BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

GLASGOW

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HAND-BOOK ON THE INDUSTRIES OF GLASGOW & THE WEST OF SCOTLAND

British Association

for the

Advancement of Science

GLASGOW 1901

In connection with the Meeting of the British Association in Glasgow in 1901, the following volumes have been prepared by the Local Committee:

FAUNA, FLORA, AND GEOLOGY OF THE CLYDE AREA.

HANDBOOK OF LOCAL INDUSTRIES OF GLASGOW AND THE WEST OF SCOTLAND.

HANDBOOK OF ARCHÆOLOGY, EDUCATION, MEDICAL AND CHARITABLE INSTITUTIONS.

LOCAL INDUSTRIES OF GLASGOW

and the West of Scotland

///

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PREFACE.

THIS Handbook has been prepared for the use of Members attending the Glasgow Meeting of the British Association for the Advancement of Science, in 1901.

The papers have been written, for the most part, as a labour of love by the gentlemen whose names appear against them, under the general editorship of Mr. Angus McLean, and the thanks of the Sub-Committee charged with the preparation of the Handbook are hereby very sincerely tendered to these gentlemen.

The Handbook has not been arranged on any pre-determined plan or system. A review of each industry has been made by a recognised authority in the subject, and no attempt has been made to control or direct the treatment of the subjects.

ROBERT CAIRD, *Convener.*

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MINING AND QUARRYING,

BY

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Lecturer on Mining and Geology in the Glasgow and West of Scotland Technical College.

MINING AND QUARRYING.

The minerals wrought in the area draining into the Firth of Clyde are chiefly coal, ironstone, and limestone, with fire clay, brick-clays, and marls, various sandstones for local buildings, whinstone for local road making, sands and gravels, along with small quantities of lead ore, barytes, and honestone. Iron pyrites has been produced, and its indirect product in the shape of alum shale. The methods of working these differ in no very marked manner from those generally employed. The bedded minerals, such as coal, fire clay, &c., where thick, are worked by the bord and pillar system, or "stoop and room," as it is locally called; where thin, chiefly by pure longwall. The sandstones, limestones, brick-clays, and whinstones are usually worked in comparatively shallow quarries by ordinary opencast methods, though the two former are often got from underground workings on the "stoop and room" system, thin limestones, in exceptional cases, being even taken longwall.

The Carboniferous rocks, which are chiefly developed in the area in consideration, lie in a practically uncovered basin; their distribution is consequently well known, and where they are productive of coals the depth of the workings is limited by the thickness of the series, the pits being, in most cases, comparatively shallow. A brief glance at the geology of the district will show the distribution of the minerals and the conditions under which they have to be worked.

In the great central valley of Scotland, lying between the Older Palæozoic rocks of the Highlands and Southern uplands, we have practically the whole of the Carboniferous rocks of Scotland. On the northern side these rest invariably on the Old Red Sandstone, while their southern margin is often determined by faults, though sometimes, by overlapping the Old Red, they come to rest on the Silurian rocks themselves.

Throughout this district the outcrop of the Carboniferous strata is only hidden by glacial drift or recent alluvium, except in Central Ayrshire, where, about Stair and Ballochmyle, Permian rocks unconformably cover them with bedded lavas and ashes and brick-red sandstones. They are not uniformly productive of coal through the whole area, the coalfield of the Clyde basin being more or less separated from the eastern fields by an upridging of the lower members of the series, another similar ridge separating it from that of Ayrshire.

In the western portion, as seen at Dumbarton and in the Campsie Hills, the lowest members of the series consist of red sandstones and marls, resting unconformably upon the Lower Old Red Sandstone. Succeeding these come an upper (the cement stone) series of thin bedded impure limestone, sometimes magnesian, and variegated marls, which bear evidence of lacus-

trine origin and—though giving few traces of animal life—yield fragmentary remains of plants, and even (at Glenarbuck, above Bowling), a worthless seam of coal. They are most remarkable, however, for the great thickness of igneous rocks interbedded with their upper members, so well seen at Ballagan, where they reach a thickness of nearly 1000 feet, and which, replacing the lower members in Northern Ayrshire, attain a thickness of 1500 feet, but thin out again southwards disappearing before Irvine is reached. These beds, poured out from volcanoes of Cement Stone age, the denuded vents of which are abundantly visible in the district, form the base of the productive coal series in the Clyde valley, and rise in terraced hills on the north from Dumbarton to Stirling, and on the south from Greenock to Strathaven.

