles, or 2560 acres, were enclosed with a ring-fence of plantation of at least 60 yards in width, the ground occupied by it would amount to 174 acres. A 6-foot stone wall round the inside of the plantation will extend to 13,600 yards, which,

at 1s. 6d. per running yard, will cost £1020. But the sheltered 2386 acres will be worth more to the tenant than the interest of the cost, and of course also to the landlord, than the entire 2560 acres unsheltered would ever be; and the fence will accelerate the growth of the trees by 10 years at least, whilst the proprietor will have the value of the thinnings of the wood to meet the cost of fencing, over and above the value of the standing timber. Planting one farm with a ring-fence shelters at the same time one side of 4 adjoining farms of the same size. Were neighbouring proprietors to undertake simultaneously sheltering of their farms by large plantations, on a systematic plan, not only would warmth be imparted over a wide extent of country, but planting and fencing would be accomplished along march-fences at a comparatively small cost to each proprietor.

A Low Sheep-farm.—A low sheep-farm contains from 500 to 2000 sheep—one that maintains from 500 to 1000 is perhaps the highest rented, being within the capital of many farmers; and one of 1000 to 2000, if it have arable land attached to it, is perhaps the most pleasant to possess, as affording employment to the farmer, while he could easily manage 6000 sheep without arable land, with good shepherds. A shepherd to every 600 sheep is considered a fair allowance, where the ground is not difficult to traverse, and it may be a fair stent to put 1000 sheep on every 1200 acres imperial.¹

Arable Land on Sheep-farms.—Every sheep-farm should have as much arable land as to supply turnips and hay to the stock, and provisions to the people who are on it. It is true, necessities and luxuries of life may be purchased; but every dweller in the country would prefer to raise his own necessities to purchasing them in town or village. It is not easy to determine the proportion which arable land should bear to pastoral, to supply every necessary; but perhaps 2 acres to every 20 breeding ewes may suffice. Taking this ratio, a pastoral farm with 1000 ewes should have 100 acres arable, which would em-

¹ Little On Mount. Sheep, 10.

ploy 2 pairs of horses to labour a 4-course shift, the pasture supplying the second year of the grass rotation. The rotation would be divided into 25 acres of turnips and potatoes, 25 of corn after them, 25 of sown grasses, and 25 of oats after the grasses. Manure will be required for 25 acres of green crop, which would partly be supplied by the 50 acres of straw, by phosphate or guano, and by sheep on the turnips. To make the straw into manure there are 4 horses, the cows of the farmer, of the shepherd, and of ploughmen; with a young heifer or two, the offspring of the cows. The arable land should be enclosed within a ring-fence of thorn, if the situation admit of its growth, or of stone.

Lands best suited for Hogs and Ewes.

The pasture division of the farm should be subdivided into different lots. Hogs are best adapted for soft rough grass, springing from a damp deep soil; and ewes for the short and bare, upon a dry soil and subsoil. Hogs attain large bone on soft rough pasture, where ewes would not thrive, and these thrive better on dry soil where hogs would be stinted. That farm is best which contains both kinds of pasture, and maintains both breeding and rearing stock.

Subdividing Pastoral Farms.—In subdividing a farm into lots, each should contain within itself the same quality of pasture, whether rough or short; for if fine and coarse grass be within the same lot, the stock will remain almost constantly upon the fine. The extent of one-fifth of coarse to fine may be permitted within the same lot. Should a large space of upper and inferior soil lie contiguous to what is much better, it should be divided by a fence, and a suitable breed of sheep reared upon it. By such arrangements, not only a greater number of sheep might be maintained upon a farm, but the larger number would always be in better condition.

Steading for Sheep-farm.—A steading suitable for the arable portion of such a sheep-farm should have similar accommodation to that included in plan, fig. 88, where the north range of building, standing E. and W., as well as

all the other ranges, is 18 feet in width.¹ Of course, where water-power is available, the water-wheel should take the place of the horse-course, *p*, fig. 88.

Drainage of Pastoral Farms.—The drainage of pastoral farms should never be neglected. The best mode of doing it will be fully explained when treating of draining. One means of keeping part, at least, of the surface dry, is to clear the channel of every rivulet, however tiny,

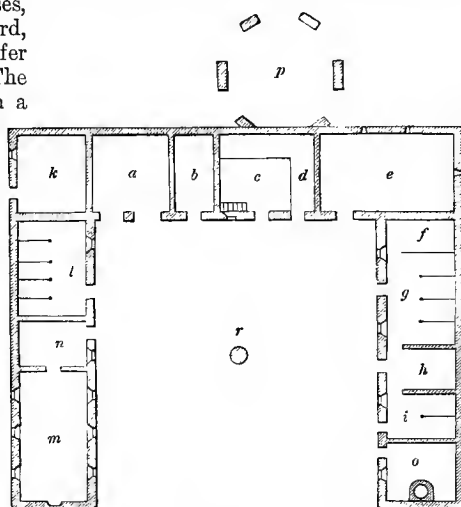


Fig. 88.—Steading for the arable part of a sheep-farm.

- | | |
|-----------------------------------|----------------------------------|
| <i>a</i> Cart-shed, 2 ports. | <i>k</i> Implement-house. |
| <i>b</i> Gig-house. | <i>l</i> Byre, 5 stalls. |
| <i>c</i> Corn-barn, 32 ft. long. | <i>m</i> Wool-room, 34 ft. long. |
| <i>d</i> Chaff-house. | <i>n</i> Outhouse. |
| <i>e</i> Straw-barn, 40 ft. long. | <i>o</i> Boiler-house. |
| <i>f</i> Loose-box. | <i>p</i> Horse-course. |
| <i>g</i> Cart-stable, 4 stalls. | <i>r</i> Pump-well. |
| <i>h</i> Hay-bouse. | Upper barn above <i>c d</i> . |
| <i>i</i> Riding-stable, 2 stalls. | Granary above <i>b a k</i> . |

that runs through the farm, every three years—especially in those parts where accumulated gravel causes a burn to overflow its banks in rainy weather, or at the breaking-up of a snowstorm. Overflowing water, acting as irrigation, sets up fresh vegetation, which becomes a habitat for the liver-fluke, and being readily devoured by sheep, is regarded as one of the main causes of rot. Confinement of water within its channels also prevents it wetting to

¹ See Plate II., fig. 2, *Book of Farm Buildings*, plan of steading for sheep-farm, with arable culture, by H. Stephens and R. S. Burn.

excess and souring the hollow parts of the land.

Securing Winter Food for Sheep.

—In recommending a connection of arable with pasture farm, the object is simply to secure an abundant supply of food for sheep in winter. Were our winters as mild as to allow sheep to range over our hills in plenty, there would be little use for arable land, for domestic provisions could easily be obtained from a market. But when storms overwhelm a whole flock, and protracted snow and frost debar the use of grass for weeks together, it is absolutely necessary to provide food upon the farm. The arable land might not itself be capable of yielding rent or profit, but it may add greatly to the value of the adjoining pasture-land. Let it be always kept in view that the *more food and shelter provided in winter for stock*, the less loss will be incurred during the most inclement season. Let one instance, out of many, suffice to show the comparative immunity from loss in providing food and shelter for sheep in winter. In the wet and cold winters of 1816 and 1818, the *extra* loss of sheep and lambs on the farm of Crosscleuch, Selkirkshire, was as follows:—

In 1816.			
200 lambs, at 8s. each .	£80	0	0
40 old sheep, at 20s. each	40	0	0
		£120	0 0
In 1818.			
200 lambs, at 8s. each .	£80	0	0
30 old sheep, at 20s. each	30	0	0
		£110	0 0
Value of total <i>extra</i> loss		£230	0 0

Whereas, on the sheltered farm of Bowerhope, belonging to the same farmer, and on which one-third more sheep are kept, the *extra* loss in those severe years was as follows:—

In 1816.			
70 lambs, at 8s. each	£28	0	0
10 old sheep, at 20s. each	10	0	0
	<hr/> £38 0 0		
In 1818.			
50 lambs, at 8s. each	£20	0	0
8 old sheep, at 20s. each	8	0	0
	<hr/> £28 0 0		
Value of total <i>extra</i> loss	£66	0	0
Deduct from loss on Crosscleuch	230	0	0
	<hr/>		
Value saved on farm of Bowerhope	£164	0	0 ¹

Food and shelter being thus both necessary for the proper treatment of sheep in winter, the means of supplying them demand the most serious attention of the store-farmer. In winter, sheep occupy the lower part of the farm. Hogs are netted on turnips in the early part of the season for a part of each day, and are afterwards turned out during the afternoon and night to a bit of rough pasture. Many farmers prefer carting the turnips daily to the hogs on the rough pasture. Ewes and other sheep subsist on the grass as long as it is green.

Turnips on Sheep-farms.—The division allotted to green crop in the arable part of the farm contains 25 acres, and allowing 3 acres for potatoes for the use of the farmer and his people, there remain 22 acres for turnips; and as land among the hills is generally dry, turnips grow well there, so that 30 double-horse cart-loads to the acre, of 15 cwt. each, may be calculated on as a return from the crop. It is thus judiciously recommended by Mr Fairbairn to strip and carry off, about the end of October or beginning of November, if the weather is fresh before the grass fails, $\frac{4}{5}$ of the turnips and store them in heaps; and allow the *ewe hogs* to eat the remaining $\frac{1}{5}$ on the ground, with the small turnips left when the others were pulled.² In stripping the land in this proportion, 1 drill should be left and 4 carried off, fig. 59.

This is an excellent suggestion for adoption on every hill-farm, as it secures turnips from frost, and gives the entire command of them whenever required in a storm.

Turnips for Hogs.—It is found that *hogs* fall off in condition on turnips in spring, in a high district, if confined upon turnip-land—not for want of food, but want of shelter and teeth. In some cases they are removed from the turnips in the afternoon to pasture, where they remain all night, and are brought back to the turnips on the following morning. In other cases, as already indicated—and this is a capital plan,—the turnips are carted daily to the hogs on a piece of rough pasture. One fair cart-

² Lammermuir Farmer. *On Sheep in High Districts*, 51.

¹ Napier's *Store-Farm*, 126.

load is allowed to every 100 hogs, and at this rate an acre of turnips, weighing about 15 tons, will keep 100 hogs about 45 days. Mr George Brown, Watten Mains, Caithness, says that the best lot of Cheviot hogs he ever saw were treated in this way.

This treatment, it is obvious, deprives the land of much of the manure derivable from turnips; and hence, before the grain is sown, farm-dung should instead be put on the land, where turnips were raised with phosphate or guano.

Feeding of the older Sheep in a Storm.—As to the older sheep, they must partly depend, in storm, upon the turnips yet in store, and hay. Hay is obtained from the 20 acres of new grass, and allowing 5 acres for cutting-grass for suppers to horses and cows, 15 acres, at 120 stones (of 22 lb.) per acre, give 2400 hay stones, or 3771 imperial. The 1000 ewes will eat $1\frac{1}{2}$ lb. each every day, besides the two cart-loads of turnips amongst them, and the hogs $\frac{1}{2}$ lb. At this rate the hay will last 31 days, a shorter time than many storms endure.

The ground would yield more hay were the young grass top-dressed with a special manure; and besides this, the rule should be to begin with a full hand of hay at the commencement of hill-farming, and preserve what may be left over in a favourable season, to mix with the new of the following, with a little salt, and thus prepare for any unusual continuance of storm. If the supply of home-grown hay is insufficient, it must be made up by purchased hay. It is bad management to run short of hay in a storm.

STELLS FOR SHEEP.

But in a storm provender cannot be given to sheep upon snow safely and conveniently, as ground-drift may blow and cover up both; so no place is so suitable for protecting sheep and provender from drift as *stells*. There are still many store-farmers sceptical of the utility of stells, if we may judge from their practice; but many repetitions of storm are not required to convince any reasonable man that stock are more comfortably lodged within a high enclosure than upon an open heath. A stell may be formed of plantation or high stone wall—

either will afford shelter; but a plantation requires to be fenced by a stone wall.

Outside Stell.—Fig. 89 is a good *outside stell*, formed of plantation. Such has been erected by Dr Howison, of Crossburn House, Lanarkshire, and has

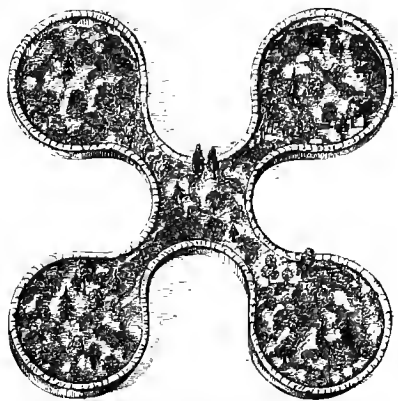


Fig. 89.—Outside stell sheltered by plantation on every quarter.

proved good for many years. The circumscribing stone wall is 6 feet high, the ground within it is planted with trees. Its 4 rounded projections shelter a corresponding number of recesses embraced between them; so let the wind blow from whatever quarter, two of the recesses will always afford shelter. The size of this stell is regulated by the number of sheep kept; but this rule is offered in regard to its power of accommodating stock—that each recess occupies about $\frac{1}{8}$ part of the space comprehended within the extremities of the 4 projections; so that, in a stell covering four acres—which is perhaps as small as it should be—each recess will contain $\frac{1}{2}$ an acre. “But, indeed,” as Dr Howison observes, “were it not from motives of economy, I know no other circumstance that should set bounds to the size of the stells, as a small addition of walls adds so greatly to the number of the trees, that they become the more valuable as a plantation; and the droppings of the sheep or cattle increase the value of the pasture to a considerable distance around in a tenfold degree.”¹

¹ *Trans. Hgh. Soc.*, xii. 334.

Forming Plantation Stells.—In making stells of plantation, it is desirable to plant the outside row of trees as far in as their branches shall not drop water upon sheep in their lair, such dropping never failing to chill them with cold, or entangle their wool with icicles. The spruce, by its pyramidal form, has no projecting branches at top, and affords excellent shelter by its evergreen leaves and closeness of sprays, descending to the very ground. The Scots pine would fill up the space behind the spruce; but every soil does not suit the spruce, so it may be inexpedient to plant it everywhere. Larches being deciduous, their branches are bare in winter. Larches grow best amongst the *débris* of rocks and on the sides of ravines; Scots fir on thin dry soils, however near the rock; and the spruce in deep moist soils. Of the Scots pine (*Pinus sylvestris*) Mr James Brown says: "This is the only one of the pine tribe which can be said to be a native of Britain, and in so far as regards the quality and usefulness of its timber, it is at least inferior to no other species which has yet been introduced, while it becomes a tree of first-rate magnitude in favourable situations. It is one of the most hardy of our forest-trees, being found in Scotland growing fully two thousand feet above the level of the sea. At one period this tree must have been very plentiful in the Highlands of Scotland."¹

Size of Stells.—Stells should be as large as to contain 200 or perhaps as many as 300 sheep on an emergency; and even in the bustle necessarily occasioned by the dread of a coming storm, so large a number as 200 could be shed from the rest, and accommodated in a sheltered recess accessible from all quarters. Thus 5 such stells as fig. 89 would accommodate a whole hirsel of 1000 sheep.

Suppose, then, that 5 such stells were erected at convenient places—not near any natural shelter, such as a crag, ravine, or deep hollow, but on an open rising plain, over which drift sweeps unobstructed, and remains in less quantity than on any other place—with a stack of hay inside and a store of turnips outside,

food would be provided for an emergency. On a sudden blast arriving, the whole hirsel might be safely lodged for the night in the two leeward recesses of one or two of these stells, and, should prognostics threaten a storm, next day all the stells could be inhabited in a short time. Lord Napier recommends a stack of hay to be placed close to the outside of every small circular stell; but so placed, it would arrest the drift which would otherwise pass on.

Concave Stells.—Instead of the small circular stell, Mr Fairbairn recommends a form without plantation, having 4 concave sides, and a wall running out from each projecting angle as in fig. 90—each

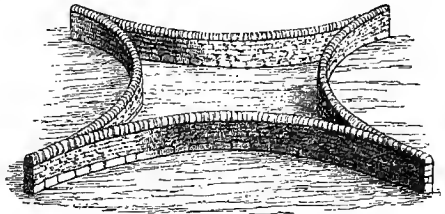


Fig. 90.—Outside stell without plantation.

stell to enclose $\frac{1}{2}$ an acre of ground, to be fenced with a stone wall 6 feet high, if done by the landlord: and if by the tenant, 3 feet of stone and 3 feet of turf; which last construction, if done by contract, would not cost more than 2s. per rood of 6 yards. In this form of stell, without a plantation, the wind would strike against a perpendicular face of the wall in either recess, and being reflected upwards, would throw the snow down immediately beyond the wall, into the inside of the stell; and hence it is that Mr Fairbairn objects to sheep being lodged in the inside of a stell.²

This form, affording more shelter, is not open to the objections to ancient stells, as *a*, *b*, or *c*, fig. 91, the remains of which may yet be seen amongst the hills. The wind, rebounding from the walls of any of these ancient forms of stell, would inevitably throw the snow down upon the sheep within or outside them.

Inside Stells.—Opinion is not agreed

¹ Brown's *Forester*, 237.

² Lammermuir Farmer *On Sheep in High Districts*.

as to the best form of stell for high pastures, where wood is seldom found. At such a height the spruce will not thrive ;

and the larch, being deciduous, affords but little shelter with its spear-pointed top. There is nothing left but the ever-

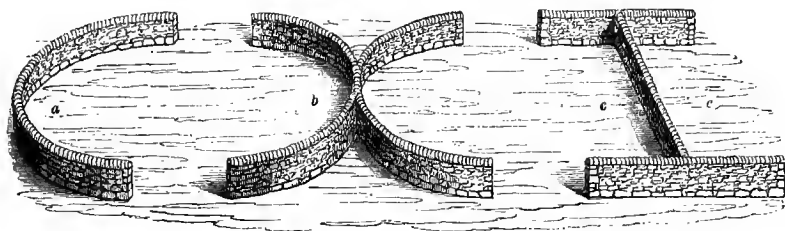


Fig. 91.—Ancient stells.

green Scots fir for the purpose, and when surrounding a circular stell *a*, fig. 92, it would afford acceptable shelter to a large number of sheep. This stell consists of 2 parallel circles of wall, enclosing a plantation of Scots pine, having a circular space, *a*, in the centre for sheep, as large

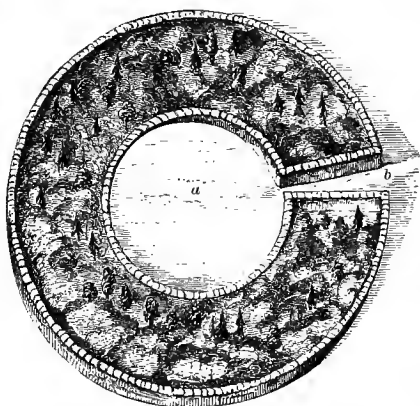


Fig. 92.—Inside stell sheltered by plantation.

as to contain any number. This may be denominated an *inside* stell, in contradistinction to the outside one in fig. 89, and has been proved efficient by the experience of Dr Howison. Its entrance, however, is erroneously made wider at the mouth than at the end next the interior circle, *a*, which produces the double injury of increasing the velocity of the wind into the circle, and of squeezing the sheep the more the nearer they reach the inner end of the passage. The walls of the passage should be parallel, and curved to break the force of the wind.

Circular Stells.—But where trees cannot be planted with a prospect of success, stells may be formed without them, and indeed usually are ; and of all forms that have been tried, the *circular* has obtained the preference on hill-farms, but determining the best size is still a matter of dispute amongst hill-farmers. Some think 8 to 10 yards inside measurement best ; others prefer a larger size, perhaps 18 yards. The circular form of any size is better than a square, a parallelogram, or a cross ; because the wind striking against a curved surface, on coming from any quarter, is divided into two columns, each weaker than the undivided blast ; whereas, on striking against a straight surface, though its velocity is somewhat checked, it is still undivided, and its force still great, when it springs upwards, curling over the top of the wall, and throwing down the snow a few yards within the stell. Any one who has noticed drifts of snow on each side of a straight stone wall, will remember that the leeward side of the wall is completely drifted up, while on the windward side a hollow is left, often clear to the ground, between the drift and the wall. Every stell, therefore, that presents a straight face to the drift, will have that fence drifted up and be no protection to sheep. Of two curves, that which has the larger diameter will divide the drift further asunder. A stell of small diameter, as 7 yards, divides a current of air which, on reuniting above, immediately lets the snow it carries fall into the stell. A stell of large diameter, of 18 yards, on dividing a column of air, deflects it so much on each side that it

has passed beyond the stell before it reunites and deposits its snow; and hence the snow is found to fall in a triangular shape, with its apex away to leeward of the stell, and leaves the interior free.

Fig. 93 is a stell of 18 yards diameter inside, surrounded by a wall 6 feet high, the first 3 feet of stone, the other 3 feet of turf; costs 2s. 4d. per rood of 6 yards if erected by the tenant, and if wholly of stone, with a cope, by the landlord, 7s. per rood; will embrace $9\frac{1}{3}$ roods, at a cost of £3, 5s. 4d., including quarrying and carriage of stones—a trifling outlay compared to the permanent advantage

derived from it on a hill-farm. The opening into the stell should be from the side towards the rising ground, and its width 3 feet. Such a structure as this will easily contain 10 score of sheep for weeks, and even 15 or 16 score may be put into it for a night without being too much crowded.

A great improvement is effected on round stells by building dykes the same height as the wall of the stell out from the stell at the four opposite points, *a*, *b*, *c*, and *d*, fig. 93. The spaces enclosed afford excellent shelter for sheep from any quarter, and the longer the dykes

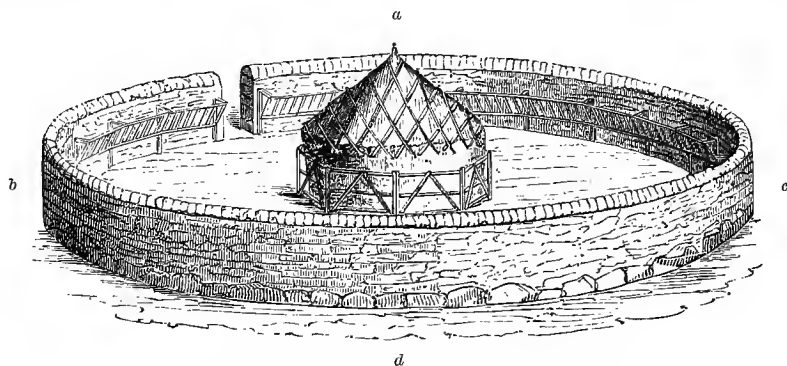


Fig. 93.—Circular stell, with hay-racks and hay-stack.

the greater the amount of shelter provided.