Above these comes a group of whitish coloured sandstones and dark shales with thin bands of limestone and seams of coal and ironstone, constituting the lower coal and ironstone group of Scotland. These beds, generally known as the Carboniferous Limestone series, were deposited in an area of depression conformably on the underlying Calciferous Sandstone series just described, overlapping the lower members, burying the newly formed volcanic banks, and sending tongues up the submerging valleys, finally, as in the Douglas basin, coming to rest directly on the Old Red Sandstone itself; the basement beds being often composed of conglomerates and ashy grits derived from the wear of the volcanic rocks. Formed in a shallow and narrow sea, we have thin bands of marine limestone separated by thick layers of sedimentary sandstones and shales, while oscillation in the movement produced land surfaces time after time, now often shown by fossil trees in their position of growth, or by coal seams and fire clays, the former of which again often gradate into cannel coal and ironstone with their fish and saurian remains.

The Carboniferous Limestone series in the Clyde valley is generally divided into three divisions—(1) Some thicker limestones (three or more) at the base of which the Hurlet with its associated coal, commonly the lowest marine limestone, is often taken as the base of the series—these limestones are subordinate to sandstones and shales, with which coal and ironstones are associated—(2nd) a thick group of sandstones, shales, fire clays, coal seams and ironstones, from which the chief yield of the lower coal and ironstone series is derived; (3rd) an upper group of sandstones and shales, with some thinner limestones and thin coal seams.

The limestones are variable in number and thickness; the thicker members generally reach 7 or 8 feet, but exceptionally may swell out to 70 feet or so. The coal and ironstones are likewise variable in different parts of the field, and often cannot be traced from one district to another close by, or if represented are unworkable. The seams are consequently known by local names.

The general development of the Carboniferous Limestone series in the West of Scotland is very varied both as regards the total thickness in the strata and the limestones and coal in them. To the north-west of the Clyde coalfield, about Kilsyth, the thickness of the strata reaches about 1700 feet, and contains fully 34 feet of coal and ironstone, though these are not all workable at one place, the seams of one area thinning out and becoming unworkable when traced into adjacent districts, so that about 8 to 10 feet may be taken as the average workable. In the upper limestone group of this same district there are some 18 feet of limestone developed,

while we have no contemporaneous volcanic rocks, the great volcanoes of the earlier period having ceased to discharge in this locality. But in the Bathgate hills volcanic activity still lingered on till the middle of the period, becoming finally extinct just before the deposition of the lowest limestone of the upper group, which further west, coming immediately above the main part of the lower coals, serves as a guide to their position, and is known as the Index limestone. In North Ayrshire, too, volcanoes still persisted in the neighbourhood of Beith and Dalry, where boreholes and pits have shown that limestones and shales, coals and ironstones are rapidly replaced laterally by volcanic ash. The limestone series thins out rapidly when followed south in Ayrshire. Near Dalmellington the total section does not exceed 350 feet, and west of this district it may be totally absent, the coal measures coming to rest directly on the Calciferous Sandstone rocks. To show still further the nature and development of these rocks, we may note that at Carluke, out of a total of 1032 feet, only 46 feet are limestone, and this in eighteen different beds, while 13 feet are coal and ironstone in eight beds, the rest being made up of sandstones and shales. At Douglas, out of 574 feet, limestone makes up 36 feet in four beds, and coal and ironstone 39 feet in eleven beds; at Dalry, in North Ayrshire, out of 909 feet, limestone makes up 178 feet in six seams, and coal and ironstone 9 feet in five seams. This variety is still further brought out if we consider the thickness of workable coal in the different areas occupied by these rocks. In the estimate referred to later, we find Garscube, north of Glasgow, appearing with 6 feet of workable coal and 2 feet of thin and uncertain coal, while Muirkirk has 25 feet of workable and 5 feet of thin and uncertain coal. Dalry has 4 feet of workable coal, Kilsyth and Carluke each 8 feet of workable coal and 2 feet of thin and uncertain coal. Contrasting with these we find 92 feet of workable coal appearing in a small area in Renfrewshire, at Quarrelton, while at Riggside there are 40 feet of workable and 10 feet of uncertain coal.

Above the upper limestone in Lanarkshire and below the slaty band ironstone, which is taken as the base of the coal measures, are a group of grey, white, yellow, or even red coarse-grained sandstones, shales, fire clays, and thin coal seams, and impure limestones. These beds are known under the name of the Millstone Grit, but are difficult to separate from the underlying limestone series. Thinning out westwards they are entirely absent in Ayrshire, the Coal Measures coming to rest directly on the limestone series. North-east of Glasgow these beds are noted for their excellent fire clays, which are largely mined at Glenboig, Garnkirk, and Gartcosh. The following shows the section of the beds worked:—

Garnkirk upper working,	7 ft. 7 in.
Strata,	45 ft.
Garnkirk under working,	11 ft. 1 in.
Strata,	162 ft.
Gartcosh upper working,	3 ft. 3 in.
Strata,	18 ft.
Glenboig upper working,	8 ft. 10 in.
Strata,	39 ft.
Gartcosh middle working,	4 ft. 8 in.
Strata,	135 ft.
Gartcosh lower working,	4 ft. 2 in.
Strata,	12 ft. to 30 ft.

Succeeding the Millstone Grit comes a group of rocks laid down under fresh-water conditions, and consisting of light-coloured sandstones, dark shales, fire clays, with numerous thick coal seams and ironstones—the upper coal series of Scotland—probably of the same age as the Lower Coal Measures of England. These are in parts covered by a group of reddish sandstones and sandy shales, with fire clays, etc., but contain no workable seams of coal. Between the base of the red rocks, which belong to the upper coal measures, to the first workable coal in the Clyde valley, is a variable thickness of strata, suggesting the unconformability of the two series, while in Ayrshire, the barren red measures, overlapping the Lower Coal Measures beneath, come to rest on the Carboniferous Limestone near Sorn, in the Kilmarnock coalfield. Under these red rocks to the north-west both the Limestone and Coal Measures thin out.

The outcrop of the Coal Measures covers an area of about 195 square miles in Ayrshire, and about 178 square miles in Lanarkshire, but in Dumbartonshire and Renfrewshire there is none. The following section represents their development in the Clyde valley:—

Red Sandstones, etc.

— Palacecraig ironstone, 9 in., a local black band.

Strata, 16 fms.

— Glasgow upper coal, 5 ft. thick, near Glasgow, generally thin and unworkable.

Strata, 16 to 20 fms.

— Ell coal, 2 ft. 2 in. to 10 ft. thick, extensively worked.

Strata, 6 to 8 fms.

— Pyotshaw, 3 ft. to 6 ft. ,, ,, ,,

Strata, 0 to 8 fms.

— Main coal, 2 ft. to 5 ft 6 in. ,, ,, ,,

Strata, 8 to 10 fms.

— Humph coal, 2 ft. 4 in. to 3 ft., little worked.

Strata, 4 to 7 fms.

— Splint coal, 5 ft. 3 in. to 8 ft. thick, extensively worked.

Strata, 1 in. to 3 fms.

— Virgin coal, from 1 ft. 6 in. to 2 ft. 8 in., worked chiefly in northern part of basin, often coalesces with the splint to form one seam in Hamilton district, or is wanting.

Strata, 9 to 14 fms.

— Airdrie blackband ironstone, 1 ft. to 1 ft. 6 in.

Strata, 12 to 21 fms.

— Newarthill and Cleland roughband ironstone, 2 in. to 8 in. local.

Strata, 9 in. to 2 fms.

— Virtuewell coal, 2 ft. to 2 ft. 6 in., worked generally in the shallower parts of the basin.

Strata, 3½ to 5 fms.

— Bellside ironstone, 5 to 9 in. local.

Strata, 11t o 13 fms.

— Kiltongue musselband ironstone and oil shale, 1 ft. 4 in. to 1. ft. 8 in., worked chiefly near Airdrie.

Strata, 4 to 7 fms.

—

Strata, 4½ to 7 fms.

— Kiltongue coal, 2 ft. 6 in. to 6 ft., worked chiefly in Airdrie, and Coatbridge district, at Calderbank replaced by blackband ironstone, 9 inches, with gas and "free" coal.

— Upper Drumgray, 1 ft. to 2 ft. 6 in. little worked.

Strata, 4 to 10 fms.

— Lower Drumgray.

Strata, 35 to 45 fms.

— Thin unworkable coals here representing the seams worked at Shotts and Fauldhouse.

— Upper slaty ironstone, 0 to 3 ft. 6 in.

Strata, 16 to 17 fms.

— Lower slaty ironstone, 0 to 8 ft. varying rapidly even in one pit.