Giving Hay at Stells.—Circular stells should be fitted up with *hay-racks* round the inside, not in the expensive form of circular woodwork, but of a many-sided regular polygon. It is a bad plan to make sheep eat hay by rotation, as some recommend, because the timid and weak will be kept constantly back, and suffer much privation for days at a time. Let all have room and liberty to eat at one time, and as often as they choose. The hay-stack should be built in the centre of the stell, on a basement of stone, raised 6 inches above the ground to keep the hay dry. A small stack, 5 yards in diameter at base, 6 feet high in stem, with a top 6 feet in height, will contain about 450 hay-stones of hay, which will last 200 sheep 33 days; but upon that base a much greater quantity of hay might be built. The hay-stack requires strong thatching. The circum-

ference of the stell measures 160 feet round the hay-racks; and were 8 or 9 six-foot hurdles put round the stack, at once to protect the hay and serve as additional hay-racks, they would afford 47 feet more—which would give 1 foot of standing-room at the racks to each of 200 sheep at one time.

It is well to have some turnips stored near the stells for use in a protracted snowstorm.

Natural Shelter.—As long as the ground continues green, natural shelter is as requisite as stells: this consists of rocks, crags, braes, bushes, heather, and such like. To render this as available to sheep as practicable, the ground should be cleared of all rubbish around them, and bushes planted in places most suited to their growth, such as the whin (*Ulex europæa*), in poor thin clay, and it is a favourite food of sheep in winter; the broom (*Genista scoparia*), on rich light soil; the juniper (*Juniperus communis*),

in sandy soil; the common elder (*Sambucus nigra*), in any soil, and it grows well in exposed windy situations; the mountain-ash (*Pyrus aucuparia*), a hardy grower in any soil; and the birch, when bushy (*Betula alba*), grows in any soil, and forms excellent clumps or hedges for shelter, as well as the hazel (*Corylus avellana*) and the common heaths (*Erica vulgaris* and *tetralix*), when they get leave to grow in patches to their natural height in peaty earth.

Whins and Broom.—Many sheep-farmers, who are alive to their business, fill their pockets every spring morning with the seeds of the whin and broom, and in their walks over the sheep-farm, scatter these seeds on any likely spot. These eventually provide food for sheep in a stormy winter, besides—especially if a favourable winter occurs after they are sown—growing into strong bushes which afford excellent shelter.

Benefits of Planting.—It is allowed by all who have given their attention to the improvement of waste lands in our country, that the rearing up of healthy plantations improves the general climate of the neighbourhood; and not only is the climate improved to a great degree, but the very soil upon which forest-trees grow is much improved by the gradual accumulation of vegetable matter from them. I would ask the plain question, What is the natural cause of so much waste land being found in the north of Scotland, and in many parts of England? Can it be denied that it is the want of trees to give shelter? Why is it that the proprietors of land complain so much of great tracts of it being worthless, growing nothing but the inferior grasses, mosses, rushes, and heaths, upon which even one sheep cannot find food upon two acres? Is it not for the want of plantations to give shelter?¹

Sheep Cots or Sheds.—Much diversity of opinion exists regarding the utility of *sheep-cots* on a store-farm. These are rudely formed houses, in which sheep are put under cover in wet weather, especially at lambing-time. Lord Napier recommended one to be erected beside every stell, to contain the hay in winter if necessary; and Mr Little

advises them to be built to contain the whole hirsel of sheep in wet weather. It seems a chimerical project to house a large flock of sheep for days, and perhaps weeks; and, if practicable, could not be done but at great cost. Others object to sheep-cots on high farms, because, when inhabited in winter, even for one night, by as many sheep as would fill them, an unnatural height of temperature is thereby generated. Cots may be serviceable at night when a ewe or two become sick at lambing, or when a lamb has to be mothered upon a ewe that has lost her own lamb; and such cases being few at a time, the cot never becomes overheated.

Paddocks for Sheep.—In an unsheltered store-farm it is requisite to have two paddocks, which are sufficient to contain all the invalid sheep, tups, and twin lambs, until strong enough to join the hirsel.

Penning Rams in Autumn.—Tups may graze with the hirsel in the early part of summer; but as no ordinary wall will confine them in autumn, they should be penned in one of the stells, or in some enclosure near the steading, on hay or turnips, until put to the ewes.

Bridging Rivulets for Sheep.—Where a rivulet passes through an important part of a farm, it will be advisable to throw *bridges* across it at convenient places for sheep to pass along to better pasture, or better shelter on the opposite bank. Bridges are best constructed of stone, and though rough, if put together on correct principles, will be strong; but if stone cannot be found fit for arches, they may do for buttresses, and trees laid close together across the stream, held firm by transverse pieces, and then covered with tough turf, form a safe roadway.

Altitude of Sheep-farms.—The highest hill-farms for sheep in Scotland occupy an altitude ranging from 1500 to 3000 feet and upwards above the sea, and indeed some of them extend to the highest points of our mountain-ranges.

At such elevations pasture must necessarily be coarse and scanty, consisting entirely of alpine plants. A considerable extent of such herbage is required to support a single sheep during the year, and consequently the farms are of great

¹ Brown's *Forester*, 8, 9.

extent, many of them extending miles in length, and embracing many thousand acres.

Blackfaced Sheep for High Altitudes.—The Blackfaced breed is admirably suited for occupying the highest range of farms, having not only a bold and daring disposition, capable of enduring much fatigue in search of food, but a hardy constitution, and yielding most delicious mutton.

Little Breeding on High Farms.—The circumstance of elevation and seclusion from roads imposes in the treatment of this breed a difference from that pursued in the lower country. Many sheep-farmers in the lower country who breed Blackfaced sheep sell what lambs they can spare after retaining as many as will keep their ewe-stock fresh. They thus dispose of all their wether hoggs, the smaller ewe hoggs, and draft ewes. Suppose 1000 ewes wean 1000 lambs, 500 of these will be wether and 500 ewe hoggs, of which latter 17 score, or 340, will be retained, to replace one-sixth of the ewes drafted every year, and the remaining 160, together with the 500 wether lambs, will be disposed of. The high hill-farmer purchases those lambs, rears them until fit, as wethers, to go to the low country to be fed fat on turnips; and, in acting thus, he never keeps breeding ewes. Many farmers hold both high and low farms, breeding and wintering on the latter, and sending the yeld sheep to the high farm during summer and the greater part of autumn.

Young Sheep best for Hill-farms.—The state of hill-pastures modifies the management on hill-farms. The hill-pasture does not rise quickly in spring, nor until early summer; and when it does begin to vegetate it grows rapidly, affording a full bite. It is found that this young and succulent herbage is not congenial to the ewe—it is apt in the autumn to superinduce in her the liver-rot; but it is well adapted for forwarding the condition and increasing the size and bone of young sheep. It is therefore safer for hill-farmers to purchase lambs from south-country pastoral farmers, who breed Blackfaced sheep largely, as well as Cheviot, than to keep standing flocks of ewes of their own. The winter half-year, too, on the hills, is a long period

to sustain a flock of ewes on extraneous food.

Turnips on Hill-farms.—Many hill-farmers are adverse to giving turnips to their sheep in winter, although this objection is not nearly so strong as in former times. Whatever may prompt hill-farmers to object to arable culture, reasons would require to be very strong to prove that Blackfaced sheep would not thrive on turnips on the hills. Doubtless on many farms, far removed from great roads, it would be difficult to bring even a favoured piece of ground into culture, and to raise green crops with even light manures; but there are many glens among the hills not far removed from tolerable roads, which might be cultivated to advantage, and the green crop and hay from which might maintain the flock well through a stormy period.

Hay for Hill-sheep.—Hill-sheep, however, getting hay in spring when the ground is covered with snow, will be some days before they will eat it, and will fall fast off in condition. Sheep so treated on their own ground will scrape the snow to get at the grass rather than eat the hay. When off their own ground they will eat it more readily. Hill-sheep getting turnips, hay, or other extra food in winter, fall fast off in condition when the snow falls again on their ground after having this artificial feeding; and this is perhaps one of the considerations which have weighed with hill-farmers in their reluctance to adopt turnip-feeding.

Utility of Arable Land on Hill-farms.—As a corroborative proof of the utility of cultivated land on hill-farms, is the practice of taking turnips or rough grazings for stock in the lower part of the country, as near their own homes as food can be procured; and of Lowland farmers, who possess hill-farms, bringing their sheep to the low country in winter, and putting them on turnips. If turnips and rough hay so taken will repay, much more would they repay if raised at home; and when sheep are thus brought safe through the dreary part of winter, they would have the additional advantage of the conveniences of home when snow covered the ground for weeks together. Stores of turnips and stacks of hay would thus be as useful at home as abroad; and when these failed, whins and bushes

would afford as good food at home as at a distance.

Scots-fir Leaves for Sheep.—Where a Scots-fir plantation is near a haunt of sheep, these need not starve, even in a snowstorm; for a daily supply of sprays, fresh cut from the trees, will support them as heartily as hay alone; and if hay is given along with the fir-leaves, they will thrive better than on either alone.¹

Losses from want of Shelter on Hill-farms.—The want of adequate shelter at home may induce some hill-farmers to send their stock to the low country in winter. The hills are bare of wood, the few trees being confined to the glens, and the sheep can find no shelter in their usual grounds; and it is surprising how susceptible of cold even Blackfaced sheep are when the atmosphere is becoming moist. They will cower down, creep into corners and beside the smallest bushes for shelter, or stand hanging their heads and grinding their teeth, having no appetite for food. If a piercing blast of wind follows such a cold day, the chances are that not a few of them perish in the night; and if thick snow-drift comes on, they drive before it, apparently regardless of consequences, and descend into the first hollow, where they are overwhelmed. Thus the utility of stells becomes manifest, and many hearty wishes are no doubt expressed for them by the farmer and his shepherds when they have them not in the hour of peril.

Such regrets, however, are no substitute for the necessity, the utility, the humanity of cultivating such an extent of ground, in favoured spots, as would raise food to support the whole flock through the protracted period of the longest storm. The bad effects of storms should be the strongest incentives to make extensive plantations for shelter on all mountain-ranges. Though some trees might fail to grow, it does not follow that others would not grow well enough to afford invaluable shelter in the bleakest period of the year. At least, the catastrophes of winter should urge hill-farmers to construct commodious stells in the most exposed situations.

Bratting Sheep.—There are other modes of protecting hill-sheep from the severities of weather besides stells, and which may be regarded as more personally comfortable to them. One of these is *bratting*, which is covering the sheep with a cloth.

But this method is impracticable except in a very small flock, as the expense is great, and it is now seldom if ever attempted.

A brat may be made in five minutes, and fitted on in other five. The method

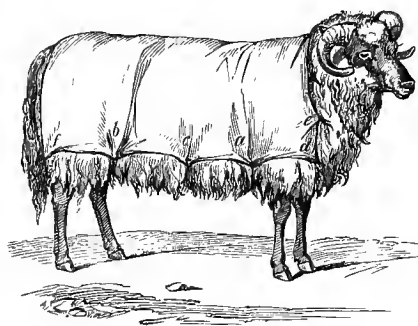


Fig. 94.—Bratted sheep.

- a A tie below the belly behind the shoulder.
- b One before hind legs.
- c Under the middle of the belly.
- d e Across the breast.
- f Behind the hind legs.

of bratting a sheep is seen in fig. 94, representing a bratted sheep.

Irrigation on Hill-farms.—Since hay is the principal food for mountain sheep in snow or black frost, it is of importance to procure this valuable provender in the best state, and of the best description. It has long been known that irrigation promotes, in an extraordinary degree, the growth of natural grasses; and perhaps there are few localities which possess greater facilities for irrigation, though on a limited scale, than the Highland glens of Scotland. Rivulets meander down those glens through haughs of richest alluvium, which bear the finest description of natural pasture plants. Were those rivulets subdivided into irrigating rills, the herbage of the haughs might be multiplied many fold, and hill-farmers are earnestly urged to convert them into irrigated meadows. Although each meadow may be of limited extent, the

¹ Little On Mount. Sheep, 44.

grass they afford is greatly increased in quantity and value when converted into hay.

One obstruction alone existing to the formation of meadows is, the fencing required to keep stock off while the grass is growing for hay. But the fencing should be made for the sake of the crop protected by it. Hurdles make an excellent fence. This difficulty is now greatly lessened by the introduction of cheap wire-fences. Besides places for regular irrigation, there are rough patches of pasture, probably stimulated by latent water performing a sort of under-irrigation to the roots of the plants, which should be mown for hay; and to save further trouble, *this* hay should be ricked on the spot, fenced with hurdles, around which the sheep would assemble at times to feed through them in frosty weather from the rick, and wander again over the pasture for the remainder of the day; and when snow came, the stells would be the places of refuge and support. As the hay in the stack is eaten, the hurdles are drawn closer to the stack, to allow the sheep again to reach the hay.

The practice now generally adopted, however, is to lay out the hay in hand-fuls on the snow, keeping plenty of room between the lines of hay.

Construction of Hurdles.—Hurdles are constructed in different forms. Fig. 69 is the strongest and most durable, but also the most expensive in the first cost. Each hurdle, with its fixtures, consists of 14 pieces—viz., 2 side-posts *a*, 4 rails *b*, and 3 braces *c*, *d*, *d*, which form the single hurdle; and 1 stay *f*, 1 stob *g*, and 4 pins *g*, *h*, and *i*, are required for fixing each hurdle. The scantling of the parts are the side-posts *a*, 4½ feet long, 4 inches by 2 inches. The rails *b*, 9 feet long, 3½ inches broad by 1 inch thick. The braces, 2 diagonals *d*, 5 feet 2 inches long, 2¼ inches broad, by ¾ inch thick; and 1 upright *c*, 4 feet long, and of like breadth and thickness. The stay *f* is 4½ feet long, 4 inches broad, and 2 inches thick, and bored at both ends for the pins; the stob *g*, 1½ foot long, pointed and bored. The pins *h* *i*, 1 foot 1¼ inch diameter.

The preparation of the parts consists in mortising the side-posts, the mortises

being usually left round in the ends, and they are bored at equal distances from the joining and stay pins. The ends of the rails are roughly rounded on the edges, which completes the preparation of the parts; and when the flake is completed, its dimensions are 9 feet in length, and 3 feet 4 inches in breadth over the rails; the bottom rail being 9 inches from the foot of the post, and the upper rail 5 inches from the head.

Another form of flake, more extensively employed, has 5 rails, which are 1¾ inch square. The ends of the rails are turned round by machinery, and the side-posts bored for their reception, as well as the pins, also by machinery. The bottom rail is 9 inches from the foot of the posts; the spaces *between* the first and second, and the second and third rails, are each 7 inches, and the two upper spaces are respectively 8 and 9 inches, leaving 5 inches of the post above the upper rail.

Growing Willows for Hurdles.—Where the common crack-willow (*Salix fragilis*) will grow, every farmer may have poles enough every year for making 2 or 3 dozen hurdles to keep up his stock. To establish a plantation, large cuttings 9 or 10 feet long should be pushed, not driven, into moist soil, and on being fenced from cattle, will soon shoot both in the roots and head, the latter being fit to be cut every seventh year.

A larger kind of hurdle, called *park hurdles*, worth 2s. each, is made for subdividing meadows or pastures, and are a sufficient fence for cattle. The small hurdles are used for sheep, the larger to fence cattle, whereas the Scotch flakes answer both purposes at once, and are therefore more economical.

Sheep-nets.—*Nets*, which confine sheep on turnips in winter, are made of good hempen twine, and the finer the quality of hemp, and superior the workmanship bestowed on it, the longer will nets last. Being necessarily much exposed to the weather, they soon decay, unless properly prepared and cared for. Now, it is the custom to dip sheep-nets in a preparation of tar and oil, which has a most beneficial effect, increasing their durability considerably. A net properly treated should last 4 or 5 years.

Nets are wrought by hand and by machinery. By hand they are simply made of *dead netting*, which consists of plain work in regular rows. A shepherd ought to know how to make nets as well as mend them, and cannot mend them well unless he understand how to make them. Net-making is a very suitable occupation for women. Nets made by hand will last longer than those made by machinery.

All the instruments required in this sort of net-making are a *needle* and *spool*. "Needles are of two kinds,—those made alike at each end with open forks, and those made with an eye and tongue at one end and a fork at the other. In both needles the twine is wound on them nearly in the same manner—namely, by passing it alternately between the fork at each end, in the first case, or between the fork at the lower end and round the tongue at the upper end, in the second case; so that the turns of the string may lie parallel to the length of the needle, and be kept on by the tongue and fork. The tongue-and-eye needle is preferable both for making and mending nets, inasmuch as it is not so liable to be hitched into the adjoining meshes in working; but some netters prefer the other kind, as being capable of holding more twine in proportion to their size." An 8-inch needle does for making nets, but a 4-inch one is more convenient for mending them.

Spools, being made as broad as the length of the side of the mesh, are of different breadths. They "consist of a flat piece of wood of any given width,

of *stout* wood, so as not to warp, with a portion cut away at one end, to admit the finger and thumb of the left hand to grasp it conveniently. The twine in netting embraces the spool across the width; and each time that a loop is pulled *taught*, half a mesh is completed. Large meshes may be made on small spools, by giving the twine two or more turns round them, as occasion may require."

"In charging your needle, take the twine from the *inside* of the ball. This prevents tangling, which is at once recommendation enough. When you charge the needle with *double* twine, draw from two separate balls."¹

In joining the ends of *twine* together, in mending, the *bend* or *weaver's knot* is used; and in joining top and bottom ropes in setting nets, the *reef-knot* is best, as the tighter it is drawn the firmer it holds.

Sheep-nets run about 50 yards in length when set, and weigh about 14 lb. Hogg-nets stand 3 feet in height, and wethers 3 feet 3 inches, and both are set 3 inches above the ground. The mesh of the hogg-net is $3\frac{1}{2}$ inches in the side, and $9\frac{1}{2}$ meshes are required; and of the wether $4\frac{1}{2}$ inches, and $8\frac{1}{2}$ meshes are required.

It is imagined that nets will not confine Blackfaced sheep on turnips, because they would be broken by being entangled in the sheep's horns; but the objection is unfounded, as horned sheep soon learn to keep clear of the net.

The *diseases of sheep* will be treated of in a subsequent section.

CATTLE IN WINTER.

HOUSING OF CATTLE.

The construction of farm-buildings does not come within the ordinary routine of farm-work. It is a matter of the utmost importance for the successful management of a farm, and may be most conveniently considered by itself, with other outstanding subjects.

Before the advent of the winter season cattle of all kinds have been assigned to their winter quarters, in which we find them when we set out upon the round of the agricultural year. Assuming, then, that houses of a suitable kind have been provided, we shall here notice only some

¹ Bathurst's *Notes on Nets*, 15, 17, and 138.

points, connected with buildings, which have a direct and specially important bearing upon the winter rearing and feeding of stock.

Accommodation in Steadings.—As a farm of mixed husbandry comprises every variety of culture, so its steadying should be constructed to *afford accommodation for every variety of produce*. The grain and straw, being useful and bulky articles, should be accommodated with room as well after as before they are separated by threshing, which process is executed with horse, water, or steam power. Room should also be provided for every kind of food for animals, such as hay and turnips.

Of the animals themselves, the horses being constantly in hand at work, and receiving their food daily at regular intervals of time, should have a stable which will not only afford them lodging, but also facilities for consuming their food. Similar accommodation is required for cows, the breeding portion of cattle. Calves have cribs as long as very young, and a court with shed afterwards. Young cattle are usually reared in partially or entirely roofed spaces, called courts, with troughs for food and water. Cattle feeding for sale are either put into courts, or into small sheds called hammels, or fastened to stakes in byres or loose in boxes. Young horses are reared either by themselves in courts with sheds and mangers, or kept with the young cattle. Young pigs often roam about everywhere, and lodge amongst the litter of young cattle; whilst sows with sucking-pigs are provided with small enclosures, fitted up with a littered apartment at one end, and troughs for food at the other. It is considered useful to have a few young pigs running through cattle courts, to pick up refuse, but, as a rule, even young pigs will be found worthy of apartments for themselves. In any case, pigs should not be allowed to roam all over the steadying, making things untidy, which, by the way, they much delight in doing.

The smaller implements of husbandry, when not in use, are put into a suitable apartment; whilst the carts are provided with a shed, into which also some of the larger implements which are only occa-

sionally used are stored by. Wool is stored in a cool clean room. An apartment containing a furnace and boiler, to heat water and prepare food when required for any of the animals, is most useful in a steadying.

These are the principal accommodations required in a steadying where live stock are housed; and in the most convenient arrangement of the apartments, the entire building will cover a considerable space of ground.

Arrangement of the Steading.—The leading principle on which these arrangements are determined is very simple. Straw being the bulkiest article on the farm, heavy and unwieldy, in daily use by every kind of live stock, and having to be carried and distributed in small quantities by bodily labour, its receptacle, the *straw-barn*, occupies the central part of the steadying, and the several apartments for live stock are easily accessible from it.

That so bulky and heavy an article as straw should in all circumstances be moved to short distances, and not at all, if possible, from any other apartment but the straw-barn, the *threshing-machine*, which supplies the straw from the grain, is placed so as to throw the straw into the straw-barn.

The *stack-yard*, containing the unthreshed straw with its corn, is contiguous to the threshing-machine.

The passage of straw from the stack-yard to the straw-barn through the threshing-machine being directly progressive, the stack-yard, threshing-mill, and straw-barn are most convenient when placed in a line, and in the order mentioned.

Different classes of stock require different quantities of straw to maintain them in the same degree of cleanliness and condition. Those requiring the most are therefore placed *nearest* the *straw-barn*.

Attention to Littering.—When cattle are put into their winter quarters, it is specially important that careful attention should be given at the outset to littering. Their apartment, be it close houses or courts, should be liberally littered with straw, for a thin layer at first is uncomfortable, and will soon be compressed down. A thick layer of straw is not

only comfortable in itself, but acts as a drain for a long time, whether to urine or rain, in whatever size of courts.

Sometimes a deficiency of straw is experienced in the early part of winter, from various causes, amongst which may be mentioned a dislike in farmers to begin to thresh the new crop in early winter, even when no old straw or old stack of corn is left from the former crop; and a ready excuse is found in the want of water or wind, or disinclination to put on steam to move the threshing-machine: but however recently built the stacks may be, or inconvenient to thresh their produce at the time potato-lifting or wheat-sowing is going on, it should be done rather than stint cattle of bedding; for should bad weather ensue—an event not unlikely to happen—cattle become chilled at once in ill-littered quarters, especially at first, and a great part of the winter may be gone ere they recover from its effects; and hence arise diseases and serious suppression of condition.

With even plenty of old stacks, a want of water to drive the threshing-machine may really be experienced, and this is no uncommon occurrence in the beginning of winter on farms which depend upon surface-water only for their supply; and a windmill is in no better condition at that season from want of wind. In case such contingencies *may* happen, it is the duty of the farmer to provide a sufficient quantity of litter in good time; and there are various ways of doing it. Those who still use the flail may employ it at any season; and those having horse threshing-mills are equally independent of water and wind.

Substitutes for Straw as Litter.—Bog-land supplies coarse herbage, which, being made into hay in summer, makes excellent litter; but precaution is requisite in using fresh or even old grassy turf as a bottoming for the litter of courts, as it absorbs water like a sponge on the first fall of rain, when scarcely any quantity of straw will prevent the cattle trampling the bedding into a poached mass.

“Peat-moss litter”—dry compressed peat—is now extensively used with excellent results, especially for horses. Ferns cut and dried, as also dried rushes,

grass, and fallen leaves from woods, form an excellent foundation for litter.