In the Hamilton district the seams below the splint are probably thin and unworkable or nearly so, but traced to the east and north the lower strata increase in thickness, and with this increase the thin seams below the lower Drumgray become workable, forming valuable coalfields in the districts of Shotts, Fauldhouse, and Armadale, the development there being shown by the following section of the Benhar and Fauldhouse coalfield: —

— Benhar or Virtuewell coal, 4 ft.

Strata, 9 fms.

— Ladygrange coal, 1 ft.

Strata, 12 fms.

— Kiltongue musselband.

Strata, 7 fms.

— Kiltongue coal, 4 in.

Strata, 15 fms.

— Ball coal (Shotts furnace or Upper Drumgray coal), 2 ft. 3 in.

Strata, 7 fms.

— Shotts low coal, 1 ft. 8 in.

Strata, 6 fms.

— Shotts smithy coal (Lower Drumgray), 1 ft. 8 in.

Strata, 5 fms.

— Shotts gas coal, 2 ft. 6 in.

Strata, 15 fms.

— Mill coal or Crofthead four-foot coal, 3 ft.

Strata, 8 fms.

— Coalinshields seam, 2 ft. 4 in.

Strata, 5 fms.

— Armadale main coal, 2 ft.

Strata, 10½ fms.

— Coalinburn seam, 1 ft. 10 in.

Strata, 12 fms.

— Lower slaty ironstone, 10 in.

As already stated, there is a small detached basin of Permian strata in central Ayrshire covering the Coal Measures. Everywhere at the base of these is found an igneous series with interbedded lavas and ashes, above which come the massive brick-red sandstones, largely quarried about Mauchline, and highly prized as building stone. These strata are the highest which are exposed in the district.

Throughout the whole area the solid rocks are to a great extent hidden by deposits of glacial and post-glacial age, long and deep banks of stiff boulder clay, studded with stones, being distributed everywhere over the lower ground. Between the stiff lower clay, with its well-glaciated stones, and the looser upper clay, with its big and angular local blocks, in many parts occur the laminated inter-glacial clays; while resting beneath the boulder clay, and in the bottom of old valleys cut out by the pre-glacial rivers, clays or fine sands and gravel are found—the clay and sand dykes

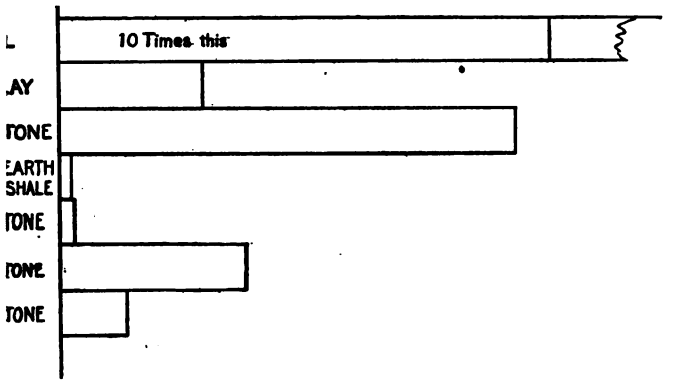
of the miner, and often troubling him in the shallower workings. Above the boulder clay come those beds of sand and gravel running up the valleys and even across the watersheds—glacial in origin, and constituting the Kames of the geologist. Lastly, fringing the shore and stretching up the valleys, are beds of finely laminated clay and sands, the deposits marking a post-glacial submergence of the land, while in more elevated districts lake hollows between the boulder clay ridges have been silted up with similar deposits.

The Carboniferous rocks—of such moment to the West of Scotland—have been largely faulted, as is well seen to the south-east of Glasgow, where, by an upthrow to the south, the volcanic zone is made to abut the upper red rocks of the coal measures, a throw of some 2400 feet, which terminates the coalfield in that direction. To the north-east of Glasgow a similar fault of less magnitude brings out the volcanic rocks to the north, and terminates the carboniferous limestone coalfield. Between these two the outcrop of the coal measures is repeated again and again by step faults, bringing down the upper beds on the north side as by the natural rise they outcrop.

The coal working is also rendered more difficult by the intrusion of igneous rocks among the coals. These intrusions belong to at least two ages. The later ones consist of vertical, or nearly vertical, dykes of dolerite running across the country in an east and west direction, and cutting everything in their course, with the exception of the glacial deposits. The earlier eruptive rocks consist chiefly of large irregular sheets of dolerite, often thrust in between the beds for great distances, though commonly transgressing the bedding when followed laterally. Where these are thrust along a coal seam the coal is totally destroyed, and for this reason a field may be unworkable. But when a sufficient thickness of rock intervenes between the igneous rock and the coal only, a slight change is produced in the seam—often, indeed, for the better—a high-class steam coal, or even anthracite, being produced. These earlier intrusive masses have been referred to Permian age; the later to Tertiary. In Ayrshire, besides the numerous dolerite sills—the whin float of the miner—a number of volcanic necks break through the Carboniferous rocks, probably the denuded remains of Permian volcanoes.

All the formations described give products of economic, though of very varied, importance. From the Silurian rocks of the south-east portion of Lanarkshire—about Leadhills—and in the adjoining district of Wanlockhead in Dumfriesshire, gold has been profitably worked in the past from the gravels of the streams; and it is still sought by the miners on special occasions, such as the marriage of the members of the Hopetoun or Buccleuch families, for the purpose of presents, but its systematic working has been abandoned since about the year 1620. Lead ore has likewise been extensively wrought in the same localities for nearly three hundred years, from mineral veins in the same rocks, but at present the output is somewhat restricted, amounting last year to 1839 tons, and this chiefly from Dumfriesshire. A small quantity of silver is produced along with the lead.

Sandstones are worked for building purposes to a slight extent in the Old Red Sandstone, which, however, does not generally yield useful stone. They have been worked largely in the Permian rocks, whose bright red sandstones, about Mauchline, form a valuable building stone. The massive white sandstones of the Carboniferous Limestone series and the Lower Coal Measures give many bands suitable for building



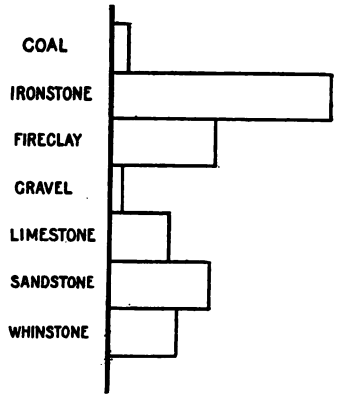


FIG. 2 (RENFREWSHIRE).

purposes, from which the light-coloured building stones of the district are quarried, or even mined, 27,630 tons of sandstone being produced in Lanarkshire last year from underground workings.

Limestone is got from the various beds in the Carboniferous Limestone series in different parts of the area under consideration. Where the thick bands come to the surface, as in Northern Ayrshire, it is worked by quarrying—which is, indeed, the general method, though a considerable amount of limestone is worked from the thinner seams by mining where they are sufficiently pure. The limestone is chiefly wrought as a flux for iron smelting, but for this purpose the local supply is insufficient, much limestone being brought in from more favourably situated districts. Some of the more argillaceous bands are used for the manufacture of cements.

Bricks are largely made from the laminated clay beds of the raised beaches and of interglacial position, as also from the boulder clay, which is cleared of stones for that purpose. The fire clay beds of the coal measures and millstone grit series afford good material for the manufacture of fire bricks, gas retorts, and other furnace fittings, as well as various kinds of enamel ware, while the red marls of the Calciferous Sandstone period, and the more highly ferruginous of the post-glacial clays, are used for the production of bright red bricks, tiles, pipes—the so-called terra-cotta.

The gravels and sands of glacial and post-glacial origin, and even those in the pre-glacial valleys, are worked for building purposes, and for use in foundries. Good road metal is furnished in the various districts by local igneous rocks—the red felsites and porphyrites of the Old Red Sandstone period, the black basalts and porphyrites of the Calciferous Sandstone, the earlier doleritic sheets and masses cutting through the Carboniferous rocks, or the later Tertiary doleritic dykes, some of which are, in addition, cut into sets for paving, or dressed for curbstones. In Ayrshire the earlier sheets intruded in the Carboniferous rocks are indirectly responsible for another important product—the well-known Water of Ayr stone—formed from carboniferous shale by contact with the intrusive dolerite. Of this (the honestone) last year's production amounted to 303 tons.

Lastly, though of by far the greatest importance, the Coal Measures and Carboniferous Limestone rocks furnish us with abundant coals, with blackband and clayband ironstones, and with oil shale in addition to the fire clay already mentioned.