By one or all of these means a comfortable bed may be provided for cattle at the commencement of winter, independently of straw.

Rones.—Another point which should have immediate attention, if it has not already been looked to, is the condition of the rones around the eaves of farm-buildings. If *rones* (rain-water spouts) were put up along the eaves of all the roofs of the sheds and hammels connected with any court, they would render every court comfortably dry. This safeguard against wet is much neglected in the steadings of this country.

Cattle-troughs.—All cattle-courts and hammels should be provided with *troughs for turnips*, and they are placed conveniently against the walls, as in fig. 95. Some board the bottom with wood;

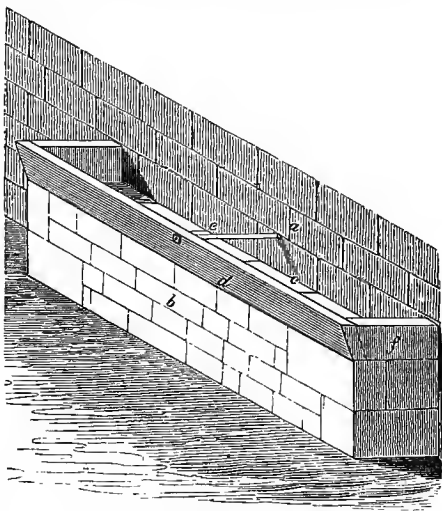


Fig. 95.—Turnip-trough for courts.

- a The wall.
- b Building to support bottom of trough.
- c Pavement bottom of trough.
- d f Planking of front and end of trough.
- e Iron bar to strengthen the planking.

and, where that is plentiful, it is cheap, and answers the purpose, and is pleasanter for cattle in wet and frosty weather; but where pavement can be easily procured, it is more durable. A plank 3 inches thick and 9 inches in depth keeps in the turnips. Old plank-

ing from wrecks, and old spruce-trees, however knotty, have been found a cheap and durable front planking for turnip-troughs. The planks are spliced together at their ends to any length, and held on edge by rods of iron battled with lead into the wall, and fixed with nut and screw. The height in front should be 2 feet 9 inches for calves, and 3 feet for older beasts, and it will become less as the straw daily accumulates. This form of trough is also used in the ham-mels. Turnip-troughs for boxes are made of wood. Those short in length for byres are made of pavement or stone.

In fig. 96 is represented a very convenient movable cattle-trough, made by

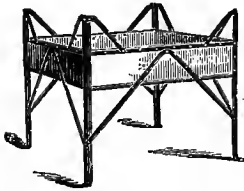


Fig. 96.—Iron cattle-trough.

E. Thomas & Co., Oswestry. It is constructed of extra strong galvanised iron, fitted to an angle-iron frame.

Concrete Troughs.—

Troughs are now frequently made of concrete, and when made of good material—good Portland cement and sand and gravel, free from earthy matter—are very durable.

“In making troughs of concrete, it is first of all necessary to have the sides framed with smooth planks, leaving sufficient space between the double rows for the desired thickness of concrete. In making the concrete, 1 part of Portland cement goes to 6 or 7 of broken stone, burnt ballast, gravel, or slag. These last must be free from loam, mud, fine sand, or dirt of any kind. This mixture is used for the bottom and the side, and allowed to stand for 12 or 18 hours to harden, when a thin coating of cement and good water-sand in about equal proportions is put on for a finish. The mould-boards should always be well soaped before the concrete is poured in. If Roman cement is used, it must be remembered that it is only one-third the strength of the above.”¹

Troughs made of fire-clay are clean, durable, and convenient. Asphalt is not suited for turnip-troughs, as it be-

comes soft in the sun and heat under cover, and is easily fractured at any time.

Straw-racks.—*Straw-racks for courts* are made of various forms. A common kind is in fig. 97, of a square form,

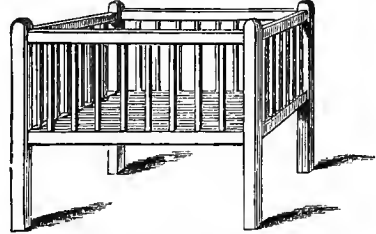


Fig. 97.—Wooden straw-rack for courts.

spurred round the sides and bottom to keep in the straw. It stands upon the litter. The cattle draw the straw through the spars as long as its top is too high for them to reach over it, but after the dung accumulates, and the rack thereby becomes low, they get at the straw over the top. It may be pulled up as the dung accumulates. It is made of wood, 5 feet square and 4 feet in height.

Fig. 98 is a rack of malleable iron to supply the straw always over its top, and

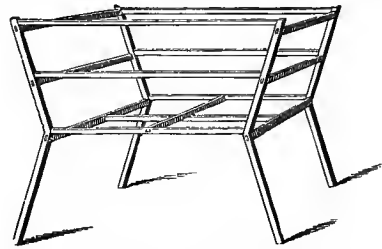


Fig. 98.—Malleable-iron straw-rack for courts.

is rodded in the sides to keep in the straw. It remains constantly on the ground, and is not drawn up as the dung accumulates. It is 5½ feet in length, 4½ in breadth, and 4½ in height; the upper rails and legs are of 1 inch square iron, and the other rails ¾ inch. This is a durable straw-rack.

A very useful combined rack and feeding-trough, specially suited for calves, made by E. Thomas & Co., Oswestry, is shown in fig. 99.

Turnip-stores.—Few things indicate

¹ *Farming World*, June 1888, 485.

greater care for cattle than providing stored turnips for their use—being not only convenient, but the best mode of keeping them clean and fresh. The turnip-stores should be placed as near as possible to the cattle, and be easy of access to carts.

Water - supply in Buildings.—Supply of water to courts is of paramount consideration. Water-troughs may be supplied with water either directly from pump-wells, or by pipes from a fountain at a distance. As a pump cannot conveniently be placed at each trough, we have found a plan of supplying any number of troughs from one pump to answer well, provided the surface of the ground will allow the



Fig. 99. — Combined rack and trough.

troughs being placed *nearly* on the same level. One plan is to connect the bottoms of two or more troughs on the same level with lead pipes placed under ground; and on the first trough being supplied direct from the pump, the water will flow to the same level in all the other troughs. This arrangement is so far objectionable, that when one of the troughs is emptying by drinking, the water is drawn from the other troughs at the same time, but then the quantity drawn from any single trough is small.

Position of Water-troughs.—Were a receiving-trough placed a few inches *below* the top of the supplying one, and were a lead pipe to come from the bottom of the supply-trough over the edge of the receiving, the water might be entirely emptied by drinking in one, without affecting the quantity in the

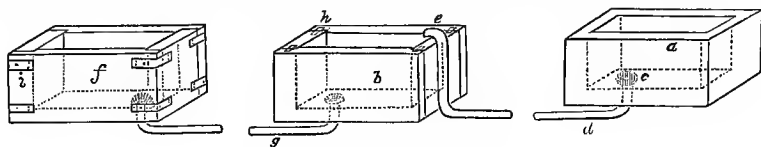


Fig. 100. — Water-troughs for courts.

other. Let *a*, fig. 100, be the supply-trough immediately beside the pump in one court, and let *b* be the trough in another court, 3 inches below the level of *a*. Let a lead pipe *d* be fastened to the bottom of *a*, the orifice raised up, and protected by the hemispherical drainer *c*. Let this lead pipe *d* be passed under ground to the trough *b*, and emerge by its side over the top at *e*. When *a* is filling with water from the pump, the moment the water rises in *a* to the level of *e*, it will flow into *b*, and continue to do so until *b* is filled, if the pumping be continued. The water in *a*, *below* the level of *e*, may be used in *a* without affecting that in *b*, and the water in *b* may be used at all times without affecting that in *a*.

Water-troughs.—Water-troughs may be made of various materials: *a* is hewn out of a solid block of freestone, which makes the closest, most durable, and best trough. If of flagstones, as *b*, the sides are sunk into the edges of the bottom in grooves luted with white-lead, and held

together with iron clasps *h* at the corners. This makes a good trough, but is apt to leak at the joints. Trough *f* is made of wood dovetailed at the corners, luted with white-lead, and held together by clasps of iron *i*. When made of good timber and painted, they last many years. They are frequently made of cast-iron.

Water-cistern.—Water-troughs are sometimes supplied from a large cistern, somewhat elevated above their level, and filled from a well with a common or force pump. In this case a cock, or ball-and-cock, is required at each trough: if a cock, the supply must depend on the cock being turned in due time; and if a ball-and-cock, the supply depends on the cistern having water in it: but this method is expensive, and liable to go out of order when cattle have access to it.

In an abundant supply of water from natural springs, accessible without a pump, a lead pipe would emit a constant stream of water into each trough, the surplus being conveyed by drains to the horse-pond.

Still another mode may be adopted where water is plentiful, and it flows constantly into a supply-cistern. Let the supply-cistern be 2 feet in length, 1 foot wide, and 18 inches in depth, provided with a ball-and-cock, and let a pipe proceed from its bottom, as *g* in trough *b*, fig. 100, to a trough *f*, into which let the pipe enter by the end or side a little way, say 3 inches, below its mouth. Let a pipe proceed from the end of trough *f* into the end of another trough, and so on, into the ends of as many succeeding troughs, on the same level, as are required, and when the water is withdrawn

by drinking from one trough, the ball-and-cock will replenish it direct from the supply-cistern. The objection to the ball-and-cock does not apply in this as in the other case, as they are out of the reach of cattle.

Hydraulic Ram.—Where no water can be found at the steading by a well, should a rivulet pass it at a lower level, a good supply of water might be obtained by means of a hydraulic ram (p. 26), fig. 101, where *a a* is the supply-pipe, which leads the running stream down to the chamber *b b*, bolted to the bed-plate *c c*. A valve *d d* is provided to the

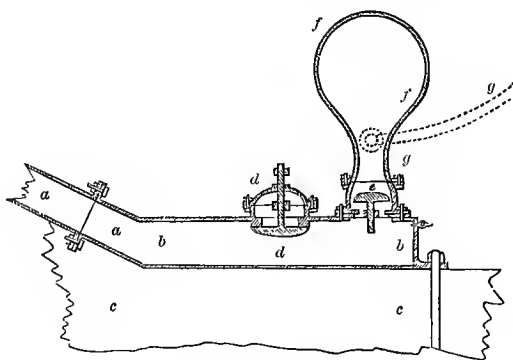


Fig. 101.—Section of hydraulic ram.

chamber *b b*, which has a tendency to fall from its seat so as to keep the water-way open, till the stream flowing from the pipe *a a* acquires sufficient momentum to close it. The velocity of the stream being thus checked, the water raises the valve *e*, which moves the reverse way of the valve *d d*, and enters the air-vessel *f f*, from which it is finally passed by the pipe *g g*, which can be raised to any required elevation to a supply-cistern above the level of the ram. On the water passing into the air-chamber *f f*, it is pressed upon by the air in the upper part of the vessel, which closes the valve *e*. The momentum of the flowing stream in the pipe *a a* and chamber *b b* being thus exhausted, the valve *d d* falls, and allows the water to escape from *b b* through the valve-opening, till the flowing stream acquires such momentum as again to close the valve *d d*. When this happens the valve *e* is again opened, and a second quantity of water discharged

into the air-vessel *f f*. The action thus described goes on continually, night and day, resulting in a regular beating or pulsation of the valves *e, d d*, each rising and falling alternately.¹

Protection to Timid Animals.—The sheds of large cattle-courts are usually provided with more than one arched port, with the view of allowing a timid animal to escape by one of the openings while chased by an unruly companion. But both the safety and comfort of cattle are more secure with only one port *at one end* of the shed, because then there will be no corner at the outlet to pin the timid one into, and draughts of air will thereby be prevented through the shed—the laudable object of escape to the ill-used one being thus ensured, while the comfort of all will not be sacrificed for the safety of one; and it is doubtful, after all, if the danger can be avoided until a general

¹ See *Book of Farm Imple.*, 543.

agreement ensues among the cattle after a common use of the same apartment for a time. Cattle bought from different quarters are much less likely to agree in the same court than those brought up together from calf-hood.

The risk of loss by animals injuring each other is lessened by carefully assorting the lots, so that, as near as possible, cattle of one age and size may be together. It is desirable not to have too many in one apartment—not more than 20, and as few as 8 or 10 if convenient.

Hammels.—A hammel consists of a shed and an open court, communicating by a large opening. A convenient hammel for two oxen is one 12 feet by 10, with a court 14 feet by 10. A straw-rack should be fastened against the inner wall of the shed. A water-trough at a corner of the court is a requisite. To give permanency to hammels, sheds should be roofed like the other buildings. Temporary erections are constantly requiring repairs, and in the end cost as much as substantial work. There should be rones. The opening of the shed, 5 feet in width, should be at one side, and not in the middle of the hammel, to afford more room and warmth to the interior. The corners of the scuncheon should be chamfered, to save the cattle being injured against sharp angles. The division-walls betwixt the courts should be of stone and lime, 1 foot in thickness and 6 feet in height. Those within the sheds should be carried up close to the roof, but frequently they are only so to the first baulk of the couples, over which a draught of air is generated from shed to shed, much to the discomfort of the animals.

Hammels are preferred by many to large courts, even for young beasts, as it is advisable to have heifers separated from steers, and each class subdivided to suit strength, age, and temper. It is surprising how much better the same animals look and thrive when well assorted. The dung is seldom removed from hammels until the end of the season, when it is generally used for turnips. The temperature in the courts of hammels facing the S. is generally agreeable, and that in the sheds is always decidedly temperate.

Cattle-boxes.—Some prefer boxes to

hammels, especially for fattening cattle. These boxes are just small compartments or subdivisions of a larger building, usually about 8 feet square, each animal having a box to itself. Cattle fatten more rapidly in boxes than in any other way; but they entail more labour as well as more litter, and of course are relatively more costly than larger compartments. The dung is removed from boxes at intervals, when it is thought to have too much accumulated. Boxes are fitted up of wood, the rails to separate the oxen, the troughs to contain turnips, and the racks for straw or hay. Being under cover, the temperature of boxes should be high for winter.

Stalls for Cows.—Cows stand in stalls, and stalls, to be easy for them to lie down and rise up and be milked in, should never be less than 5 feet in width. Four feet is a more common width, but is too narrow for a large cow, and even 7 feet is considered in dairy districts a good double stall for two cows. Many farmers contend that every cow should have a stall for her own use in lying, standing, eating her food, and being milked, and of such length and breadth as she may lie at ease betwixt the manger and the gutter. A width of 13 feet makes a handsome byre, apportioned thus: manger 2 feet, length of a large cow 8 feet, the gutter 1 foot broad, leaving 7 feet behind the gutter for a passage. If a passage of 3 feet for food is given at the head of cows, the passage for milk-work will be curtailed from 7 to 4 feet, which may be inconvenient for dairy purposes, but may do for feeding cattle.

Stalls for Feeding Cattle.—Fattening cattle are very often tied in stalls, and this economises both space and litter. A stall of 4 feet in width will suffice for a feeding ox, or even, for the sake of economy, a double stall of 8 feet for two oxen. In every other respect feeding cattle should have the same accommodation as cows.

The ceiling in byres should be open to the slates, and for every four cows there should be a ventilator in the roof for regulating the temperature and admitting fresh air. A door, divided into upper and lower halves, should open outwards to the court on a gable-check, for the easy passage of cows to and from

the court, and each half-door fastened on the inside with a hand-bar. This half-door and windows with glass panes, with the lower part furnished with shutters to open, will give sufficient light, as also air. The plastering of the walls adds greatly to the comfort and cleanliness of byres.

Fig. 102 is a section of *travis* and *manger* of a byre. The opening through the wall is not necessary, and the shed behind it may be dispensed with; but where it is, it forms a convenient turnip-store, to which access might be obtained from the byre by a back-door. The earth

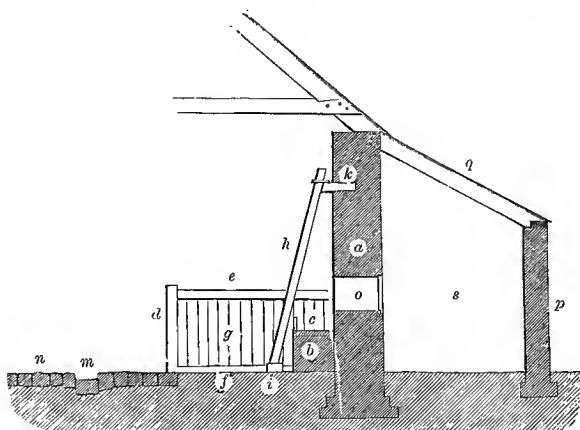


Fig. 102.—Byre travis, manger, and stake.

- | | | |
|--------------------------------|-----------------------------------|------------------------|
| a Wall of byre. | g Travis of wood, 6 feet long. | o Opening through wall |
| b Building supporting manger. | h Hardwood stake for the bluder. | for turnips. |
| c Manger with a front of wood. | i Stone base for stake. | p Wall of shed. |
| d Hardwood hind post. | k Block of wood for top of stake. | q Roof of shed. |
| e Hardwood top rail. | m Dung-gutter of pavement. | s Shed for food. |
| f Curb-stone. | n Paved floor. | |

on the space upon which the cows kneel is beaten smooth and firm.

The *stalls* are most comfortably made of wood, though some recommend stone, which always feels hard, and even seems cold.

Single and Double Stalls.—A wide single stall is not only useful in supplying food from within the byre, but admits of cows being more easily and conveniently milked. A double stall for cows is objectionable on many accounts: a cow is often a capricious creature, and not always friendly with her neighbour, and one of them in a double stall must be bound to the stake on the same side she is milked from; and, to avoid this inconvenience, the dairymaid puts the cow aside nearer her neighbour in the same stall, which must prove unpleasant to both. Neither is it a matter of indifference to the cow from which side she is milked, for many will not let down their milk if the milkmaid sits down at the unaccustomed side. The best plan is for each cow to have a roomy stall

to herself—although this, of course, entails more space and greater outlay in building.

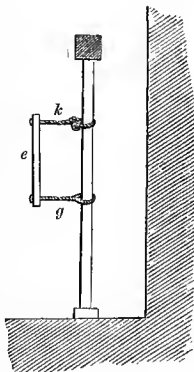
Mangers.—The *mangers* of byres are usually placed on a level with the floor, with a curb-stone in front to keep in the food, and paved in the bottom. Such a position is highly objectionable, as, on breaking turnips, whether sliced or whole, the head of the animal is depressed so low, that an undue weight is put upon the fore-legs, and an injurious strain imposed on the muscles of the lower jaw. The manger should rest on a building raised from 15 to 20 inches from the ground, and a plank set on edge in front to keep in the food. Out of such a manger a cow or ox will eat with ease any kind of food, whether whole or cut. Mangers are generally made too narrow for cattle with long horns, and the consequence is the rubbing away of their points against the wall, to the injury of both. Mangers are now often formed of concrete or fire-clay.

Flooring of Byres.—The *floor* of byres is usually paved with rectangular

stones; but now concrete floors, indented on the surface, in causeway form, to prevent slipping, are often met with. The gutter should be broader than an ordinary square-mouthed shovel, and flagged at the bottom, and having right-angled curb-stones. Such a gutter is quickly cleaned out. A gutter should run from this one through the wall to a liquid-manure tank. The causewaying of the stalls should extend no farther than the hind-posts, because cattle, in lying down and rising up, first kneel upon their fore-knees, which would be injured if pressed against stones, even when covered with litter. A pressure on the knees may produce a permanent swelling in them. The earth beaten firm will make a good flooring there. We have seen this part of cow-stalls covered with india-rubber pavement.

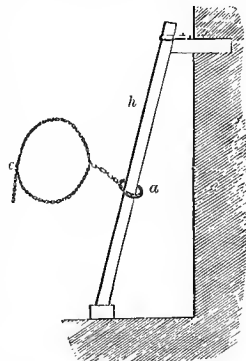
Various forms of flooring for stalls with the view of saving litter have been tried, such as flooring with wood, and causewaying with bricks made with a hollow centre through which the urine is enabled to pass directly into the gutter.

Binding Cattle.—Cows and oxen are bound to a stake in stalls by means of a ligature which goes round the neck behind the back of the head. One method of binding is with the *baikie*, made of a piece of hardwood, *e*, fig. 103, standing upright, and flat to the neck of the cow. A rope *g* fastens the lower end of it to the stake, upon which it slides up and down in a perpendicular direction, by means of a loop which the rope forms round the stake. This rope passes *under* the neck of the animal, and is never loosened. Another rope *k* is fastened at the upper end of the piece of wood *e*, and, passing *over* the neck of the animal and round the stake, is made fast to itself by a knot and eye, which serves the purpose of fastening and loosening the animal. The neck, being embraced between the two ropes, moves up and down, carrying the *baikie*

Fig. 103.—*Baikie*.

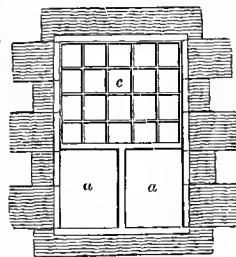
along with it. This method of binding, though quite easy to the animals themselves, is objectionable in preventing them turning their heads round to lick their bodies; and the stake being perpendicular, the animals can move their heads only up and down, and are obliged to hold them always over the mangers.

A much better method of binding cattle is with the *seal*, which consists of an iron chain, fig. 104, where *a* is the large ring of the binder, which slides up and down the inclined stake *h*. The iron chain, being put round the neck of the cow or ox, is fastened to itself by a broad-tongued hook at *c*, which is put into any link of the chain that gauges the neck, and it cannot come out until turned on purpose edgewise to the link of which it has a hold. This sort of binder is in general use in the midland and northern counties of Scotland. It is most durable, and gives the animal liberty not only to lick itself, but to turn its head in any direction it pleases; and the inclination of the stake *h* gives the animal further liberty of lying down or standing back free of the manger.

Fig. 104.—*Cattle seal or binder*.

A chain binder, swivelled and sliding on an upright bar, fixed to the travis, makes a good and safe form of fastening.

Windows in Byres.—A light and airy window is essential to the comfort of a byre. It consists of two shutters, *a*, fig. 105, 2 feet in height, which open by cross-tailed hinges, and are kept shut with thumb-latches. The window-

Fig. 105.—*Byre window*.

frame is made of wood or cast-iron, $2\frac{1}{2}$ feet in height and 3 in width. The frame is glazed with 4 rows of panes in the height and 5 rows of panes in the breadth.

Ventilation of Byres.—It greatly promotes the comfort and health of animals confined for many hours every day in one apartment to have fresh air admitted to them without the creation of draughts, and no means of obtaining this object is so much in our own power as placing *ventilators* in the roof of the part of the steading occupied by animals.

Fig. 106 is a *ventilator*, in which the Venetian blinds *a* are fixed, and answer the double purpose of permitting the escape of heated air and effluvia, and of preventing the entrance of rain or snow. The blinds are covered and protected by a roof *b* of slates and zinc; *c* is an apron of zinc upon the slates of the roof.

Such a ventilator would be more ornamental and protective to the blinds if its roof projected 12 inches over them.

One ventilator, 6 feet in length, 3 feet in height in front, and 2 feet above the ridging of the roof, for every 6 horses, cows, or oxen, might suffice to maintain a complete ventilation.