The relative importance of the different minerals is shown by the following diagrams, figs. 1, 2, 3, and 4, which give the total output of the chief minerals for the four counties of Ayrshire, Renfrewshire, Dumbartonshire, Lanarkshire, during the year 1899. In addition to the minerals shown in the diagrams, Ayrshire produced 251 tons of honestone, 2596 of gannister, and 106 of gravel; Renfrewshire produced 800 tons of barytes; Lanarkshire 300 tons of lead ore (the return of the same mineral from Dumfriesshire being 1848 tons), and 35,514 tons of mineral (other than coal, fire clay, ironstone, or oil shale) from coal mines; Argyleshire, which partly falls within the area of the Clyde basin, yielded, in addition to a little coal, the following:—granite, 46,460 tons; limestone, 6072; sandstone, 350; slate, 30,580; whinstone, 19,668; a total of 103,130; and Bute, 11,792 tons of sandstone; 5579 tons whinstone; and 106 tons gravel.

The importance of coal above all the other minerals is obvious. Lookin at the diagrams we see that in Lanarkshire the production of coal is abou fifty times as great as that of fire clay, the next in the list, while it is ju over eleven times as great as the combined production of all the oth minerals—the quantity of coal and oil shale being 16,493,080 tons, and th of all the others being 1,493,348 tons. In Ayrshire over ten tim more coal is produced than ironstone, and twenty-five times more tha sandstone, in Dumbartonshire six times more coal than whinston while in Renfrewshire alone of the four counties the coal production insignificant. In figs. 1 and 4 but one-tenth and one-fifteenth of the co output could be expressed respectively. A few more details concerning t industry are therefore given.

The nature of the coals is well shown by the following analyses of selecte samples, freshly mined, by Mr. W. Carrick Anderson:—

Coals.	Hamilton District.					Kilsyth, Haughrigg.	Bannockburn Main.	Kilsyth Coking.
	Ell.	Main.	Splint.	Gas from splint coal seam.	Virgin.			
Hydrogen,	4·52	4·98	4·82	5·54	5·10	5·06	5·14	5·20
Carbon,	71·88	73·62	75·50	76·16	74·67	80·67	82·80	81·50
Oxygen,	11·10	9·50	8·71	7·52	8·62	7·50	5·67	7·53
Nitrogen,	1·53	1·54	1·50	1·52	1·54	1·84	1·80	2·04
Moisture,	9·99	9·08	7·27	5·56	7·77	1·98	1·75	1·72
Ash,	0·98	1·28	2·20	3·70	2·30	2·95	2·75	2·01
Volatile Matter, (other than water)	33·33	35·84	36·22	38·25	33·53	32·55	27·40	28·45
Fixed Carbon,	55·70	53·79	54·31	52·49	56·40	62·52	68·10	67·82
Specific gravity,	1·266	1·261	1·292	1·290	1·286	1·291	1·306	1·27
Calorific power,	7,480	7,590	7,425	7,370	7,480	7,535	7,865	7,81

The quantity of water contained in these samples of freshly mined co is not seriously different from that in samples which have stood even f a year exposed to the atmosphere, being generally slightly less in t freshly mined samples. There is thus a remarkable difference between t Hamilton coals (upper series) and the Kilsyth coals coming from the low coal series. The same is shown in their properties, the upper coals bei free burning and showing but slight tendency to fusion and caking, wh the Kilsyth coals cake on heating, and produce a good metallurgical co Some of the seams in the upper coals, however, yield hard and strong co which is largely used in the blast furnace for the production of iron, for example, the Splint and Upper Drumgray.

Diagram 5 shows the progress of the coal industry in the three counti during the past quarter of a century. In Lanarkshire a fairly steady r in the output has taken place, broken only by the depressions of '79 and '8 and by the strike of '94, which caused a shrinkage in the return for t year, only to be followed by an abnormal increase in the next. This h

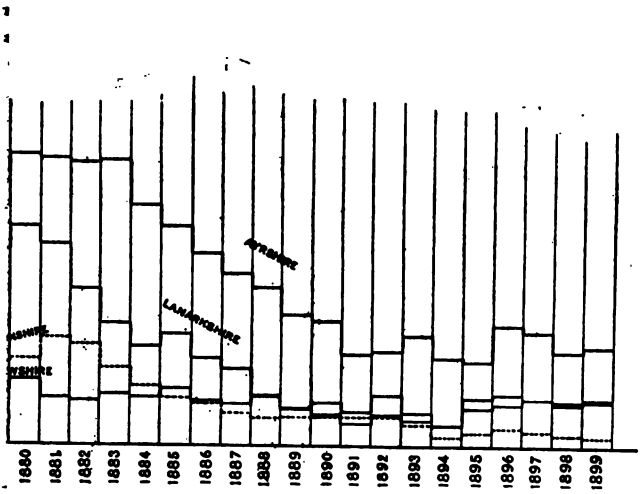

LANARKSHIRE
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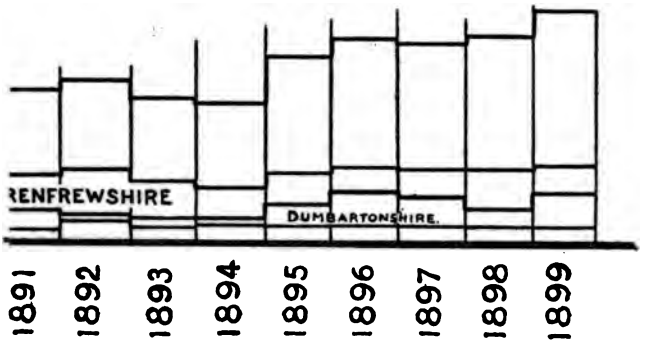
FIG. 7.


RENFREWSHIRE
DUMBARTONSHIRE.
1891
1892
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1899

been more than maintained to the present, so that in 1900 the output exceeds 17 million tons as compared with a little more than 10 millions in 1876. In Ayrshire progress has been slow, the output being practically stationary up to three years ago, having since then increased. Diagrams 6 and 7 show the progress of the fire clay and ironstone industries.

The effect of the gradual exhaustion of the better seams of ironstone and of the competition of foreign ores is seen in the decline, most marked in Ayrshire and in Lanarkshire, of the local production, which from 2,232,237 tons in 1881 has dropped to 721,793 in 1890. Against this the continued increase in the production of coal comes out in strange relief. How long this can continue is a question of vital interest to the West of Scotland, and this point, to which an answer was given by the Royal Commission on Coal, has been re-examined, on the light of further developments, by Mr. R. W. Dron, in a paper recently read before the Institution of Mining Engineers. Reckoning as proved coal those seams above 2 feet think which outcrop in the Coal Measures and Carboniferous Limestone, and as doubtful and unproved the seams under 2 feet thick, and those of the Limestone series which are covered up by Millstone Grit and Coal Measures, he arrives at the conclusion that in Ayrshire (giving his figures in round numbers) 216 million tons have been wrought, leaving 1140 million tons of proved coal to be still worked, added to 1100 million tons reserve of thin and doubtful coal. The corresponding figures for Lanarkshire he gives as 841 million, 1060 million, and 885 million tons; for Renfrewshire, 5 million, 79 million, and 87 million tons; and for Dumbartonshire 21 million, 44 million, and 49 million tons. Adopting the increase of production estimated by the Royal Commission, and assuming it to go on till the exhaustion of all the coal, he points out, speaking for Scotland generally, that all the proved coal would be exhausted by the year 1994, and the reserve coal by the year 2086. Assuming, however, the increase goes on till 1941, when the total estimated output of Scotland will reach 40 million tons per annum, after which it becomes stationary, the coal resources would be exhausted by the year 2160, but cheaply-worked coal would only last to the end of the present century. Considering Lanarkshire, Mr. Dron points out that, could it keep its present proportion, 55 per cent. of the total Scottish output, all its workable coal would be exhausted in forty years' time, while Ayrshire could maintain three times its present output for ninety-six years.

It is interesting to compare this estimate with one made near the beginning of last century (about 1835), when for Lanarkshire alone a total of 1700 million tons of coal were regarded as being available, and for the estates of Rosehall, Carnbroe, Woodhall, Stevenson, Carfin, and Cleland, all in the parish of Bothwell, and on which pits were working, it was estimated that they could keep up an output of 400,000 tons per annum for upwards of three thousand years!

Even at that date signs of the great future development were to be found. In the parish of Old Monkland in 1794 but 3600 tons of pig-iron were produced with the consumption of about 36,000 tons of coal. In 1806 from 9000 to 10,000 tons of pig-iron were produced, requiring about 130,000 tons of coal; and in 1839 176,800 tons of pig-iron were produced, with a consumption of 530,400 tons of coal, the parish at that time being unable to supply its own ore, but deriving its chief supply from the adjacent parish of New Monkland, where the blackband ironstone was of such value

that a royalty of 8s. 6d. per ton of calcined ore was paid, and one owner, Sir W. Alexander of Rocksilloch, derived an income of £12,500 per annum from this mineral from land which, if let for tillage at that time, would have brought in about £650.