But such openings in the roof will not of themselves constitute ventilation, un-

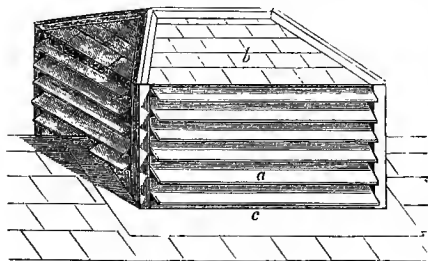


Fig. 106.—Ventilator.

less an adequate supply of fresh air is admitted below; and the supply might be obtained from small openings in the walls, including chinks of doors and windows when shut, whose gross areas are nearly equal to those of the ventilators. The openings should be in such situations and numbers as to cause no draught of air upon the animals, and might be conveniently placed, protected by iron or zinc gratings on the outside to prevent

the entrance of insects, in the wall behind the animals, and of such form as to disperse and spread the air upwards as it enters.

Other forms of ventilators are in use, consisting of a large zinc pipe projected through the roof and bent downwards; or simply a few of the slates or tiles of the roof raised up a little, either of which is better than no ventilator at all. But for simplicity, cheapness, and efficiency, the ventilator represented in fig. 107 is very satisfactory. It consists of a square

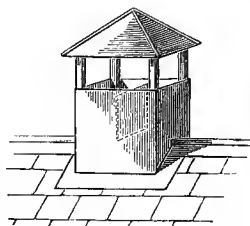


Fig. 107.—Watson's ventilator.

box of 2 or 3 feet above the ridging of the roof. The box is equally divided in its length by a partition of wood, extending from a couple of inches from the upper edge of the box to a few inches below its lower edge under the roof. The effect of this simple partition is to cause a current of warm or vitiated air to pass upwards from the apartment to the atmosphere through one of the divisions of the box; while an opposite current of pure cool air from the atmosphere passes downward into the apartment through the other division—both currents being equal and above the reach of the animals, and never cease to pass day and night. The ventilation is complete, as well as the diffusion of cool air through the apartment. Rain or snow would be prevented falling through the ventilator by a square prismatic cover, as in the figure.

Ventilators so ingeniously arranged as to revolve rapidly with the slightest current of air are now frequently used. See *Ventilation of Stables*.

Byres for Feeding Cattle.—The construction of byres for *feeding oxen* and *milk cows* is very similar, but feeding-byres are usually made much too small for the number of oxen confined in them. When stalls are put up, they seldom exceed 4 feet in width; more frequently two oxen are put into a double stall of 7 feet, and not unfrequently travises are

dispensed with altogether, and simply a triangular piece of boarding placed across the manger against the wall, to divide the food betwixt each pair of oxen. In double stalls, and where there are no stalls, even small oxen, as they increase in size, cannot all lie down at one time to chew their cud and rest; and thus hampered for room, and the chewing of the cud interfered with, they cannot thrive as they should do. In such confined byres the gutter is placed too near the heels of the oxen, and prevents them standing back when they desire; and if any do stand back, it must be in the gutter, at a level lower than the stall. Short stalls, it is true, save litter being dirtied, by the dung dropping from the cattle directly into the gutter, and this saves the cattleman some trouble; but the saving of both trouble and litter is at the sacrifice of comfort to the animals.

Economy overdone.—In the construction of byres, economy of space and expense may easily be overdone. Cow-keepers in towns may be justified in pushing economy to an extreme point; but no landowner or farmer should sanction such a plan. In fitting up a byre for milk cows or feeding oxen, it should be borne in mind that a small sum withheld at its construction may cause a yearly loss of much greater amount, if it prevent feeding cattle attaining perfection, or cows bearing strong and healthy calves.

Drainage of Byres and Courts.—Neither courts, hammels, boxes, nor byres are competently furnished for comfort unless provided with good drains to carry away rapidly surplus liquid manure. A *drain* should enter into each of the large courts, across the middle of the court of each hammel, and into the byres and boxes. The ground of every court should be so formed as to have the lowest part where the drain should have its mouth. The mouth should be furnished with a strong block of hewn free-stone, into which is sunk flush an iron grating, having the bars only an inch asunder, to prevent straw getting into the drain. Fig. 108 is a grating, made of malleable iron, to bear rough usage, such as the wheel of a cart passing over it; the bars being placed across with a curve *downwards*, to keep them free from pressure

when the water passes through the straw. We have seen gratings in steadings with the ribs bent *upwards*, in the idea they are not so liable to be choked up. The idea is quite correct in regard to the open

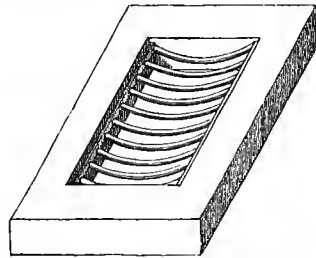


Fig. 108.—Drain grating for courts.

gratings of sewers in towns, as with ribs bent *downwards* there, the accumulated stuff brought upon them by the gutters would soon prevent water getting into the drains; but the case is different in courts where the straw, covering the gratings, lies loosely over the ribs bent downwards, and acts as a *permanent drainer*; whereas were the straw to be pressed constantly against the ribs bent upwards, the water could not percolate through it. Any one who has seen the straw of dunghills pressed hard against a raised stone in the ground below it, will easily understand this effect.

Liquid-manure drains may be built with stone-and-lime walls, 9 inches high and 6 inches asunder, flagged smoothly in the bottom, and covered with single stones, as shown in fig. 109. They are

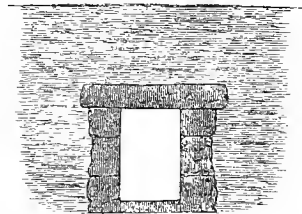


Fig. 109.—Liquid-manure drain.

better of cylindrical glazed stoneware tubes, fig. 110, of a diameter suited to the quantity of liquid to be conveyed. The spigot and faucet drain-tube consists of *a a* the spigot tube, and *c c* the faucet of the tube *b b*. In laying these tubes, it is necessary to observe that they have

a full bearing given them, and not to allow the plain ends to rest entirely on the socket, as by doing so the pipes are exceedingly apt to be broken. Another precaution is, that the clay or cement used to make good the joint is not pushed into the interior of the pipe, to make a ridge there, and cause a permanent obstruction to the liquid manure.¹

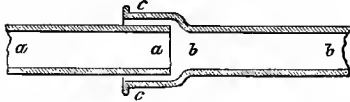


Fig. 110.—Section of a spigot and faucet drain-tube.

As liquid-manure is sluggish in its motions, the drains for it require a greater fall than rain-water drains. They should run in direct lines, and have few turnings on their way to the tank, which should be in the lowest ground, not far from the steading, and out of the way. The advantages of these drains being made straight is, that should they choke up, water would soon clear the obstruction, and this will be the more easily effected in stoneware tubes.

Liquid-manure Tank.—One tank would suffice for even a large steading. Were the practice adopted here, as in Flanders, of applying liquid manure in the field direct from the animals, a small tank at every court and feeding apartment would be convenient.

The *liquid-manure tank* should be built of masonry, or of brick and lime, or formed of concrete. Its form may either be round, rectangular, or irregular, and it may be arched, covered with wood, left open, or under a slated or thatched roof; the arched forming the completest roof, the rectangular form may be chosen. We have found a tank of an area of only 100 square feet, and a depth of 4 feet below the bottom of the drains, contain a large proportion of the whole liquid manure collected during the winter, from courts and hammels well littered with straw, in a steading for 300 acres, well provided with rain-water spouts.

Liquid-manure Pump.—A cast-iron pump should be affixed to one end of the tank, the spout of which should be elevated so as to allow the liquid to run

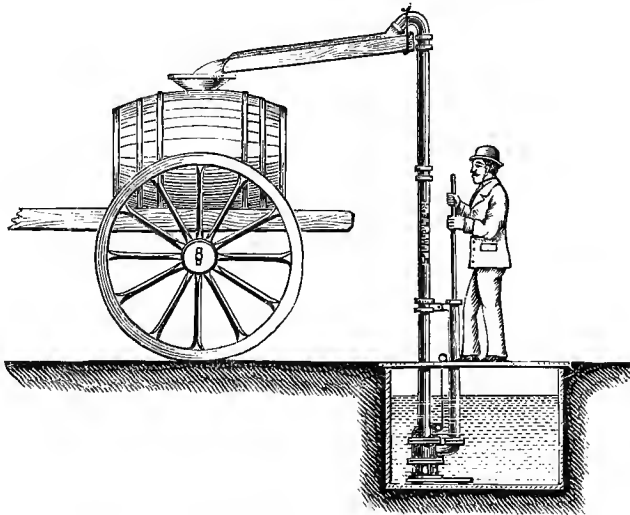


Fig. 111.—Simplex pump.

into the trough in the bung-hole of a large barrel placed upon the framing of

a cart, or over a series of compost dung-hills. A very useful pump for this purpose, made by Ben. Reid & Co., Aberdeen, is represented in fig. 111.

Rain-water Spouts.—It is clear that

¹ See *Book of Farm Buildings*, 239-241, for drain-tubes.

if all the rain that falls upon the roof of the steading makes its way into the courts and hammels occupied by cattle, it will pass through the manure rapidly, and dissolve a large proportion of its soluble parts, and so far deteriorate the quality of the dunghill. The liquid manure thus conveyed to the tank will, therefore, largely consist of rain-water; and when it is carried from the tank to the fields, or spread over the compost-heaps, much labour will thereby be imposed in carrying simply rain-water. Of what utility would so much rain-water be to the compost-heap? Would it not be better to prevent the rain-water entering the courts at all, and only to carry the pure liquid manure which has flowed from the dunghills, when the straw in them was unable to absorb and retain any more of it? No doubt it would. There should, therefore, not be much liquid manure at a steading of feeding beasts. The largest proportion of pure liquid manure is found on dairy-farms, where cows are supplied largely with succulent food in the byre, and with very little litter.

The only way of preventing rain-water getting into courts is to have them entirely roofed, or the eaves of the roofs of the houses which surround the courts provided with *rain-water spouts*, to carry the rain in drains from the farmstead.

As to the rain from other parts of the roofs, *drains* should be made along the bottom of every wall. They should be 6 inches below the foundation-stones of the walls, having drain pipe-tiles, and the drain filled to the surface of the ground with broken stones. The broken stones will receive the rain dropping from the roofs, and the pipe-tile conduit will carry it away; and should the stones ever become hardened on the surface, or grown over with grass, they can be loosened by a hand-pick. Strong pipes are now made on purpose for drains of all dimensions.

Rain-water spouts are made of wood, cast-iron, lead, or zinc, the last being durable, very light, and cheapest in the end, and are fastened to the wall by iron holdfasts. Wooden spouts, subject to alternate drought and wet, soon decay. Lead is far too expensive for a steading. Cast-iron is clumsy, and rusts.

NOMENCLATURE OF CATTLE.

The names given to cattle at their various ages are these: A new-born animal of the ox tribe is called a *calf*, a male being a *bull-calf*, a female a *quey-calf*, *heifer-calf*, or *cow-calf*; and a castrated male calf is a *stot-calf*, *ox-calf*, or simply a *calf*. Calf is applied to all young cattle until they attain one year old, when they are *year-olds* or *yearlings*—*year-old bull*, *year-old quey* or *heifer*, *year-old stot*. *Stot* in some places is a bull of any age.

In another year they are *2-year-old bull*, *2-year-old quey* or *heifer*, *2-year-old stot* or *steer*. In England, females are *stirks* from calves to 2-year-old, and males are *steers*; in Scotland, both young male and female are *stirks*.

The next year they are *3-year-old bull*, in England *3-year-old female a heifer*, in Scotland *3-year-old female a quey*, and a male is a *2-year-old stot* or *steer*. In some parts of England *bullock* is a general term for all adult cattle.

When a quey bears a calf, it is a *cow*, both in Scotland and England. Next year the *bulls* are *aged*; the *cows* retain the name ever after, and the *stots* or *steers* are *oxen*, which they continue to any age. A cow or quey that has received the bull is *served* or *bulled*, and are then *in calf*, and in that state are in England *in-calvers*. A cow that suffers abortion *slips* her calf. A cow that has either *missed* being in calf or has *slipped* calf is *cill*; and one that has gone dry of milk is a *yeld-cow*. A cow giving milk is a *milk* or *milch cow*. When 2 calves are born at one birth, they are *twins*; if three, *triplets*. A quey-calf of twins of bull and quey calves is a *free martin*, and seldom produces young, but exhibits no marks of a hybrid or mule. The male twin can be trusted to procreate.

Cattle, *black cattle*, *horned cattle*, and *neat cattle*, are all generic names for the ox tribe, and the term *beast* is a synonym.

An ox without horns is *dodded*, *humbled*, *hummele*, or *polled*.

A castrated bull is a *segg*. A quey-calf whose ovaries have been extracted to prevent breeding is a *spayed heifer* or a *spayed quey*.

CATTLE-COURTS, COVERED AND UNCOVERED.

The covering of cattle-courts has a very close and important bearing upon the winter rearing and feeding of cattle; and as it might be possible, even after the winter season has set in, to throw a roof over the whole or part of a court hitherto open, it may be useful at this point to consider fully the question of covered courts.

There has been much discussion from time to time as to the relative merits of open, wholly, or partially covered courts for cattle. The greater convenience of having cattle loose in courts instead of tied up in byres, or shut up singly or in couples in boxes or in small lots in hammels, is generally acknowledged. That some portion of the court should be roofed is also undisputed; but even yet, after much experience and careful consideration of the particular point, farmers as a body are still divided as to whether the whole or only a portion of the court should be roofed.

Pros and Cons.—The *pros* and *cons* of the question are soon stated. It is urged in favour of the covered court, that it economises litter by keeping out the rain; and against the partially open court, that it wastes litter by admitting rain. It is claimed for the covered court that the dung made in it is more valuable than the dung made in the exposed court, on account of the greater conservation in the former of the fertilising properties in the dung. The general soundness of these arguments in favour of the covered court is not seriously denied; but there is considerable disagreement as to the *degree* of difference between the two systems in these particular points.

It is acknowledged, of course, that the covered court is more costly than the partially covered one, but the advocates of the former contended that the advantages indicated far outweigh the excess in first cost.

As to the influence of the two kinds of courts upon the progress of the cattle there is great divergence of opinion. Some say animals fatten more quickly in the wholly covered court than in the other; while many experienced stock-owners argue that if the greater part of the court is roofed so as to ensure a dry,

comfortable bed to the cattle, they will thrive better with a portion, perhaps a third or a fourth, or less, of the court without any covering.

It may be interesting to consider in detail the chief points which have been put forward both in support of and against covered courts.

ADVANTAGES OF COVERED COURTS.

The late Mr John Coleman, York, one of the most practical and trustworthy agricultural writers of this century, was from experience and observation a confirmed believer in the benefits claimed for covered courts. In a paper read before the London Farmers' Club in November 1885, he discussed the subject exhaustively, dealing with it under these five heads: 1. The increased value of the manure made in covered courts; 2. The saving of litter; 3. Economy of food; 4. Details of construction; and 5. Cost and return.

Increased Value of Manure.

On this branch of the subject Mr Coleman said recent discoveries all tended to demonstrate the importance of using farmyard manure in a fresh and not rotten condition. Weight for weight, he believed manure made in covered yards was worth on an average double that in open yards, but owing to the smaller quantity of straw used, the weight of manure yielded per beast would be reduced about one-third.

Quantity of Manure per Head.—What weight of manure may be calculated on under the two conditions is a point on which authorities differ.

Taking one beast with another, he estimated the average consumption of litter in open yards at about 20 lb. a-day, and that in covered yards at 10 lb. a-day; and he believed that the production of manure made under cover could not exceed one ton per month, as against one and a half ton in an open yard.

Professor Stockhart calculated the weight of a cow's excreta daily at 22 lb. of urine and 55 lb. of solid, and if they added 10 lb. of straw, this would give 87 lb. a-day, equal to 22 cwt. per month. But our mixed cattle would not evacuate nearly so much, and 75 lb. would prob-

ably fully represent the average weight of straw and excreta, which give close upon a ton a month. If these figures were correct, and assuming a period of eight months' feeding, they had—

8 tons of covered-yard manure at 7s.	£2 16 0
12 tons of open-yard manure at 3s. 6d.	2 2 0
Total gain in manure per head	0 14 0
Add savings of carting, heaping, and turning	0 4 0
Savings in manure per head	£0 18 0

Covered - court v. Open - court Dung.—As bearing out the above estimate, Mr Coleman stated that he had grown better crops of potatoes with 10 cart-loads of covered-yard manure than with fifteen cart-loads of equal weight of open-yard manure from animals receiving similar food; and Lord Kinnauld's experiments, reported in the *Transactions of the Highland Society*, proved the superior efficacy of covered-yard manure, weight for weight, to that from open yards, made under similar conditions as to food and age of animals.

	OPEN YARD.	COVERED YARD.
1st year potatoes	£7, 12s.	£11, 5s.
2d year wheat	42 bushels	54 bushels.
Straw	150 stones	215 stones.

Of course these experiments were defective, inasmuch as we had no facts as to the comparative quantity of manure produced, but they are conclusive as to value. It would be of great practical interest if this question were made the subject of accurate experiments, and with this might be combined the comparative and actual value of artificial foods consumed under these different conditions, and thus actual facts as to the unexhausted value of food would be obtained, in place of the theoretical estimates, which are of such doubtful accuracy.

Saving of Litter.

Assuming that the calculation as to the relative quantity of straw used were correct, it followed that the saving of straw per head during a period of eight months' feeding would average about a ton per beast.

Value of Straw.—Now, this at only its consuming value would add £1 a-head to the savings; but often in these days straw was worth much more.

Surely there were few landlords or agents who would interfere with the sale of spare straw, provided that the land was well farmed. The manuring value of straw ranged from 10s. to 15s., according to sort, and that might be easily and beneficially replaced by purchased cake. If only the tenant would keep his yards full of growing and feeding cattle during the winter, the agent need not distress himself about the sale of straw or anything else. There was every prospect of straw becoming dearer, because the area under arable farming steadily decreases. It could not be imported to a large extent, being too bulky even in a compressed state to bear long carriage, and it was one of the merits of the covered-yard system that it allowed of such a large saving of litter, available for sale when there is excess, and allowing of greater economy in use when it was scarce.

Some years since it was an argument against covered yards that in certain outlying districts, such as the wolds and limestone districts, where arable lands prevailed, the straw could not thus be consumed, and would have to be rotted down, because there was no market—a difficulty which hardly exists now.

As a practical illustration of the saving of straw, Mr Coleman stated that on a farm of which he had the management for many years—650 acres in extent, about one-third arable—the annual outlays for straw, in the old open-yard days, ranged from £70 to £100, which was almost entirely saved by covering over the yards. In his calculations he estimated the gain at £1 a beast.

So great was the demand for straw in the large manufacturing centres of the north, that during summer it was largely imported from France and Germany to Hull, and carried by railway to the north of Lancashire.

Economy of Food.

Mr Coleman contended that, given well-constructed—i.e., well-ventilated—yards, there must be economy of food. In early days the mistake was sometimes made of having the place too hot and close. Then, to correct this, the opposite and greater mistake was made of draughts over the animals' backs. They could not

have too perfect ventilation, and it should be from every part of the roof, and not by leaving any of the sides open.

They were sometimes told that the south side of the yards should be left open in order that the cattle may feel the sun. This he believed to be a mistake, for with the small amount of sun in the winter time they would get a great deal of searching wind, and it was just this that they wanted to avoid.

The chemist and animal physiologist told them that warmth—that is, the absence of cold—is equivalent to food. The great waste of the system occurred when the animals were exposed to a keen, bitter blast, or a drenching driving rain from the east. It stood to reason that there must be a saving of fuel when the fire burned in an equable temperature; but what this amounted to, though the advantage was quite apparent to their observation, had never yet been determined with scientific accuracy.

Mr Moscrop stated that he proved in an experimental trial that under-cover animals, each of which had a separate box, gained as much weight with something under one-eighth less food as others kept in the common form of court and shed, when the open part bore to the shedding the proportion of four to one. The gain was nearly 1s. per head per week, which was entirely attributable to the superior warmth, comfort, and repose enjoyed by the cattle under cover.

Dealing with a breeding farm, where they had animals of all ages—at any rate, from a year old and upwards—Mr Coleman thought it would be within the mark to assume that the saving of food for a given result would average 6d. a-head per week, and this over a period of eight months was equal to 16s. a-head.

Total Saving.

Thus Mr Coleman made out the following as the gain by the adoption of covered yards on each head of stock wintered:—

Increased value of manure and saving of labour	£0 18 0
Saving of one ton straw, consuming value	1 0 0
Saving of food at 6d. a-head per week, over 32 weeks	0 16 0
Total saving per beast	£2 14 0

It would be seen later on what was the cost to be incurred in order to gain these advantages; enough had been advanced to prove that the use of covered yards was one of the greatest and most important of modern economies; and in these days, when every branch of farm practice is undergoing a searching criticism, it was well that public opinion should be turned in this direction.

Construction of Covered Courts.

Mr Coleman then entered into the question of construction of covered courts.

Drainage of Courts.—As to drainage Mr Coleman advocated surface-channels, and disapproved of covered drains with cesspools and tanks.

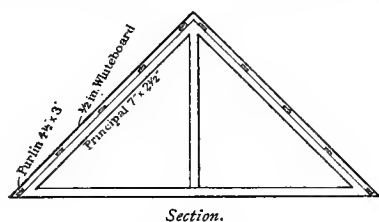
Roofing.—As to covering, many recommended galvanised iron, and with present low prices it was possible that this might be as cheap as any other substantial roof. But there were some objections to iron roofing, one of which is, inferior ventilation. The air must be collected to certain points, generally to openings on either side of the ridge, and under the eaves, which must have a tendency to create draughts, which should be avoided. The other objection is that the galvanised coating is subject to injury from the presence of certain gaseous products in the air, which might arise from the animals themselves, and must exist whenever the manure is being removed. The risk of such injury might be prevented by keeping the surface well painted, but this entailed extra cost. A third objection was that iron roofs were cold in winter and hot in summer.

Numerous forms of roof had been designed with a view to reducing expenses. Ordinary framed roofs, with principals, purlins, and rafters, might be used for small spans, and are probably necessary when a heavy covering like pantiles, or Bridgwater tiles, are used; but there is a limit which is soon reached as to the spans of such roofs, hence they had to introduce supporters in the form of pillars, which were objectionable as taking up room, and as being liable to be run against by careless carters when the manure was being removed. Mr Coleman gave a detailed description of a roof, the cost of which would range from

5s. to 6s. 6d. a-yard of ground covered. He pointed out that wood equalised temperature better than either tiles or slates.

A still cheaper form of roof was described by Mr Coleman—a roof which, he said, could be made at a cost of from 2s. 6d. to 3s. per superficial yard of covered ground, or half to one-third of the cost of more durable structures. This cheap form of roof was illustrated in the *Field* of December 5, 1885, and through the courtesy of the publisher we are enabled to present these drawings here (fig. 112).

The roof consists of light principals 7 inches by 2½ inches, placed at in-



Covering, with spaces
½ in. apart.

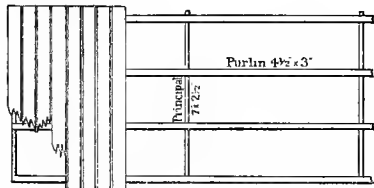


Fig. 112.—Roof for court: Elevation, showing boards, purlins, and principals.

tervals of 14 feet from centre to centre, carrying purlins varying in number according to the span of the roof, but placed about 4 feet 6 inches apart. The covering consists of rough ½-inch white-wood boards, any width not exceeding 9 inches, which are securely nailed to the purlins, but are not actually in contact with them, this being prevented by first driving *three clout nails* into the face of the purlins for each board, which thus ensures a clear space of about ¼ inch. The object of this arrangement is that any moisture which may run down the inner face of the boards should not rot the purlin.

It will be seen by the elevation that a

space is left between each board of about ⅞ inch. This is one of the special features of this roof, it having been proved by experience that boards actually in contact keep out rain better than when just laid close. As a further protection (though whether absolutely necessary or not is a question to be decided by further trials), about ¼ inch from the edge of each board a small groove is hollowed out, which could not be shown in the drawing. It may be doubted if this is essential, and if not, it is objectionable, as weakening the boards.

The history of this simple and ingenious form of roof is interesting. About 1875, a brickmaker, working for Mr Edward York, of Marston, near York, found that shelter-boards not absolutely touching kept his bricks drier than when in contact, and he adopted the principle for a shed roof. Mr Cundy, of Wetherby, agent to Mr Montagu, an adjoining landowner, having seen the roof, covered a yard by way of experiment. Having been satisfied with the results, he had several yards so covered, and his experience of eight or nine years is thus far satisfactory.

The cost, as has been stated, need not exceed 2s. 6d. to 3s. per superficial yard of ground covered. Ordinary red-wood is recommended for the purlins and principals, and white-wood for the covering. Any intelligent carpenter might construct such a roof from the drawings: a gauge should be used to secure uniform space between the boards. The explanation of this rather curious fact as to the weather-proof condition is, that the globules of rain run down unbroken between the edges of the boards. It is quite certain that, even with a driving rain, the amount of moisture which penetrates is quite immaterial, that cattle so protected thrive well, that manure is not wasted, and that litter is economised.

Mr Coleman remarked that when it was remembered that the great object in these bad times was to make money go as far as possible, a cheap and yet efficient roof, such as he had described, was most desirable; and there was no reason why the boards should not be renewed after 25 or 30 years. The

yard he saw was 30 ft. wide by 54 ft. long.

A roof of this description he considered well adapted for a tenant to invest in, when the landlord was unable or unwilling to do the work, but was yet open to an agreement as to tenant right; and in case of old buildings, when it was not worth while to do expensive work, it frequently happened they found large exposed yards surrounded by old buildings, which were much too useful to be swept away, although in process of time they might become untenable. In such cases the ability to cover the yards at a small cost was a matter of great economy.

Whenever it was determined to erect new buildings, Mr Coleman said he could state from his own experience that, according to the accommodation provided, the principle of covering over the fold-yards was actually economical, because they required so much less ground-space per head of stock. In the case of open yards and shelter-sheds, the accommodation was determined by the number of animals that could be sheltered, and they had in addition all the open spaces, which necessarily increased the area of walling; but where all was covered, a very much smaller area was required per head of cattle. Averaging the size of the animals on a breeding farm, his experience was that 120 square feet was ample for each beast; and this brought him to the last section of his subject, viz. :—

Comparative Cost and Return.

Mr Coleman, in considering the question of comparative cost and return, said he had shown them that roofs might be constructed at from 2s. 6d. to 6s. 6d. a yard superficial, and if they preferred tiles, they could make an ordinary framed roof at about 7s. 6d. a yard. Assuming the highest cost, and that 120 square feet of ground were required for each beast, they had $13\frac{2}{3}$ yards at 7s. 6d., which came to £5 per head. To repay this amount in 30 years, interest and principal, at $6\frac{1}{2}$ per cent, would involve an annual charge of 6s. 6d. a-year per head—surely not a heavy outlay for the advantages of a well-constructed covered court.

Advantages of Covered Courts.

According to the figures submitted by Mr Coleman, it would appear that the saving per animal in covered courts, during a period of eight months, amounted to a sum of £2, 14s. Hence, he continued, there could be no doubt as to the economy and advantages of the system, and all that remained was to urge upon all who had not already covered yards for the winter feeding of their animals, to lose no chance, to relax no effort, to get this work carried out, which ranked next in importance in farm economy to drainage. He was quite certain that the increased return from having covered buildings for the winter accommodation of live stock would be many times the sum required to repay principal and interest on the sinking fund principle.

Subsidiary Uses of Covered Courts.

— There were some additional advantages, such as the summering of calves on the soiling system. The opportunity for exercise and protection from sun and flies were often very advantageous. The yards might be of great service in harvest if the doorways were made high enough to take in a load of corn and hay.

As negative evidence, he might add, none of those who enjoyed the experience of properly covered yards had ever wished them away; on the contrary, every year's experience increased the estimation in which they were held.

Value of Covered Courts in Wet Weather.—The advantage of having a roof over the cattle-court is never greater or more obvious than in times of heavy rainfall. Mr John Chalmers Morton mentions this particular point as one of the lessons gathered from the experience of farmers in the disastrously cold and wet year of 1879.¹ Mr Clare Sewell Read, M.P., the celebrated Norfolk farmer, stated that the benefit of a covered court had on his farm been strikingly exemplified in wet weather. The owner of his farm had covered and fitted up to him a cattle-yard 80 feet square, at a cost of £100 for the roof, and £160 for boxes, mangers, &c., for

¹ *Jour. R.A.S.E.*, vol. xvi. p. 249.

which he had to pay £8 a-year. He considered that his stock in this covered yard, by their greater progress and saving of litter, had in a few months of exceptionally wet weather paid for the whole year's rent of the yard.

Covered-court Manure for Potatoes.—It has been found in practice, as shown above by Mr Coleman, that manure made in covered courts is specially valuable for potatoes. Mr George Hope, Fenton Barns, grew 4 tons of potatoes more per acre from manure made under cover than from manure made in the open yard. It has also been observed that for this crop the manure is most efficacious when driven directly from the court, and at once covered in the potato-drills.

Preventing "Fire-fang" in Manure.—It has often been mentioned as one of the objections to having cattle-courts entirely covered, that it is difficult, without the assistance of dew and rain, to get sufficient moisture into the litter to prevent the dung from becoming hot, and dry, and damaged, from what is commonly known as "fire-fang." In reference to this, Mr H. Howman, Balloughton, Coleshill, in a paper read before the Midland Farmers' Club, says: "I have met the difficulty by not allowing one bit of straw to be placed in the yards for litter without first being put through the litter-cutter and cut into about 6 inches in length; and this, I am convinced, is an absolute necessity for the proper working of manure. After two years' experience of the plan, against the cost of cutting up the straw, which is done by hand, I gain these advantages—the yards are littered more evenly and regularly, and not so much straw is used; while in emptying the yards, a great saving of labour is gained, because the manure is forked out so much more easily, and it is ready to be carted on to the land direct from the yards, and all the wasteful and laborious carting it into a heap to be rotted and wasted by the rain is saved."

Fermentation in the Dung doing no Injury.—Dr John Voelcker states that the fermentation which usually takes place in dung really does no injury. In the centre of the heap there is no doubt a considerable amount of fermentation,

but as the gases rise towards the surface they get cool and fixed.

Loss in Manure by Washing.—With dung lying in an open court, the greatest risk is loss through the best ingredients being washed out by rainfall. The late Dr A. Voelcker found that sometimes the loss from this cause amounted to as much as two-thirds of the whole manurial value of the heap.

Indeed the risk of loss from washing in this way is considered so great by some careful farmers, that they have roofs put over their dung-pits for the sole purpose of guarding against it.

PARTIALLY OPEN COURTS.

A few men of high standing as agricultural authorities have from time to time "put in a word" for the open or partially open court.

Tillyfour's Opinion.—The late Mr William M'Combie of Tillyfour, M.P., who was one of the most successful breeders and feeders of cattle in his day, was no advocate for covered courts. His practice upon his own farms was to keep all the store-cattle which he intended to graze next season "in open straw-yards, with a sufficient covering for bad weather, and as dry a bed as the quantity of straw will permit;" and he tells us that in buying cattle for grazing, he carefully avoided those which he knew to have been wintered upon forcing food "in hot byres or close straw-yards," remarking that such cattle "will soon make a poor man of you." He says that cattle which have been highly fed in close houses with cake and corn, as well as turnips and straw, are very liable to suffer damage from inclement weather at the beginning of the grazing season; and that, although he did not mean that a few weeks of a little cake and corn would ruin a beast for grazing, yet he was strongly opposed to store-cattle being pampered or forced with high feeding during winter.

But Mr M'Combie did not go the length of recommending open courts for the fattening of cattle. His fattening cattle were usually tied up in close but fairly well ventilated byres. And it is important to note that even for store-cattle he was careful to provide "a sufficient covering for bad weather." So that

it may safely enough be concluded that, in the light of more recent experience, Mr M'Combie would have become a believer in the *partially covered court*.

Store-cattle Thriving best in partially Open Courts.—Mr M'Combie's objection to "close" houses or courts for store-cattle is shared by many leading farmers. A very large number of practical farmers in all parts of the country, who acknowledge the benefits of entirely covered courts for fattening cattle, still prefer the partially roofed courts for store-cattle, believing that by the admission of a greater amount of fresh air the animals become more robust, and thrive better than if they were housed more closely. But there is seldom more than a third, more frequently not nearly so much, of the court uncovered. This open space should always be at the best sheltered part of the court, usually facing south.

Even by the strongest advocate of covered courts, the desirability of securing the free admission of fresh air, especially where young growing cattle are kept, is recognised and acted upon. Very often there is a good deal of open space at one end or side of the court. Mr Clare Sewell Read states that he is in favour of having the south end of roofed courts partially open.

No Fire-fang in Open-court Dung.—Some practical men have contended that it is easier to keep dung in good condition in open than in close courts. The manure in the open court becomes more moist than in the covered court, and is therefore not so liable to damage by fire-fang. On the other hand, it is argued that in the open court the plant-food in the dung gets washed away by rain; but the advocates of the open or partially open courts point out that loss in that way may be averted by having the bottom of the court rendered watertight by a layer of concrete or pounded clay, and the overflow of liquid manure conducted either into a compost-heap or into specially prepared tanks, from which it may at convenient times be taken for irrigation, or for pouring over dry manure or heaps of compost.

It was at one time thought that dung sustained serious loss by evaporation; but it has been shown, notably by Dr A. Voelcker, that while the loss by washing

may be very great, that by evaporation is usually trifling.

RECAPITULATION.

Upon the whole, therefore, with all in view that has been said for and against covered courts, there need be no hesitation in deciding that for fattening cattle the wholly covered, judiciously ventilated court is the best. For store-cattle the full roof is not so essential or advantageous. Even for these the greater part of the court should certainly be roofed; and if they have a dry bed and ample protection from wet and cold, the young growing animals will be little the worse—many affirm they will be the better—of access to an uncovered space, where they can breathe pure air, and enjoy any gleam of sunshine that may gladden the winter's day.

REARING AND FEEDING CATTLE IN WINTER.

This has come to possess a far greater relative importance, and to bulk more largely in farm management than in former times, when corn-growing was the mainstay of British agriculture. At the present time much greater dependence is placed upon live stock than has ever before been the case in this country, and on this account increased interest and significance are attached to all matters of practical importance relating to the animals of the farm. At this season, therefore, it becomes necessary to consider fully and in detail the indoor or house management and feeding of cattle. First, then, let us notice the

Duties of the Cattle-man.

Conveniently placed Straw-barns.—A laborious part of the duty of a cattle-man in winter is carrying straw in large bundles on his back to every part of the steading. It may easily be imagined, from this statement, that when the straw-barn is inconveniently placed, or at a considerable distance from the byres and hammels, the labour of the cattle-man must be very much increased; indeed from that circumstance alone he may require assistance to fulfil the duties he has

to perform. An inconvenient straw-barn may thus be the cause of incurring the expense of another man's wages for the winter.

The straw-barn should be placed in a central position as regards all the apartments occupied by the live stock, and which are so arranged that the stock which requires most straw are placed nearest the straw-barn. This principle of arrangement in all steadings is fully illustrated in the *Book of Farm Buildings*, pp. 1 to 38.

A hard and fast rule as to the exact position of the straw-barn, or indeed of any one of the different apartments into which a farm-steading has to be divided, cannot be safely laid down. Still, in the arranging of a steading, the economising of daily labour should have careful consideration.

Method of Carrying Straw.—A convenient means of carrying straw is with a soft rope about the thickness of a finger, and 3 yards in length, furnished at one end with a small light iron ring, through which the other end slips easily along until it is tight enough to retain the bundle, when a simple loop-knot keeps good what it has got. Provided with 3 or 4 such ropes, the cattle-man can bundle the straw at his leisure in the barn, and have the bundles ready to remove when required. The iron ring permits the rope to free itself readily from the straw when the bundle is loosened.

Cattle-man's Dress.—The *dress* of a cattle-man is worth attending to, as regards its appropriateness for his business. Having so much straw to carry on his back, a bonnet or round-crowned hat is the most convenient head-dress; but what is of more importance, when he has charge of a bull, is to have his clothes of a sober hue, free of gaudy or strongly contrasted colours, especially *red*, as that colour is peculiarly offensive to bulls. It is with red cloth and red flags that the bulls in Spain are irritated to action at their celebrated bull-fights. There have been many cases of bulls turning upon their keepers who were partially habited in red, or some strongly contrasted bright colours. Indeed, like "a red rag to a bull" has become quite a common simile, when speaking of a certain cause of irri-

tation. Be the cause of the disquietude in a bull what it may, it is prudential in a *cattle-man* to be habited in a sober suit of clothes. A short strong apron will save his clothes materially in carrying scullfuls of turnips to the cows, or oil-cake to other cattle.

Regularity in Hours of Feeding and Cleaning.—*Regularity of time* in everything done for them, is one of the chief secrets in the successful treatment of cattle. Dumb creatures as they are, they soon understand any plan that affects themselves—and the part of it to which they will reconcile themselves most quickly is regularity in the time of feeding; and any deviation from it will soon cause them to show discontent. Regularity consists in giving the same sort of cattle their food at the same periods of the day, and each day in succession. The cattle-man cannot follow this regular course without a watch; and no one should be selected for that charge who does not possess one.

The Cattle-man's Hours.—The cattle-man's day's work commences at break of day and ends at nightfall in winter, expanding the day with that of the season, until daybreak appears at 5 in the morning, and nightfall occurs at 6 in the evening. Beyond those hours he is not expected to work, excepting at 8 at night, when he examines in winter, with a light, every court and byre, to see that the cattle are in health and comfort before he goes to bed. Every hour of daylight in winter has its stated work; and it is only in the morning and evening, as the day lengthens, that any change in the time is allowable. As the same amount of work must be done every day, he has most to do in the least time in the shortest days in winter, and as the days lengthen he has more leisure.

The Cattle-man's "Time-table."—Let us accompany the cattle-man through a whole day's work. In some cases he breakfasts before he begins his labours; in others, not till he has gone his first "round." At daybreak, or not earlier than 5 in the morning should the day dawn before that hour, he goes to the cow-byre, and removes the dung in the stalls into the gutter with a graip, to make the stalls clean for the dairymaid

when she comes to milk the cows. This business may occupy about 10 minutes.

On farms on which calves are bred, the cows are heavy with calf in winter; so most of them will be dry in that season, and those still yielding milk, being the latest to calve, will give but a scanty supply. It is not as *milk-cows* that breeding-cows are treated in winter, receiving but little succulent food.

The *graip*, fig. 113, with which he clears the dung into the gutter, consists simply of 4 long prongs, and a helve of wood set in a socket, having a slight bend near the prongs. This bend gives a leverage power to the handle, when the *graip* is used to lift rank wet litter; and it serves also to keep the hands clean from the dung. The stalls are thus cleared of dung for the dairymaid to proceed with the milking. Farm *graips* and forks are now, as a rule, made of steel, and they are vastly superior to the clumsy iron tools of former times. The *graip* here represented is made by Spear & Jackson, Sheffield.

He then goes to the servants' cow-byre, and does the same piece of work there for the servants' wives, who also milk their cows at this time. It may occupy him 5 minutes.

He shuts the doors of both byres, leaving the half-doors open for the admission of fresh air. The cows are now milked.

He then goes to the feeding beasts in the hammels, and cleans out with a *shovel* the refuse of the turnips of the former meal from the troughs, always beginning at the same hammel; and as soon as one hammel is cleared out, he replenishes its trough with turnips from the store at hand, the turnips having been broken with one of the implements in use. This may occupy him 40 minutes.

The byre and stable *shovel* is fig. 114. It has a broad square mouth, to stretch across the bottom and enter the corners of the gutters of the byre, or turnip-troughs of hammels and courts. Its helve is of wood, having a slight curve in it, to clear the hands from the dung. Another kind of shovel is often used, and it is specially adapted to clear the gutters of byres of dung in a quick and efficient manner. It is square in the mouth, and of a breadth to fit into the gutter, having the sides raised up 2 inches, and the back 3 inches, with socket for the handle. It has a wooden handle, with a cross head. This shovel is worked by simply pushing it forward along the gutter, at the end of which the dung is accumulated and removed. Such an implement hastens work in a large dairy, or where there

are few hands.

From the hammels the cattle-man proceeds to the cattle-courts, where the young heifers and bullocks are, and cleans the turnip-troughs of the refuse, supplying them with turnips from the store. He may be occupied with them for 25 minutes.

The bulls in the hammels next receive his care. Their turnip-troughs are cleaned out, and a few fresh turnips given them, sliced in baskets from the store. The two hammels may engage him 10 minutes.

The extra beasts also in the adjoining hammels should next be attended to, by cleaning out their turnip-troughs and giving them a fresh supply of sliced turnips from the same store. These may take 10 minutes to be attended to.

The heifers in calf in the same row of hammels should have no turnips in the morning, only some fresh oat-straw. It may take 8 or 10 minutes to go for this to the straw-barn hard by, and put it into the racks.

Having thus given all the cattle at liberty their morning's ration, the cattle-man takes a bundle of fresh oat-straw



Fig. 113.—*Graip*.



Fig. 114.—*Square-mouthed shovel*.

from the straw-barn, returns with it to the cow-byre, and gives a little to each of the cows, and then removes all the dung and dirtied litter from the stalls and gutter with the graip, shovel, and wheelbarrow into the dung-house, sweeping the gutter and causeway of the byre clean with a broom. This work may engage him 30 minutes.

In like manner he gives the servants' cows a little fresh oat-straw, and cleans out their byre of dung and litter. In doing this he may be engaged 25 minutes.

The wheelbarrow, fig. 115, is of the common form, with close-boarded bottom,

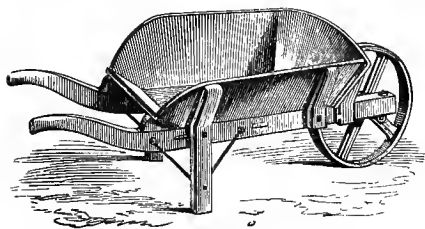


Fig. 115.—Wheelbarrow.

sides, and back, and of a capacity sufficient to carry a good load of litter, but of such breadth as will easily pass, with a load, through the byre-door.

When the byres have thus been cleaned, the cattle-man takes a bundle of litter from the straw-barn, and returns with it to the byre; and on clearing the troughs of the refuse fodder of the previous night, and sprinkling it over the stalls for litter, the cows are ready for straw or hay and turnips.

Turnips for Cows.—After milking is finished by the dairymaid in the morning, a common practice is to give the cows, though heavy in calf, a feed of cold turnips into their empty stomachs, which we consider a very injudicious practice. That it is so is evidenced by the fact of the foetus indicating unequivocal symptoms of its existence in the womb after this or a drink of cold water in the morning. It is more prudent to give cows some fresh straw or hay, to prepare their stomach for the cold watery turnips. Cows in calf should never get as many turnips as they can eat. They should be fed moderately, the object being not to fatten, but support them in a fair condition for calving; for were

they fed fat, they would run the risk of losing their life at calving by inflammation, and their calves would be small. On the other hand, it is bad management to let cows get low in condition.

It is not easy to specify the weight of turnips that should be given to cows; for some may advantageously get more than others. Fuller information on this point will be given subsequently, when dealing specially with the feeding of cows.

After the racks and troughs have been supplied with the fodder and turnips respectively, in the same order of distribution, from stall to stall, daily observed, the stalls are littered with the straw the cattle-man brought with him; and on shutting the principal door, and leaving the other half-door open for air, he leaves them for a time to rest and chew their cud—for nothing irritates cows more than to go about them, or remain in the byre and make a noise, while they are eating their principal meal. This work may require about 30 minutes.

Turnips are supplied to cows, either from a passage running along the heads of the stalls, as in feeding-byres, or from the causeway by the stalls themselves, in whichever way the byre has been constructed. Small doors opening through the wall, at the head of stalls in byres, are objectionable, as they are a means of superinducing catarrh or other head complaint in cattle.

A common practice is carrying turnips by the stalls in baskets called *sculls*, which are hollow hemispherical-shaped baskets of willow or wire, having either an opening on each side to take hold of the stout

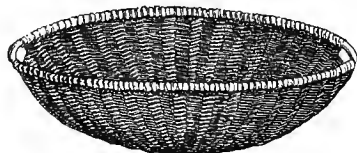


Fig. 116.—Willow scull or basket.

rim for handles, or handles attached to the rim at the ends. A willow basket, fig. 116, being in perspective, requires no description.

Turnips for Servants' Cows.—The servants' cows are then littered to lie down and rest, the turnips being given to them by the servants themselves, in

such quantities, and at such time, as they think proper. The littering may occupy about 10 minutes.

The supply of turnips to servants' cows depends on the terms of agreement made with the servants. When a specified number of cart-loads are given, the servant may not choose to give them to his cow during the earlier part of the winter, if she is dry; but if in milk, the servant's family give what quantity they choose from their own store. If the farmer has agreed to treat his servants' cows in the same manner as his own, the cattle-man takes charge of them in every respect as he does those of his master.

The heifers in calf now get a few turnips sliced. This may occupy 10 minutes.

The extra beasts feeding in the hammels should now receive some fresh oat-straw as fodder. The time engaged in this may be about 10 minutes.

Foddering and Littering.—All the cattle having now had their morning meal, the next step the cattle-man takes is to supply them in the hammels and courts with fodder and litter where fodder has not already been given. He first pulls the old fodder out of the racks and scatters it about as litter, and then supplies them with fresh oat-straw from the straw-barn. The litter straw is then taken from the straw-barn, and used to litter the courts and hammels in such quantity as is requisite at the time, dry, fresh, or frosty weather saving the usual quantity, and rainy weather requiring more to render the courts comfortable. This distribution of the straw may occupy about 30 minutes.

"Airing" Cows in Winter.—In fair weather the cows should be turned into the court, or into a paddock of grass near at hand, to enjoy the fresh air, lick themselves and one another, drink water, or bask in the sun. They should go out every day until they calve, except in a storm and wet. One hour at least, and longer if fine, they should remain out.

Order in Letting out Cows.—In loosening cows from the stalls, a method is required to prevent confusion. Every cow, in the beginning of the season, should be put in the stall she has occupied since she first became an inmate of the byre; and she will go direct to it,

and no other, avoiding collision with the rest. They should be loosened from the stalls one by one, always beginning at the same end of the byre, and finishing at the other, and not indiscriminately. This prevents impatience in any cow until it is released, as also collision on the floor and jamming in the doorway on going out, thereby escaping accidents injurious to animals with young.

The servants' cows are let out into their court, or into another field near at hand, from the other cows. The two byres may in this way occupy 15 minutes.

It is now time to give the feeding beasts in the hammels their mid-day ration of turnips; and it is as necessary to clear the turnip-troughs of refuse as in the morning. The turnips should be sliced. This may occupy 20 minutes.

Completion of Forenoon Duties.—In enumerating the portions of time thus occupied by the cattle-man, it will be found to be 5 hours 5 minutes; and if he began his work at dawn, say at 7 o'clock, the time now will be 5 minutes past 12 at noon. The cattle-man is then ready for his dinner, both as regards time and the state of his work. Should he find he has little enough time to accomplish his work, he has the consolation that, as the days lengthen after the 22d of December, he will have longer time to do the same work, and cannot possibly have more to do at any time. The cattle-man is entitled to rest one hour at dinner, like the other work-people.

Bundling Straw.—Immediately after his dinner-hour is spent, the cattle-man goes to the straw-barn, and bundles as many *windlings* of straw for supper as there are cows or cattle in byres under his charge. This is more safely done now than at night in candle-light. A *windling* is a small bundle twisted and fastened upon itself, and is about 10 lb. in weight. He also makes up a few large bundles of fodder. Taking one of these last to the cow-byre, he places fodder into every stall. Straw is often carried by cattle-men without being put into windlings, called "*wisps*" in some parts, but greater carefulness is then required to avoid losing straw by the way.

A Bit of Discipline for Cows.—The cows are then returned from the court or

paddock into the byre; and to remove every temptation from even a greedy cow running up into another one's stall for the sake of snatching a little of her food, no green food should be lying in the troughs when they return to their stalls; and none should be given them immediately after returning to the byre, as the desire to receive it will render them impatient in the paddock, and again in the stall until they receive it. This is contrary to usual practice, but it suppresses inordinate desire, prevents violation of discipline, and necessity for correction. When subjected to regular discipline, cows soon obey it, and make no confusion, and conduct themselves peaceably. They should be bound to the stake in the same regular order they were loosened from it, from one end of the byre to the other, and the regularity provides against any cow being forgotten to be bound up.

The servants' cows are returned into their byre in the same manner.

Afternoon Foddering.—The cattle-man then replenishes the racks in the courts and hammels with fresh straw, strewing about the old fodder as litter; and he litters both with as much fresh straw from the barn as is requisite to render the courts comfortable to the cattle to lie down in the open air if they choose. In moonlight, many of the cattle will remain out in the open air all night, even though rime should be deposited on their backs.

He places the windlings in the byres, in the proportion required by the cows, for their evening foddering; and he does it in daylight to avoid the danger of going into the straw-barn for them at night with a light.

Second Ration of Turnips.—When foddering and littering with straw has been gone through, it is time to give the cows their second ration of turnips, to have them eaten up by the time the dairy-maid returns to the byre, at dusk, to milk them. Some people do not give cows when dry a second ration, but it is better to give them the same quantity of turnips at two separate times than all at once.

The *feeding oxen* in the hammels then receive their evening ration of turnips, having the troughs cleaned out and turnips sliced, and the quantity given will depend on the state of the night; for if

the moon shine through the greater part of the night, a larger allowance of turnips should be given, cattle eating busily during moonlight. It is the same with sheep on turnips.

The *young cattle* in the large courts receive their second ration of sliced turnips immediately after the feeding beasts have been served.

The *extra beasts* fattening in the hammels should be treated in the same manner as the young beasts.

The *young heifers* and *bulls* in the hammels next receive their turnips; and as they both get limited quantities of roots, their proportion is divided into two small meals, sliced—one served after all the rest in the morning, and the other after the rest in the evening. Both classes depending much upon fodder for food, it should be of the sweetest and freshest straw, and supplied at least 3 times a-day—morning, noon, and evening; and having water at command, and liberty to move about, they will maintain sufficient condition. The heifers and bulls are supplied from the turnip-store.

The cattle-man then litters the *servants' cows* for the night, by which time the cows in the other byre will be milked; immediately after which they are also littered for the night, and the doors closed upon them. This last act finishes the labours of the day of the cattle-man.

Eight-o'clock Inspection.—At eight o'clock in the evening the cattle-man inspects every court, byre, and hammel, and sees that all the cattle are well and comfortable. Until twilight permit him to see the cattle, he takes a lantern to assist him. In courts and hammels, and in most modern byres, cattle have access to the fodder at all times, the fodder being held in racks specially provided for itself. Many byres, however, are still without this great advantage, and in these, in his round at 8 P.M., the cattle-man gives the cows the windlings of straw he had made up in the straw-barn during the day, and piled up in each byre at nightfall.

Lantern.—It is very important to have the cattle-man supplied with a handy form of *lantern* that will distribute a sufficient intensity of light around, and yet be safe to carry to any part of a

steading, amongst straw or other highly inflammable material. Such a lantern (fig. 117, made by Rowatt & Sons) is now obtainable at a very low price.

Treatment of Feeding Oxen.—The treatment of *oxen* feeding in a byre is somewhat different from that of cows. As it is unusual to feed oxen in byres

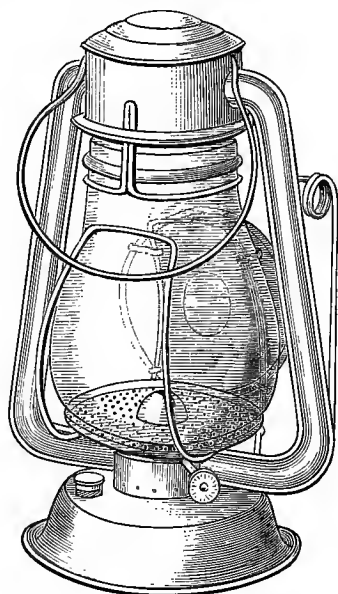


Fig. 117.—Stable lantern.

and hammels on the same farm, what has been said of feeding cattle in hammels should be considered applicable to those in byres. After the stalls of the cow-byres have been cleared into the gutter of any dung that might annoy the dairy-maid, the cattleman goes to the feeding-byre, and, first removing any refuse fodder from the stalls, and refuse of turnips from the troughs into the gutter, gives the cattle a feed of sliced turnips at once. The quantity at this time should be more than the third if fed three times, and more than the half if fed twice, of what they eat during the day, for they have wanted a long time.

Method in Feeding.—In distributing the food, the same regularity should be observed as with cows, the same ox receiving the first supply, and the same ox the last. When thus fed in regular order, cattle do not become impatient for

their turn when the cattle-man enters the byre. The best plan is to begin serving at the farthest end of the byre, as the cattle-man will then have no occasion to pass and disturb those already served; and so in the case of *double-headed* byres, in which the cattle's heads are on both sides of the passage, both sides should be served simultaneously, one beast alternately on each side, working backwards, and thus leaving the served ones undisturbed. With the half-door left open for admission of fresh and the emission of heated air through the ventilators, the cattle-man leaves them to enjoy their meal in quietness.

Whenever the cattle have eaten their turnips, and not before, the byre should be cleared of the dung and dirty litter with the graip, shovel, and besom, and wheeled into the dunghill with the barrow. A fresh foddering and a fresh littering are then given, and they are left to themselves to rest and chew the cud until the next time of feeding, which should be at mid-day. After or along with this feed, more fodder is put into the racks, and the dung drawn from the stall into the gutter. In the afternoon, before daylight goes, the dung should again be carried away to the dunghill, and then the last supply of turnips given. Fresh fodder is again supplied, and the litter shaken up and augmented where requisite. After eating a little of this fodder, the cattle will lie down and rest until visited at night.

Oxen in Boxes.—When *boxes* are occupied by feeding oxen, the cattle-man comes to them when he has left the cow-byre. His first act is to remove the refuse fodder from the racks, which is strewn about for litter, and any refuse turnips from the trough, which have fallen upon the litter. An allowance of sliced turnips is then given, and the animals are left in quiet to enjoy their meal. The farthest end of the boxes are first served, and as the boxes are arranged on both sides of the passage, each ox on alternate sides is served in succession, thus avoiding disturbance to the oxen that have been served. With half-doors and ventilators left open, fresh air will find easy access to the cattle. After the turnips have been eaten up, or nearly so, fresh fodder and litter are served, and

the cattle left to lie down and chew their cud. At mid-day another ration of sliced turnips or of cake or other mixed food is served, and after it is finished fresh fodder is supplied. In the afternoon, before daylight is gone, the last feed of sliced turnips is served; and after they are eaten, some more fodder should be given. In boxes the refuse fodder will generally serve for litter, the animals being under cover and the litter in a comparatively dry state from what it would be in hammels. After partaking of some of the fodder, the cattle will lie down to rest until visited at night.

A "Golden Rule" for Cattle-men.

—In thus detailing the duties of the cattle-man, the object has been to show how the various meals should be minutely distributed to cattle. Whatever hour and minute the cattle-man devotes, from experience, to each portion of his work, he does *the same operation at the same time every day*. By strict attention to time, cattle will be ready for and expect their wonted meals, and will not complain. Complaints from stock should be distressing to every farmer's ears, for he may be assured they will not complain until they feel hunger; and if allowed to hunger, they will not only lose condition, but become less capable of acquiring it when the food is even fully given. Whenever lowings are heard from cattle, one may safely conclude that matters are conducted irregularly. Cattle are no hypocrites, and concoct no design for making a fool of their attendant. Their outcry may therefore be believed to be sincere. The cattle-man's rule is simple, and easily remembered: *Give food and fodder to cattle at fixed times, and dispense them in a fixed order.*

Method essential both for Cattle-men and Cattle.—These minute details, in the treatment of cattle, may be regarded as frivolous. They are not so; and where a number of minutiae have to be gone into, unless they are taken in order, are apt to be forgotten, or hastily performed. Consider the number of things a cattle-man has to attend to. He has various classes of cattle under his charge—cows, feeding beasts, young steers, calves, heifers, bulls, and extra beasts; and he has to keep them clean in their various places, and supply them

with food and fodder three times in a short winter's day of 7 or 8 hours. Is it possible to attend to all these particulars as they should be, without a matured plan? A cattle-man requires a plan for his own sake; for were he to do anything only when the idea struck him, he would be as prone to forget as to remember what he had to do. The injurious effects upon the condition of cattle by irregular attendance render a plan as necessary for their sakes.

Before the full force of this observation can be seen, it must be remembered how injurious it is to have food, fodder, and litter, given to cattle too much at one time, too little at another; frequently one day, seldom another; surfeiting them one time, hungering them another; having them clean one day, and dirty another. It stands to reason that such erratic treatment cannot fail to irritate their temper and prevent them acquiring the fine condition which good management never fails to secure.

Loss by Bad Management.—Let us reduce the loss by bad management to figures. Suppose three sets of beasts, of different ages, each containing 20 beasts, 60 in all, and they get as much food as they can eat. Suppose that each beast acquires half a pound less live weight every day than it would by the best management, this would incur a loss of 30 lb. a-day of live weight, which, over 180 days of the fattening season, will make the loss amount to 5400 lb.; and according to a common rule of computation, that amount of live weight is equal to 3240 lb., or 231 stones (14 lb.) of dead weight, which, at 8s. the stone, gives a loss of £92, a sum equal to much more than twice the yearly wages and board of the cattle-man. And the loss might easily be double that amount.

Treatment of Show Cattle.—What has been said applies to feeding ordinary cattle, but selected cattle may be desired to be fattened to attain a particular object, such as a pair of very fine oxen to be exhibited at a show. They should have a hammel or box—a byre does not seem a suitable place for such—comfortably fitted up for them, and ingenuity should be exercised to render it also convenient every way, after determining the sorts of food to be given. A trough for

sliced Swedish turnips—a box for cake and meal—a rack for hay—cut hay and straw—and a trough for water. There should be abundance of straw for litter and warmth, and daily dressing of the skin to keep it clean, as *fat* oxen can reach but few parts of their body with their tongue. But all these appliances will avail nothing if regularity in time is neglected by the cattle-man.

Farmers have not yet acquired the art of administering food to stock on physiological principles, in accordance with the functions of the animal economy. Great advance has in recent years been made in acquiring knowledge on this point, but as yet the general body of farmers are to a large extent groping in the dark.

Grooming and Cleaning Cattle.—Much has been said on the propriety of wisping and currying cows and feeding oxen in the byre, and much may be said in commendation of the practice where cattle are always confined to the byre. When so confined, it seems indispensable for good health to groom them daily, perhaps with the curry-comb and brush, or “wisp” of straw or mat. Currying should be exercised on cattle only when not eating their food and not chewing their cud; and this rule should be strictly enjoined, for there is a strong propensity to dress and fondle animals when at food—from no desire to tease, far less to torment, but it seems a good opportunity for attendants to employ themselves without regarding the feelings of the animals. The untimely meddling, however, has a tendency to irritate some cattle, whilst it pleases others so much as to make them desist from eating. Many are jealous of being approached when eating their food, as is seen when a dog growls and a horse scowls.

In practice there is considerable variation in the hours as well as in the general system of feeding. It is not pretended that the hours mentioned are the best for all cases; still, these full details as to the daily routine of the cattle-man's duties are worthy of a place in this work, even if for no other reason than that they are calculated to enforce upon the mind of the farmer and the cattle-man the great importance of pursuing a well-thought-out system of cattle-feeding with unfailing precision and punctuality.

FOOD AND FEEDING.

Having traced in detail the duties of the cattle-man in regard to the hours of feeding, cleaning, and general treatment of cattle in houses, and having also in a preceding section noticed the arrangement of cattle in byres, courts, and boxes, we now proceed to consider the important subjects of “food and feeding”—that is, the food used for cattle, and the best methods and most suitable quantities, conditions, and proportions of administering it to them.

Here we at once enter into a broad field, in which there are many points—many hills and hollows, so to speak—which have never yet been fully explored and explained. To British farmers of the present day it is a subject of vast interest, and of great and still growing importance. In this work it demands, and shall receive, the fullest and most careful treatment.

It will be convenient to notice in the first place the functions of food and the various articles of food used in the rearing of farm live stock.

FOOD AND ITS FUNCTIONS.

Elements of Food.—The elements of which perfect food is composed are of three different classes: *firstly*, those containing nitrogen, which enter into the composition of bones, hair, horn, wool, skin, blood, and muscle or flesh; *secondly*, those in which nitrogen does not exist, and which mainly fulfil the office of supporting respiration and animal heat, of producing mechanical force and forming fat; *thirdly*, mineral and saline matters, such as build up the main substance of bones, and take an important part in the constitution of the blood and other juices.

Functions of different Elements.—The first are generally classed as the nitrogenised or “flesh-forming” constituents of food; the second as the non-nitrogenised constituents, or the elements of respiration and fat.

The sharp distinction thus formerly made between the nitrogenous and non-nitrogenous constituents of food has, however, by later investigation, been found to have been too arbitrary. For

example, it is now known that nitrogenous matters may become, to a certain extent, transformed into fat, which was at one time doubted or denied by physiologists; while it is now conceded that the non-nitrogenous matters play a highly important part in the production of mechanical force, formerly supposed to be due to the actual using up of muscular tissue.

Affinity of Elements of Plants and of Animals.—The elements which produce the flesh and fat of animals are supplied in their food, ready to be converted to their several uses without undergoing any great or material change. In vegetable bodies there are vegetable albumen, gluten, and casein, which are, in chemical constitution, very closely allied to the muscular and vascular tissues of the body, the curd of milk, and the fibrin and albumen of blood. The phosphates, common salt, &c., which exist largely in the bones, muscles, blood, and milk of animals, exist also in plants; whilst fat exists to some extent, ready formed, in vegetables, in which, moreover, are found in abundance such materials as sugar, starch, gum, and digestible cellular tissue, which are readily convertible into fat, or utilisable for the production of mechanical force and heat.

The proportions, however, in which these various classes of substances exist, vary in different classes of plants and parts of plants, and hence the different results experienced from the use of different kinds of food.

Different Foods for Growing and Fattening Stock.—Young growing animals require different food from those which are being fattened for the butcher. In the former, the object is to build up the bony structure, and to ensure full muscular development; whilst in the case of the animal preparing for the butcher, although we still draw on the nitrogenous or so-called flesh-producing elements of food, yet the chief demands are on the non-nitrogenous or fat-forming constituents.

Proper Mixture of Foods.—There must, however, at all times be a proper mixture of the elements. If an animal is fed exclusively on one description of food—food, for example, which contains merely nitrogenous matter—it would

gradually sink and waste, in consequence of the absence of those elements which are required to maintain an efficient supply of animal heat and to keep up the existence of fat. Again, an animal cannot exist solely on non-nitrogenised food, such as starch or sugar, and if so fed it would rapidly die.

RESPIRATION AND MECHANICAL FORCE.

Stock-owners are earnestly commended, before entering upon a consideration of the various kinds of food, to peruse carefully the following observations as to the utilisation of food in maintaining *respiration* and producing *mechanical force*—i.e., the various movements of the animals, voluntary and involuntary.

Even the casual reading of these notes will at once make clear to farmers the importance of keeping cattle in a comfortable condition—exposed neither to inclement weather nor to undue or unnecessary exercise. But do not let the reading be casual. Let it rather be painstaking and thoughtful, and the more fully and accurately the considerations submitted are borne in mind and acted upon, the more successful will be the feeding operations.

Study carefully also what is said as to *ventilation and exercise*.

Respiration.—In respiration, or the act of breathing, the animal inhales and exhales the atmospheric air. The air drawn in, or inhaled, if dry, consists nearly of—

Nitrogen . . .	79.16
Oxygen . . .	20.80
Carbonic acid . .	0.04
	<hr/>
	100.00

After the air has passed through the lungs, it then consists of—

Nitrogen . . .	79.16
Oxygen . . .	16.84 to 12
Carbonic acid . .	4.00 to 8
	<hr/>
	100.00

The amount of carbonic acid, therefore, is much greater after the air has passed through the lungs than it was when first inhaled. On an average, the natural proportion of carbonic acid in the air is found to be increased 100 times after it is expelled by breathing from the lungs.

Whence, then, is this excess of carbonic acid derived? It must evidently be from some other source than the atmospheric air. In fact, it must obviously be either derived from the body itself or produced within the body during the process of respiration. If we burn a piece of animal or vegetable substance in the air under circumstances which enable us to measure or examine the gases produced by the combustion, we shall find that the carbon, which forms an important integral part of all animal and vegetable matter, has combined with the oxygen in the air, forming carbonic acid gas; while the hydrogen of the substance has been converted into watery vapour by a like process. In fact, it is the chemical combination of the oxygen with the carbon and hydrogen of the substance that constitutes the phenomenon of combustion with its attendant heat.

Now when air is taken into the lungs it is brought, by a beautifully organised mechanism (which we cannot in this place describe), into very intimate contact with the blood, which takes up some of its oxygen, and conveys it through the circulatory system. Here the oxygen chemically acts on certain constituents of the blood, and combines with them, virtually burning them up. The main products of this combustion are the same as those produced by burning paper, or tallow, or other combustible matter in the air—viz., carbonic acid gas and water. The carbonic acid gas is eliminated in the breath, and so, to some extent, is the water, the remainder passing away in perspiration and through the kidneys, which also excrete the urea formed by the destruction or using up of the nitrogenous constituents of the blood.

Speaking practically, and not with any special regard to the niceties of physiological accuracy, we may say that the materials burnt up in the blood are the materials supplied in food,—that, except for the comparatively small proportion of food actually utilised for the formation of new tissues, all the digestible parts of the food furnish merely so much fuel to be burnt up in the blood. But is the quantity so burnt up, or oxidised, a vague or illimitable quantity? Certainly not. On what, then, does it

depend? On the following considerations:—

Temperature of Animals.—An animal has to keep up a certain high temperature. This temperature is variable in different animals, but is in most cases somewhere near 100 degrees Fahrenheit. If the blood of the animal rises above its normal temperature it becomes feverish, and a few degrees further rise are fatal. An abnormally low temperature is no more compatible with health than an abnormally high one.

How, then, is this bodily temperature kept constant amid the variations of external temperature to which all animals are more or less subjected? In answer to this we need here give only the short reply that nature, while an animal is in health, provides that more or less food-material shall be burnt, according to whether the tendency is to lose or gain in temperature. In cold weather an animal radiates heat much faster than in hot; and if respiration ceases—and with it life—the heat of the animal is rapidly dissipated, and it soon becomes as cold as the surrounding air. The rapid loss of heat in such a case is easily apparent.

We are apt, however, not to reflect that in the same cold weather a living animal loses heat even faster. But as fast as heat is dispersed from its body into the cold air, fresh heat is produced by the combustion involved through the respiratory process. If the weather becomes warmer, or the animal is taken into a warmer place, less heat is given off into the surrounding air in a given time than in the colder condition just considered. In order, then, that the animal may not grow too hot, the combustion process in the blood becomes diminished, so that less heat is manufactured.

There are other controlling agencies, such as the action of the perspiratory glands; but essentially we may say that nature keeps the animal temperature constant, by regulating the quantity of food-material burnt in the blood.

Mechanical Force.—All the material burnt in the blood, however, does not produce heat. Much of it is spent in producing mechanical force. Just as coal burnt in an engine-furnace produces force which is ultimately used in driving wheels or cranks for raising weights,

grinding corn, ploughing, threshing, or other mechanical work, so a portion of the food burnt in the blood is spent in the production of the various movements of the animal, voluntary and involuntary.

The minimum of food for this purpose is consumed by the animal in the stall where it does no work; the maximum by the horse or the ploughing ox.

Food regarded as Fuel.—The fat, the starch, the sugar, the gum, the digestible fibre, and, to a minor extent, the albuminoids or nitrogenous matters, are, then, to be regarded as so much fuel put into the animal engine, to be converted partly into heat, partly into mechanical force or movement, involving more or less work. But we have seen that the food or fuel consumed for keeping up temperature is limited by the surrounding temperature, and that consumed to produce movement or work is limited by the movement effected or the work done.

Forming Fat.—What, then, becomes of such food as is over and above what is thus required? *It accumulates in the body mainly in the form of fat.* It is, indeed, the judicious supply of this surplus food that constitutes the skill of the fattener of stock.

In feeding a horse, we give him just so much food as will enable him to do his work and keep him in "fit" condition. With the ox or the sheep or the cow, we have to make flesh or milk; and we have to bear carefully in mind that for the purposes of heat and movement—merely, that is to say, to keep the animal alive—there is a certain daily expenditure of food, the excess over which is alone available for making increase or profit.

We strive, therefore, to limit the profitless consumption of food which merely keeps the animal alive, by protecting it, when feasible, from cold, and by limiting its exercise.

Thick Hides in Cold Regions.—It is to economise food that animals in cold regions possess warmer coverings than those which inhabit hot regions. Those who have always been accustomed to the sleek fine coats of carefully tended cattle may think that the shaggy winter covering of the kyloe is grotesque, and perhaps more ornamental than useful; but they overlook the fact that the shaggy covering is an economiser of food, and

that by means of the additional warmth which it affords, the scanty food which the kyloe procures during winter in its natural state, and which would be insufficient of itself to sustain the animal—that is, to evolve a sufficient amount of heat to enable the animal to undergo the rigour of the winter—becomes equal to the purpose, in consequence of this covering. There is a less demand on the combustible materials stored up in the food, and thus the shaggy covering becomes essential to the existence of the animal.

Shelter for Cattle.—It will now be easily seen that insufficient house-accommodation is a serious disadvantage to the owner of cattle, entailing as it does an extra expenditure of food without an equivalent return. And how much greater is the loss in the case of those whose cattle are exposed during the entire winter, without any shelter beyond that which is afforded by a hedge! As truly remarked by Mr R. O. Pringle,¹ when cattle on a cold winter day

"Mourn in corners where the fence
Screens them, and seem half petrified to sleep
In unrecumbent sadness,"

there is a waste of material going on as surely as if the owner wilfully undertook the office of the incendiary, and set fire to his hay-ricks. On the approach of winter, all cattle ought to be put either into properly constructed houses or covered yards, where their food will be expended in promoting their growth and development, and not wasted in meeting the extra demand for animal-heat-producing material which exposure creates.

Ventilation.—But while shelter is essential, so also is *ventilation* in houses for cattle. Allusion has been made to the change which takes place after the air has passed through the lungs, by which carbonic acid is abundantly produced. If there is no means of escape provided, the carbonic acid will accumulate to such an extent as to be most prejudicial to the animals breathing an atmosphere which is saturated with it. It is, in fact, a deadly poison; and when we bear this in mind, we can have little difficulty in tracing to their true source many of those inflammatory diseases to which

¹ *Live Stock of the Farm*, 30.

cattle confined in ill-ventilated houses are subject, and the origin of which often at first appears so very mysterious.

A man consumes about a gallon of air per minute. "A horse," according to Boussingault, "throws off daily forty-five pounds of carbon in the form of carbonic acid gas; and in the case of the cow, four-ninths of the carbon contained in the daily food is consumed during the process of respiration." This shows how very soon the air in a closely shut-up stable or cow-house becomes vitiated, and rendered utterly unfit to support life in a healthy state.

If, therefore, it is necessary to prevent waste of food by providing proper shelter, it is no less requisite to the healthy condition of the animals that the air which they breathe shall always be kept in a state of purity.

Ample space should be secured over the heads of the animals, and hay-lofts and other obstructions to a free circulation of air ought never to be permitted. Ventilators should be inserted in the apex of the roof to permit the heated exhaled air to escape, and means taken to secure a constant supply of fresh air from beneath, without creating a thorough draught, the effect of which would be to check the perspiration, and thus lay the foundation of catarrh and other diseases.

Effects of Exercise on Feeding Stock.—The exercise which an animal takes, causes, as we have seen, a corresponding waste of food. By exercise the respirations are not only rendered more frequent, but are also increased in force; hence there is a greater consumption of carbon and hydrogen—consequently the animal requires a larger amount of food to enable it to fatten, or if this is withheld, it becomes wasted or leaner. It is well known that fattening animals become more rapidly fat when kept perfectly quiet, and free from everything which excites their attention and renders them restless.

Exercise necessary for growing Animals.—The growing animal, indeed, requires a certain amount of exercise in order to promote muscular development and strength of constitution. If sufficient exercise is prevented in this case, the young animal will, no doubt, accumulate fat freely, but its constitution will

be enfeebled; and if the same treatment is pursued through several successive generations, although the animals will gradually acquire a greater aptitude to fatten at an early age, they will also become less to be relied upon for breeding purposes. Growing and breeding animals should therefore be always permitted a sufficient amount of exercise to secure a healthy system, whilst those which are fattening for the butcher must be kept quiet and undisturbed.

VARIETIES OF FOOD.

It has been thought desirable to present in this work a full description of the various commodities used as food for stock. Prices, and home supply or deficiency, and other circumstances which tend to regulate the choice of foods, are subject to such variation, that precise directions cannot safely be given as to the kinds and proportions of foods which would be best for all circumstances. Careful consideration of the information furnished as to the different varieties of foods will assist stock-owners in deciding from time to time as to which they should select for their stock. In Pringle's *Live Stock of the Farm* (third edition, William Blackwood & Sons) a great deal of useful matter relating to foods is given; and not a little of this, revised in the light of recent discoveries and experience, is produced here, largely supplemented by fresh information of practical value.

Milk.

Milk is the most perfect and most natural of all foods for young animals. As already observed, there must be a proper mixture of the nitrogenous elements or albuminoids along with the non-nitrogenous (carbo-hydrates and fat), to form perfect food. A perfect illustration of this mixture is found in milk, the first description of food upon which the young animal subsists. It contains, 1st, casein or curd, which is chiefly analogous to the *fibrin* or lean part of the flesh; 2d, fat in the shape of butter; 3d, sugar; and 4th, certain substances which are converted into the earthy part of the bones, and the saline matter of the blood. The saline or earthy portion of milk consists of the phosphates of lime, magnesia, and

iron, chloride of potassium, and common salt.

In its ordinary state the milk of the cow consists on the average of about $3\frac{1}{2}$ per cent of casein or flesh-forming matter, $3\frac{1}{2}$ per cent of butter, oil, or fat; $4\frac{1}{2}$ per cent of sugar; $\frac{3}{4}$ per cent of saline matter; and $87\frac{3}{4}$ per cent of water. Everything, therefore, which is required to promote the development of the growing animal is contained in the milk, blended together in proportions suited for the purpose.

Wheat.

The average composition of the grain of wheat is as follows:—

Water . . .	12.5
Albuminoids .	12.0
Fat . . .	2.0
Starch, &c. . .	69.3
Woody fibre . .	2.5
Mineral matter (ash) .	1.7
	<hr/> 100.0

Flour Unsuitable for Stock.—In the shape of flour, wheat is a very starchy food, and in that form not suitable for stock; but as it leaves the straw with the bran and other coats, it comes pretty near to the desired albuminoid ratio of 1 to 5.

Fall in Price of Wheat.—Formerly, when wheat was selling at from 45s. to 60s. per quarter, it was too expensive to be used in feeding stock. Unfortunately for owners and occupiers of wheat lands, it has, since the “eighties” set in, tumbled down headlong in price, till in 1887 its average market value was not more than 32s. per quarter. At this very low price wheat may in some cases be employed with advantage as food for stock.

Damaged Wheat for Stock.—Indeed several instances are recorded of wheat, even when the market price was as high as 50s. per quarter, having been used profitably in feeding stock—chiefly in cases in which the wheat had been damaged by wet weather or mildew. In 1872 much wheat was damaged by the wet harvest, and a great deal of the sprouted grain was turned to good account in feeding stock. It was first kiln-dried and then mixed with chaffed hay or straw.

Wheat for Cattle and Sheep.—Mr

Badcock of Stogumber, writing to the *Chamber of Agriculture Journal* on the use of wheat for farm-stock, says: “I grind the wheat to fine meal. At present I am feeding ten beasts on grass, with half a peck per day, mixed with straw-chaff, and cart-horses receive one-third peck each per day, and chaff with grass. When I take my horses in house I shall give one peck of meal and two pecks of oats mixed with chaff, and a few cut mangels to every three horses per day. I do not give it to hack-horses. Fattening beasts in house receive it with roots and a plentiful supply of water, and if I feed them very high, I mix linseed-cake. I think there is nothing better for pigs. For sheep I have never used it except with cut roots; then I shake it over the roots in the troughs.”

Mr Wilcox of Almondsbury, Gloucestershire, was in the habit of feeding stock with wheat before the decline in its price, and he considered it to be more nutritious than any other food he had ever used. His method with cattle was as follows: Cut straw and hay to fine chaff—the greater proportion being straw, thrown over a given quantity (4 lb. or 5 lb.) of meal, with as much pulped-root as you feel disposed to put, mixing all together. Give it twice a-day. To sheep he always gave it crushed or bruised—say a pint or a pint and a half each per day. He thought it the finest food for sheep he had ever used.

Feeding Value of Wheat.—Mr John Speir, Newton Farm, Newton, Glasgow, has used wheat with very satisfactory results in the feeding of dairy-cows. He points out, however, that to be a successful feeding-stuff by itself it would require much more oil than it possesses, and considers that the addition of one-fourth of linseed or one-third of linseed-cake, would much enhance its feeding value. He adds: “Even to cattle—mixed with an equal proportion of decorated cotton-cake and peas or beans, all ground into rough meal (not flour)—the very best results have been obtained. It is better boiled and given whole than ground into flour, but as rough meal it is better than either, as it never then gets into the doughy state, and it mixes freely with chaff and pressed or sliced turnips.”

Taking as his standard of value, the digestible carbo-hydrates at $\frac{1}{2}$ d. per lb., and the digestible fat and albuminoids at $2\frac{1}{2}$ d. per lb., Mr Speir places the feeding value of wheat at £6, 8s. 4d. per ton, with maize at £5, 18s. 2d., linseed at £13, os. 11d., and linseed-cake at £9, 9s. 6d. If linseed-cake fell in market price to, say, £7 per ton, then wheat would, according to this calculation, be worth only £4, 15s. 2d. per ton as food for stock. Mr Speir takes linseed-cake as the standard or most important food for meat-production, and so estimates the feeding worth of other foods by its market price.

For milk-production Mr Speir takes beans as the chief food, and according to the above method of calculation, when the market price of beans is £7 per ton, wheat would be worth £5, 12s. 3d., or 17s. per ton more than when compared with linseed-cake for meat production.

Even at the low price of 31s. per quarter to which it fell in 1887, wheat realises in the grain market over £7 per ton. On the basis of the calculations made by Mr Speir, it would seem that it would still be more profitable to sell wheat than consume it by stock, for linseed-cake can now (1888) be purchased at from £7 to £8 per ton.

Wheat for Sheep.—Experiments conducted by the Royal Agricultural Society of England at Woburn, place wheat in a more favourable light than Mr Speir's

calculations—at any rate as food for sheep. During the winter 1885-86 a series of experiments with linseed-cake, wheat, and other cereals as food for sheep gave results which were unexpectedly favourable to wheat. Indeed, considered as food only—that is, omitting the question of manurial value—wheat gave the best monetary return, linseed-cake coming second. Reckoning manurial value according to Lawes's table, these two stood about equal.

With the view of correcting or verifying these results, another series of experiments were conducted at Woburn in the winter of 1886-87. The experiment continued for 95 days, and the sheep—40 crosses between the Hampshire and Oxford Down breeds, divided into 5 pens of 8 sheep each—were put on roots for a short time before the experiment began, to accustom them to the diet. Each pen received as much sliced swedes and chopped hay as the animals could eat, and had, in addition, for each animal $\frac{1}{2}$ lb. for the first week, and thereafter $\frac{3}{4}$ lb. per day of the particular kind of food being tested. The foods on trial were—pen 1, linseed-cake; pen 2, wheat; pen 3, decorticated cotton-cake; pen 4, linseed-cake and barley in equal proportions; and pen 5, decorticated cotton-cake and barley-meal in equal proportions.

The following table shows the weights at the conclusion of the experiment, as well as the increase in the 95 days:—

WEIGHTS OF 5 PENS OF SHEEP AT THE END OF 95 DAYS, DEC. 23, 1886,
TO MARCH 28, 1887.

	PEN I. Linseed-cake.	PEN II. Wheat.	PEN III. Decorticated cotton-cake.	PEN IV. Linseed-cake and gritted barley.	PEN V. Decorticated cotton-cake and gritted barley.
	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.
Total weight of 8 sheep on March 28, 1887	13 2 3	13 1 12	13 3 9	12 3 23	12 2 1
Total weight on Dec. 23, 1886	11 0 17	11 0 16	11 0 15	11 0 16	11 0 17
Total increase in weight of 8 sheep during 95 days	2 1 14	2 0 24	2 2 22	1 3 7	1 1 12
Equivalent in lb.	266 lb.	248 lb.	302 lb.	203 lb.	152 lb.
Increase per head during the whole 95 days	33 lb. 4 oz.	31 lb.	37 lb. 12 oz.	25 lb. 6 oz.	19 lb.
Daily increase per head	5.6 oz.	5.2 oz.	6.4 oz.	4.3 oz.	3.2 oz.

Reckoning linseed-cake at £8, 14s. 10d. per ton, decorticated cotton-cake at £7, 4s., wheat at £6, 8s. (30s. per quarter), barley at £5, 6s. (22s. per quarter)—which were the market prices at the time—Dr John Voelcker shows that the relative cost per lb. of the increase in live weight produced by the various foods was as follows:—

Pen	d.
I. Linseed-cake	1.84
II. Wheat	1.50
III. Decorticated cotton-cake	1.33
IV. Linseed-cake and barley	1.96
V. Decorticated cotton-cake and barley	2.34

It is thus seen that decorticated cotton-cake not only produced the largest increase, but also did this at the lowest cost. In the first experiment it was undecorticated cotton-cake that was tried, but it did not come out so well. Wheat comes second, and is just about as far ahead of linseed-cake as it was in the experiments of the preceding winter.

The following table shows the manurial values of a ton of linseed-cake, wheat, and decorticated cotton-cake, as estimated by Lawes and Gilbert; and also the manurial value, according to this standard, of the 522 lb. of each of these foods consumed by each of the pens of 8 sheep during the 95 days of the experiment:—

	Per ton.	Manure Value.	Per 522 lb. consumed.
Linseed-cake	£3 8 6	£0 18 3½	
Wheat	1 8 7	0 6 8	
Decorticated cotton-cake	5 13 0	1 6 4	

Now, considering these foods in regard to their value both for feeding and manurial purposes, we arrive at the following table:—

	Linseed-cake.	Wheat.	Decorticated cotton-cake.
Cost of additional food for each lb. of live weight	d.	d.	d.
Less manurial value	1.84	1.50	1.33
Net cost of additional food for each lb. of live weight	.82	.32	1.04
	1.02	1.18	.29

full relative manurial values here stated are realised; yet the great superiority of decorticated cotton-cake over both wheat and linseed-cake, in the feeding of sheep, stands out indisputably.

The wheat was given whole, as it had been found in the previous year that this form answered best. Dr J. Voelcker remarks that "the fact that all the sheep fed on wheat went through the experiment without any illness whatever, confirms the observation before made, that it can be quite safely used for sheep."

The quantity of roots, sliced swedes, consumed per head, began at about 23 lb. per day and rose gradually to about 30 lb. The pen on linseed-cake consumed most roots, averaging about 29 lb per day for the 95 days; pens 2 and 3 averaging 28 lb. per day per head; and the other two 26½ lb.

At first the sheep consumed about 4 oz. of hay-chaff per head daily, and increased in a week to about 8 oz.

There did not seem to be much difference in the growth of wool in the various pens; but it was observed that the quality of the wool of the cake-fed sheep was decidedly better than that of the wheat-fed ones.¹

Bran.

In milling wheat for use as human food, the bran is usually separated from the flour. An average analysis of bran is as follows:—

Water	14.0
Albuminoids	14.5
Fat	4.0
Starch, &c.	51.5
Woody fibre	10.0
Mineral matter (ash)	6.0

100.0

Bran is much used as food for live stock, sometimes in the form of mashes, and at other times mixed with other kinds of foods. When used by itself, or mixed with cold water, it has a slightly laxative effect, which renders it useful in preparing horses for physic, and in some cases may so act as to obviate the necessity of giving purgative medicine. The ash of bran contains a large proportion

It is seldom found in practice that the

¹ Jour. Royal Agric. Soc. Eng., xxiii. 417.

of phosphates, or the earth of bones, much larger than the ash of barley or oats. Hence it is particularly useful as part of the food given to milch cows, when such are "in profit," or full milk—milk being rich in phosphatic constituents.

Bran acts beneficially in counteracting the heating properties of maize and other meals.

Bran for Stock-feeding.—Mr G. H. C. Wright, Sigglesborne Hall, Hull, says that, given to cows in excess, bran deteriorates the butter by diminishing the size of the fat globule of the milk; and adds: "I consider that bran is more suitable for feeding stock than for dairy-cows; for the feeding beasts, a daily ration of 1 stone of bran, 1 stone hay, and 2 stone turnips, will give a much larger increase in the weight of the cattle than any corn-meal used in conjunction with the hay and the turnips, and will prove to be a cheaper artificial food. In the case of dairy-cows, this is reversed; grain-meal will give a much better result than bran, both as regards quality and quantity of milk."¹

This, it should be mentioned, is not in accordance with the opinions hitherto most generally accepted. The value of bran for fattening stock deserves fuller investigation by actual experiment.

Barley.

The following is an average analysis of barley:—

Water	14.0
Albuminoids	10.5
Fat	4.5
Starch, &c.	62.0
Woody fibre	7.0
Mineral matter	2.0
	<hr/>
	100.0

Barley is thus exceedingly rich in the fattening properties of food. It is seldom—and never should be—given in its dry whole state as food for stock; but in the form of rough meal, or malt, or cooked, it is employed very extensively in feeding stock. Like wheat, it has fallen greatly in price, and its home consumption, now very much larger than in former times, is steadily increasing.

¹ *Jour. Brit. Dairy Fr. Ass.*, 1888, 14.

Cooked Barley.—When barley is cooked, it must be allowed to simmer slowly at least twelve hours, until the whole forms a mass of rich pulpy matter, perfectly free from whole grains; and in cooking, the greatest care must be taken to prevent the barley from becoming burned, by adhering to the boiler in which it is prepared. When thoroughly cooked, it becomes a most valuable ingredient in the food of fattening animals, and horses thrive remarkably well upon it—so much so, that a course of boiled barley given at least once a-day will very soon renovate horses that have been worn out with hard work.

Boiled barley is used by some of the most successful exhibitors of shorthorns in the preparation of their cattle for the show-yards. Along with a little oilcake, it gives that finish—brings out that mellowness in handling—which is so much desired in such cases.

Barley-meal for Pigs.—For the fattening of pigs, barley-meal is the king of all foods. For pork-production, it is, on account of its exceptionally high percentage of starchy matter, the most perfect food yet discovered, and no other animal will yield a larger percentage of butcher-meat from a given quantity of barley than a pig of a good sort.

Steeping Barley.—Whole barley should be steeped in water at least twenty-four hours before being given to stock; but the more common practice now is to grind it or to crush it into rough meal. Some think it advisable to steep the ground barley in water.

Malt.

The Malt-tax Controversy.—Barley is converted into *malt* by being first steeped and then allowed to germinate; the original object of this process being to prepare the barley for distillers and brewers. As to the simple question of the relative feeding merits of *malted* and *unmalted* barley, there was a lively and long-continued controversy. Formerly the duty now levied directly upon manufactured spirits, ales, and porters, was imposed upon malt, so that the farmer could not malt barley for feeding his stock without paying the malt-duty. This was a momentous grievance to the farmer, on whose behalf it was urged

that malt was much more valuable as food for stock than unmalted barley. Human nature is a little curious in some of its moods, and it is just possible that the barrier which formerly existed to the use of malt as food for stock may have had something to do with the high opinion then expressed as to its value for that purpose. Be that as it may, the duty was removed from the malt, and now that farmers can make malt for their stock as freely as they desire, less is heard of its alleged special feeding virtues than when they had no such liberty. Indeed, it is used as food only to a very limited extent.

That malt is a valuable and palatable food, there is no doubt whatever. The contention that it is superior food to unmalted barley has not been borne out by practical experience.

Rothamsted Experiments on Malt.

—Sir John Bennett Lawes carried out an elaborate series of experiments upon the use of malt in feeding various kinds of stock, and it may be useful to produce here the following summary of a report which Sir John made upon the subject to the Government:—

The Loss and Chemical Changes which the Grain undergoes by Malting.

1. In malting barley of fair malting quality, in the usual way, there was a loss of nearly 19 per cent of its weight, about 12 of which was water, the remaining 7 being solid matter or food-material.

2. In malting barley of good feeding but inferior malting quality, there was a loss of about 22 per cent of its weight, of which 15 was water, and 7 solid matter or food-material.

3. The loss of solid matter consisted chiefly of starch or other non-nitrogenous substances, but comprised also a small amount of nitrogenous or "flesh-forming" and mineral matters.

4. The most characteristic change which the grain undergoes by malting is the conversion of a portion of its starch into dextrine, and the further conversion of a portion of the latter, amounting to from 8 to 10 per cent of the grain, into sugar.

5. By malting, the grain acquires properties by virtue of which, when the

malt is digested with water, much of its own remaining starch gradually changes into dextrine and sugar; and if the digestion be aided by heat, not only the whole of the remaining starch of the malt itself, but the starch of a considerable quantity of unmalted grain or other starchy substances mixed with it, may become so converted.

6. Owing to the great loss of moisture and non-nitrogenous substances—in fact, of total weight—which grain undergoes by malting, a given weight of the malted grain contains a larger quantity of nitrogenous or flesh-forming substances than an equal weight of the unmalted grain; but as there is an actual loss of those substances by malting, a given weight of malt will, of course, contain less of them than the amount of barley from which it was produced.

Malting, and the use of Malt for Feeding.

7. It is probable that if grain were malted extensively for feeding purposes, the growth would not be carried so far as in the manufacture of malt for brewing, and the loss of solid matter or food-material would, of course, be less accordingly.

8. As the "malt-dust" contains a considerable amount of food-material, abstracted from the grain during growth, when malt is used for feeding, the "dust" should either not be separated, or, if separated, should be given to the animals along with the screened malt.

9. Owing to the loss of weight which grain undergoes by malting, equal weights of malted and unmalted grain should not be employed in comparative feeding experiments, but only so much malt (with the dust) as would be produced from the amount of raw grain given, or to be substituted, in the parallel experiment.

10. Malt given as food to animals may be supposed to act simply by supplying more or less of the starch of the grain from which it was produced in the more soluble, and, perhaps, therefore more easily digestible, conditions of dextrine and sugar, or also by aiding the conversion into dextrine and sugar of the starch of other foods given with it.

The Experiments with Milking Cows.

11. A comparative experiment was made in which, besides other appropriate

food, ten cows received, for a period of ten weeks, 3 lb. of fair malting barley per head per day, and other ten received the amount of malt (with its dust) produced from 3 lb. of barley from the same stock.

12. In the experiment in which the malt was given, it contributed about $7\frac{1}{2}$ per cent of the solid matter of the total food.

13. The result was, that almost exactly the same amount of milk was yielded for a given amount of food with the unmalted and with the malted barley, but that the milk from the cows having the unmalted barley contained the higher proportion of cream.

The Experiments with Fattening Oxen.

14. A comparative feeding experiment was made for a period of twenty weeks, in which, with other appropriate food, ten oxen received 4 lb. of good feeding barley per head per day, and other ten the amount of malt (with its dust) produced from 4 lb. of barley from the same stock.

15. In the experiment with malt, it contributed about $13\frac{1}{2}$ per cent of the dry or solid substance of the food.

16. Both lots of oxen gave more than an average amount of increase, whether reckoned in proportion to a given live weight within a given time, or to a given amount of food consumed; but the ten having the unmalted barley gave rather more than those having the malted.

17. The barley-fed oxen also gave rather the higher proportion of dead weight to live, and although neither lot was fully ripe, the barley-fed animals were more even in condition and quality than the others; but the beef of some of the malt-fed ones was decidedly superior in point of ripeness and quality, and that of others decidedly inferior, to that of any of the barley-fed oxen.

18. It would seem, therefore, that the effect of the malt as food was more dependent on the constitution and condition of the individual members than was that of the barley; and it should be remarked that the oxen which fattened the best upon the malt were not the most backward or weakly animals, but those which were the heaviest and in the best condition at the commencement.

The Experiments with Fattening Sheep.

19. Comparative experiments were made for a period of twenty weeks with five lots of sheep of twelve each. Besides other appropriate food given equally to all, the allowance per head per day was—to lot 1, from $\frac{3}{4}$ to 1 lb. of fair malting barley; to lot 2, the malt (with its dust) from an equal amount of the same barley; to lot 3, from $\frac{3}{4}$ to 1 lb. of good feeding barley; to lot 4, the malt (with its dust) from an equal amount of the same barley; and to lot 5, an equal amount of the same barley, two-thirds unmalted and one-third malted.

20. In experiments 2 and 4, the malt contributed about $22\frac{1}{2}$ per cent, and in experiment 5 about $7\frac{1}{2}$ per cent, of the dry or solid substance of the food.

21. All five lots of sheep gave about an average amount of increase; there was very little difference in the result obtained with the unmalted and the malted grain, but such as it was, it was rather in favour of the unmalted.

22. The mutton of all five lots was of very good quality—there was no appreciable difference between the lots in this respect; but the barley-fed animals gave slightly the higher proportion of dead weight to live weight.

The Experiments with Fattening Pigs.

23. The appropriate food of the fattening pig contains a larger proportion of starch than does that of either cows, oxen, or sheep. If, therefore, the starch of food be rendered more digestible and assimilable by its artificial conversion into the more soluble forms of dextrine and sugar, it might be supposed that it would be peculiarly advantageous to malt a part, or the whole, of the characteristically starchy food of the fattening pig.

24. Experiments were made for a period of ten weeks with six lots of pigs of eight each. Besides 1 lb. of pea-meal per head per day given to all—lot 1 had crushed malting barley; lot 2, the crushed malt (with its dust) from the same barley; and lot 3, the unmalted and the malted barley, each separately, *ad libitum*; lot 4 had crushed feeding barley; lot 5, the crushed malt (with its dust) from the same barley; lot 6, the same barley, four-fifths unmalted and one-fifth malted, *ad libitum*.

25. In experiment 2 the malt contributed $87\frac{1}{2}$, in experiment 3 about 13, in experiment 5 about 89, and in experiment 6 about $16\frac{1}{2}$ per cent of the dry or solid substance of the food.

26. The pigs having pea-meal and entirely unmalted barley (lots 1 and 4) gave a full average amount of increase, both in relation to a given live weight within a given time, and to a given amount of food consumed: those having only a small proportion of malted barley (lots 3 and 6) increased in both respects nearly, but not quite, as well; but those having the pea-meal and entirely malted barley (lots 2 and 5, more especially lot 2) gave less increase in relation to a given live weight within a given time, and required the expenditure of considerably more barley to produce a given amount of increase.

27. The pigs having the unmalted barley (lots 1 and 4) also gave the best average proportion of dead weight to live weight, and their pork was of very good quality; the pork of the other lots was also of very good quality, but the more evenly so where a small proportion of malt was given (lots 3 and 6).

Woburn Experiments on Malt.—In the winter 1882-83, the late Dr A. Voelcker carried out a series of experiments at Woburn, under the auspices of the Royal Agricultural Society, with the view of testing the relative merits of malted and unmalted barley and other foods for sheep, and the results from the barley in the two forms were so nearly equal, that he says the only legitimate conclusion that could be drawn is, "that barley-meal and linseed-cake given to young growing sheep in moderate proportions, together with roots and some hay and straw-chaff, is as good as the same feeding mixture in which the same amount of barley is used in a malted state."¹

Fair Comparison of Malt and Barley.—In experimenting upon malted and unmalted barley, it, of course, should be borne in mind that it is not fair to compare the feeding value of a given weight of malt with that of the same weight of barley, and then to credit the malt with the full superiority that might be

observed. We have to remember, bearing in mind the statement of Sir John Bennett Lawes already given, that the given weight of malt is derived from a considerably larger weight of barley, and that the malting process itself, represents a money cost. It is a fair comparison only when the malt is fed, as in the Rothamsted experiments, side by side with the quantity of raw barley which it represents: or we might go further and say, with a somewhat larger quantity, seeing that the cost of malting may be taken to represent the value of a little additional food. In trials made by practical farmers such niceties of calculation and experiment, though of vital consequence, are too often overlooked, which may account for the non-realisation of the evidently over-sanguine expectations originally formed as to the coming importance of malt as food for stock.

At any rate, the present negative attitude of the farmers towards malt, now that it is within their unrestricted reach, is with some justice claimed by the followers of Sir John Bennett Lawes, as a practical testimony to the soundness of his views.

Mr James Howard, M.P., on Malt.—Mr James Howard, of Clapham Park, Bedford, M.P., states that for many years he used malt for getting horses into condition, and that the results were very satisfactory. After the repeal of the malt-tax, malt became an article of regular diet upon his farms. Working horses, young horses, feeding cattle, store cattle, sheep on roots, sheep in houses, as well as lambs, all had malt along with other food, and Mr Howard expresses satisfaction with the results. Each working horse got per week $1\frac{1}{2}$ bushel of oats, 1 peck of maize, 1 peck of malt, and 14 lb. of bran—the maize and malt being crushed together: he would not use malt without crushing it. Upon this feeding, at less cost, his horses did better than when fed upon 2 bushels of oats, $\frac{1}{2}$ bushel of maize, and 14 lb. of bran per week. Young growing horses had $1\frac{1}{2}$ lb. malt per day, along with 3 pecks of oats and 14 lb. of bran per week. Wether-sheep on roots had $\frac{1}{2}$ lb. malt daily, along with 1 pint of tail barley. Feeding cattle had $2\frac{1}{2}$ lb. (increased to 4 lb. as they approached maturity) of malt per day,

¹ *Jour. Royal Agric. Soc. Eng.*, xix. 430.

mixed with 1 gallon of meal and 1 gallon of linseed and cotton cake. Young store cattle got about $\frac{1}{2}$ lb. malt and 1 lb. cotton-cake per day—all these being winter rations. Mr Howard found it desirable to begin with small quantities of malt, and increase by degrees.¹

Cost of preparing Malt.—Mr F. Beard, Horton, near Canterbury, states that he found the cost of converting barley into malt was rather less than 2s. per quarter, and he considers that its value as a condiment, apart altogether from its feeding value in the ordinary sense, would quite pay for the cost of conversion.²

Special Properties of Malt.—It has, however, been proved that malt does possess certain useful properties in the feeding of stock which are not possessed to the same extent by unmalted barley. The late Mr Richard Booth, of Warlaby, considered that malt was superior to any other article for feeding cattle up to the very "tip-top" condition to which they require to be brought when they are intended for the show-yard. The late Mr Hudson, of Castle Acre, instituted an experiment between cattle fed on malt and a lot of similar cattle fed upon barley-meal. The result was decidedly in favour of the malt-fed animals. And the butcher who slaughtered Mr Hudson's cattle stated that the cattle which had been fed on malt "were of a much better quality than the others; the grain was finer, and altogether of a superior description."

Malt has been used with good results in rearing young pure-bred bulls. An experienced Northumberland breeder of shorthorns used regularly to sell his barley and buy malt, for the purpose of feeding his calves and young cattle, as he said he could not do without it.

All kinds of farm-stock thrive on malt, and it has the best effects when given to animals which are delicate, recovering from an illness, or "off their feeding." It has been found that the addition of malt to other food prevents "scour" in sheep.

Malt evidently assists digestion, and thus it is not only a useful article of food

in itself, but, by the manner in which it acts, it tends to render other kinds of food, along with which it is given, more useful than they would be without it. The late Dr A. Voelcker stated, that "when an animal has got into fine condition, and has to be supplied with a large amount of food in order to its rapid development, the addition of malt is most useful. It seems to help the digestion remarkably—it might be said, wonderfully. Now we can easily understand this; for it is not only the sugar of malt which acts usefully, but it has also the peculiar power of changing the starch in barley-meal rapidly into sugar. This shows there is something in malt, over and above the ready-made sugar, which accounts for its efficiency in certain circumstances."

The truth probably is, that such special value as malt possesses is to a great extent a *condimentary* value. Just as cattle-spices are valuable for imparting a relish to diets in which straw-chaff or poor hay predominates, stimulating the salivary and gastric juices to do rather more work than they would otherwise be apt to perform under the circumstances, so malt, owing to its sweet and appetising flavour, may impart a relish to food that may be of value.

This would apply either in the case of coarse or poor food, or in the case of an animal a little out of health, and, no doubt, also in the case of an over-fed and therefore dainty animal being finished for the show-yard; and it is especially, it may be noted, with regard to such cases as the last-named that we have evidence of the value of malt.

It by no means follows that a food which best puts the finishing touches on an abnormally fat animal (which is rarely produced at a profit) is to be regarded as, on that account, an economical article of diet for profitable meat-production.

Bere and Rye.

These are very similar, but slightly inferior, to barley, in feeding value.

Rye is generally used in this country in a green state when given to cattle. The grain is useful for feeding purposes, although somewhat inferior to barley. Sir Charles Cameron gives the following as

¹ *Jour. Royal Agric. Soc. Eng.*, xvii. 88.

² *Ibid.*, xvii. 87.

an analysis of the grain of rye grown in Ireland:—

Water	16.0
Albuminoids	9.0
Fat-formers	66.0
Woody fibre	8.0
Mineral matter (ash)	1.0
	<hr/> 100.0

Rye-meal is given with advantage to milch cows.

Malt-combs.

When barley is converted into malt, the effect of the steeping process is to cause the grain to throw out young shoots, just as the seed does when put in the soil. These young shoots are afterwards separated from the malt, and are known as "*malt-combs*," or "*cummins*," or "*malt-dust*." The combs are used as feeding-stuff, and have been found useful, along with other articles, as food for milch cows. The following analysis of malt-combs was made by Sir Charles Cameron of Dublin:—

Water	8.42
Albuminoids	21.50
Digestible fat-forming substances	53.47
Woody fibre (indigestible)	8.57
Mineral matter (ash)	8.04
	<hr/> 100.00
Yielding nitrogen	3.44
Containing potash	1.35
" phosphoric acid	1.74 ¹

Sir Charles Cameron says that "its composition indicates a high nutritive power, but it is probable that its nitrogenous matters are partly in a low degree of elaboration, which greatly detracts from its alimental value."

Malt-combs for Cows.—The late Dr A. Voelcker considered that malt-combs possessed high milk-producing qualities, and that the food might be given with great benefit to dairy-cows.²

Malt-combs as Manure.—Malt-combs are also used as manure, but the late Dr A. Voelcker considered it wasteful to apply them directly to the land; they should first be passed through the animal's body.

Brewers' Grains.

Brewers' grains, or "draff," as the article is called in some parts, consists of the refuse malt after it has undergone fermentation. The grains left in the distillation of spirits are said to be richer than those left in brewing ale or porter. The following is an average analysis of brewers' grains:—

Water	755.
Albuminoids	5.0
Fat	1.0
Soluble carbo-hydrates	12.5
Woody fibre	5.0
Mineral matter	1.0
	<hr/> 100.0

Desiccated Grains.—A process of preparing grains by drying and other modes of manipulation has been invented, and the article so prepared is sold under the name of "*Desiccated Grains*." The grains in this state are more concentrated than they are in the ordinary state, and may be given to all kinds of live stock as follows: For horses, substitute at first 3 lb. of grains for 3 lb. of oats, and increase proportion until half the feed is composed of grains. Cattle—the grains may be mixed with other food, and should be damped where oilcake is used: the animals should be supplied with water when equal parts of grain and cake are used. Milch cows—damp with boiling water, and allow the grains to swell; 10 to 15 lb. per day may be given. Sheep—to be given alone, or with an equal weight of corn or cake. Pigs—damp well with boiling water as much as will be required for a day's use.

Desiccated v. Wet Grains.—A ton of desiccated grains would be equal to between three and four times its weight of wet grains. The drying chiefly effects economy in carriage. But when a brewery or distillery is within easy reach, it is, of course, more economical to use wet grains than the artificially dried, and therefore somewhat more costly article.

Grains for Dairy-cows.—Grains are a particularly favourite food with cow-keepers, as they produce a large flow of milk—more remarkable, however, for its abundance than its richness, that is, where grains are largely the preponderating food. When mixed with a fair pro-

¹ *The Stock-Feeder's Manual*, 228.

² *Jour. Royal Agric. Soc. Eng.*, vol. xiv, 248.

portion of other richer concentrated food, such as cake or grain, the grains form a most admirable article of diet for cows in milk. The judges of the Royal Agricultural Society prize farms in the "Derby District" in 1881 state that, from what they had learned on the competing farms, "there appears no food like them for the production of milk, and when mixed with more costly feeding-stuffs, the milk is not only abundant but exceedingly good."¹

As to the quantities of grains given to cows, full information will be found under the heading of "Winter Feeding of Cows."

Storing Grains.—Grains are usually very much cheaper in summer than in winter, sometimes even as much as two-thirds less than in the height of winter. As would be expected, therefore, means have been found of storing grains. This is done successfully by burying them in pits in ensilage fashion. Great pits from 6 to 10 feet deep are dug in the dry ground, and 5000 or 6000 bushels of grains are trodden in. When the surface is reached the grains are well heaped up in the middle, beaten down, cased with chaff or road-scrappings, and then well covered with a thick coat of soil, so as to resemble a large mangel-hole. Sometimes these pits are lined with bricks, and more frequently a proper vault, either above or under the ground, is made. An old barn, with brick partitions run across it, makes a capital receptacle for storing grains. Some farmers use salt in packing the fresh grains, and are very particular in the covering that is applied to the surface; but it appears that if ordinary care is taken to exclude the air, grains may be kept in the roughest manner and be perfectly sweet and good at the end of six or even nine months.²

Very often the grains-pit is sunk in the end or in a corner of the cow-house. At any rate, it should be close at hand for ease of feeding. A pit lined with concrete is very suitable, and even where only a few weeks' supply is kept at a time, it is found convenient to have such a pit.

Distillery Wash.

"Dreg" or "wash" is a liquid residue from malt used in distilleries. It con-

sists of a thick and a thin liquid. The thin part of the liquid is about half the nutritive value of its weight of common turnips, and the thicker or sedimentary portion about equal to its weight of the average composition of turnips. Dr Anderson considers that 15 gallons are equal in nutritive value to 100 lb. of turnips. This liquid is used chiefly by dairymen; but cattle fattened at or near distilleries get large quantities of it as well as of grains.

Oats.

The following is an average analysis of the whole grain of the oat:—

Water	14.0
Albuminoids	13.0
Fat	6.0
Fat-formers	54.0
Woody fibre	10.0
Mineral matter (ash)	3.0
	<hr/> 100.0

No other variety of grain is so extensively used in this country as food for live stock as are oats. And in the form of meal it is a very wholesome food for man, still used very largely—but we fear not so extensively as in former times—in Scotland. It was Dr Johnson who described oats as "the food of men in Scotland, and horses in England." It was probably a Scotchman who retorted,—
"Ay; and where will you find such men and such horses?"

Oats are highly favourable to the formation of muscle. Their nutritive value, however, is by no means regular, some varieties being one-third more nutritive than other kinds.

Bruising Oats.—Oats ought generally to be bruised before being given to animals, as the food then becomes not only more thoroughly masticated, but also much less liable to produce inflammatory action, which sometimes arises from the over-liberal or inconsiderate use of the whole grain.

Nutritment in Oatmeal.—In the form of meal it is seldom used as cattle-food, except as nourishing drinks or gruel; but when ground into meal, the more thoroughly it is sifted the more nutritious it becomes. This is exactly the reverse of what takes place in the case of flour, because a large proportion of the flesh-forming and also of the fat-forming sub-

¹ *Jour. Royal Agric. Soc. Eng.*, xvii. 462.

² *Ibid.*

stances contained in wheat is removed in the bran. Fine oatmeal contains nearly double the amount of nitrogenised matter found in fine wheat-flour.

There is no need to enlarge here upon the merits of a food which is so generally esteemed for this purpose as oats are. Details as to the allowances of oats to animals are given in treating of the feeding of the various kinds of stock.

Indian Corn.

The prevailing cheapness and high nutritive properties of Indian corn or maize have brought it into extensive use as food for farm live stock. The following is an average analysis of Indian corn:—

Water	11.5
Albuminoids	10.0
Fat	5.0
Starch, &c.	70.0
Woody fibre	2.0
Mineral matter (ash)	1.5
	<hr/>
	100.0

It will be seen that this food is very rich in starchy matters. Given by itself, or in large proportions, it has a heating and binding tendency; but it does well with other foods, such as linseed-cake, and is now one of the most extensively employed articles of food for all kinds of farm live stock, including poultry.

Buckwheat.

The following is an analysis of the grain of buckwheat:—

Water	14.0
Flesh-formers	9.0
Fat	0.5
Starch, &c.	59.5
Woody fibre	15.0
Mineral matter (ash)	2.0
	<hr/>
	100.0

This plant is comparatively little grown, being easily susceptible of injury from frost if the seed is sown earlier than the middle of May. The crop is sometimes cut green, and used for soiling. The grain is used chiefly for feeding game or poultry.

In Ireland the term "buckwheat" is sometimes locally applied to some of the varieties of common wheat, with which the true buckwheat has no connection.

Rice.

The following is an analysis of rice:—

Water	14.0
Albuminoids	5.3
Fat	0.4
Starch, &c.	78.1
Woody fibre	1.5
Mineral matter	0.7
	<hr/>
	100.0

Rice is used as food for poultry, and is of a very fattening nature, being exceptionally high in starchy matter.

Rice-meal.

Much more important than rice, as a feeding-stuff, is the so-called "*rice-meal*," which consists of the ground refuse left after dressing or trimming rice for human food. This rice-meal consists mainly of the coating of the reed (or bran), with more or less of the adherent starchy matter.

The following is an average analysis of good rice-meal:—

Water	9.6
Albuminoids	11.3
Oil	12.0
Starch, &c.	51.5
Woody fibre	6.0
Mineral matter	9.6
	<hr/>
	100.0

This material, it will be seen, contains a fair quantity of albuminoids, and is rich in oil, and is in much request for pig-feeding. Rice-meal is now also being used as food for cattle, and the experience of it has, on the whole, been very satisfactory. Mr Garrett Taylor, Trowse House, Norwich, has used it largely both for dairy-cows and young store-cattle, and he speaks of it very favourably.

Care should be taken to obtain the genuine article, as this food is sometimes adulterated with ground rice shudes—the outer husks of the rice—which have very little nutritive value, but consist mainly of a siliceous woody fibre.

Dari or Durra.

This is the seed of the plant called Indian millet or Guinea corn, which is largely cultivated in India, China, Africa, Italy, the West Indies, &c., where it is used for feeding horses, pigs, and poultry. It weighs upwards of 60 lb. a bushel, is of the size of a large millet-seed, is

covered with a husk or envelope, and gives, when crushed, a beautiful white flour. Dr A. Voelcker gives the following analysis of Dari grain :—

Water	11.31
Oil	4.02
Albuminoid compounds	10.06
Starch and digestible fibre	68.10
Woody fibre (cellulose)	3.65
Mineral matter (ash)	2.86
	<hr/> 100.00

Dari Grain for Cattle.—Ground into meal this grain is an excellent fattening food for cattle. As Dr Voelcker remarks: "It contains an appreciable amount of ready-made fat, and a large proportion of starch, which is with ease transformed into fat in the animal economy; but it is rather deficient in albuminoids, and for this reason Dari meal should be given to stock in conjunction with cake, beans, or peas, or, speaking generally, with food rich in albuminous compounds."¹

Dari grain is also good food for poultry.

Beans, Peas, and Lentils.

These leguminous plants closely resemble each other in their composition. From their nature they are better suited to be used as a portion of the food of working or growing animals or milch cows, than of those which are being fattened for the butcher. At the same time, when used along with other kinds of food, particularly such as are of an oily nature, they may be given with much advantage to fattening stock. Lentils are chiefly imported, but they may be profitably grown in this country on light, dry, sandy, or calcareous soils. The following table gives the average composition of beans, peas, and lentils :—

	Beans.	Peas.	Lentils.
Water	13.5	14.0	14.0
Albuminoids	25.5	23.0	24.0
Fat	1.5	2.0	2.5
Starch, &c.	46.5	48.5	49.5
Woody fibre	10.0	10.0	7.0
Ash	3.0	2.5	3.0
	<hr/> 100.0	<hr/> 100.0	<hr/> 100.0

Vegetable Casein.—It is worthy of note that the albuminoids in these three seeds (and also in other leguminous seeds) are in a form almost identical with the casein of milk, and hence termed "vegetable casein." It is on this account that meals made from these seeds form useful ingredients in mixtures for calves.

Beans for Dairy-cows.—Bean-meal is by many recognised authorities assigned the very highest position as an article of diet for dairy-cows. Mr John Speir, Newton Farm, Newton, Glasgow, says that "for the production of butter or cheese of the best quality, no feeding-stuff ever had or still keeps the reputation beans do;" and he adds, "they are also very palatable to all stock of the horse, sheep, and cow kind, although swine are not so fond of them." Beans, like the other leading leguminous foods, have an albuminoid ratio double what a proper food should exhibit; and, therefore, they are well suited for mixing with other foods rich in carbo-hydrates, such as turnips, potatoes, oats, rice, straw, and hay. Professor M'Connell says that "beans have made a name for themselves as food for dairy-cows, but prices and handiness make it more desirable to use something else." He adds that he gives his cows a mixture of crushed beans and oats and bran.

Preparing Beans as Food.—Beans should invariably be ground into rough meal before being given to stock, but should not, as is sometimes done, be steeped in water before being mixed with the other foods, as then, on account of its highly albuminous nature, the meal is apt to get into a doughy, indigestible mass. "Bean-meal holds the premier place as a milk-producer; but being so highly albuminous, it requires to be mixed with some more bulky food in order to keep its particles apart, and allow the juices of the stomach and intestines to dissolve them. Unless thus mechanically divided and kept apart, such a highly concentrated food becomes more a poison than a food. Mixed with cut hay or straw the meal becomes one homogeneous mass of such a porous nature, that each atom of its constituents can separately be attacked by the juices of the digestive organs; whereas if mixed in water alone, the bulk of it is voided

¹ *Jour. Royal Agric. Soc. Eng.*, xiv. 247.

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