In 1831 Dr. Cleland found that coal, coming to Glasgow from thirty-seven pits, amounted to 561,049 tons, of which 124,000 tons were exported, leaving 437,049 tons for use of families and public works in the city and suburbs; and in 1834 the estimated quantity brought to Glasgow was 611,000 tons. In 1835 the best hard splint coal was laid down at the quay for 6s. 3d. per ton. Lesmahagow cannel, regarded as the best in Scotland, fetched 8s. per ton at the coalhill, and was laid down at Glasgow Gas Works for 16s. per ton, while cannel from the Glasgow pits fetched 10s. 6d. per ton, and in the parish of Dalserf house coal sold at from 3s. to 3s. 6d. per ton.

METALLURGY,

BY

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THE METALLURGICAL INDUSTRIES.

The metallurgical industries of Glasgow and the surrounding districts are not very numerous, being confined almost exclusively to the manufacture of iron and steel, but this is of such importance that it may be regarded as being, after engineering, the most prominent industry of the district.

COKE MAKING.

The production of coke is always intimately associated with the iron and steel industries, though perhaps less so here than elsewhere, because the blast furnaces being, without exception, fed with raw coal, there is no demand for coke for smelting purposes. It is, however, largely required for foundry use for smith work and other minor purposes.

Two kinds of coke are made—hard or foundry coke, suitable for use in the cupola or blast furnace; and soft coke or smithy char, suitable for use in the smith's forge.

The foundry coke is made almost entirely in bee-hive ovens of the ordinary type, about 11 feet 6 inches in diameter and 8 feet 6 inches high, the charge for each oven being about 7 tons of coal, and the yield between 4 and 5 tons of coke, the coking occupying about five days. The coke is hard and dense, with the columnar structure and metallic lustre characteristic of good bee-hive coke, and it is equal to that made in any part of the kingdom.

Recovery of by-products from coke ovens has not been attempted on a large scale up to the present. The Merryton Coal Co., Limited, Bannockburn, have a set of Coppeé ovens in use; Messrs. W. Baird & Co. have a circular Bauer oven at their works at Dalry, and they have recently erected a set of Semet-Solvay ovens at one of their Kilsyth works.

Smithy char is made entirely in bee-hive ovens; the charges are smaller, and the time of coking is about forty-eight hours. The yield of coke is about 80 per cent., the same coal being used as for the manufacture of foundry coke.

The largest makers of coke in the Glasgow district are Messrs. W. Baird & Co., whose works are at Port-Dundas, Kilsyth, and Dalry.

In Glasgow there are also Messrs. James Wood & Co., Baird Street (foundry coke and smithy char); and Messrs. John Knox & Co., Mid Wharf, Port-Dundas (smithy char). In the district there are over a dozen other works, usually in the neighbourhood of the pits where the coal is raised.

THE IRON AND STEEL INDUSTRIES.

As far as this district is concerned, the iron and steel works may be grouped into four classes—

1. Blast furnace works, where pig-iron is made.
2. Malleable iron works.
3. Mild-steel works.
4. Manufacturing works apart from those where the metal is produced, tube works, etc.

BLAST FURNACE WORKS.

The following is a list of the works at present having furnaces in blast, with the number of furnaces in blast at 30th June, 1901:—

	LANARKSHIRE.	
	The Langloan Iron Co.,	3
	Baird, W., & Co., Gartsherrie,	12
(s)	Coltness Iron Co.,	7
	Dixon, W., & Co., Limited, Calder,	6
	Dixon, W., & Co., Limited, Govan,	5
	Dunlop, James, & Co., Limited, Clyde,	4
(s)	Glasgow Iron and Steel Co., Wishaw,	4
	Merry & Cuninghame, Limited, Carnbroe,	4
	Shotts Iron Co.,	4
	Summerlee and Mossend Iron and Steel Co.,	6
	AYRSHIRE.	
	Baird, William, & Co., Eglinton	5
	Baird, William, & Co., Lugar	5
	Dalmellington Iron Co.,	5
	Eglinton Iron Co., Muirkirk,	2
(s)	Glengarnock Iron and Steel Co., Ardeer,	3
	Glengarnock Iron and Steel Co., Glengarnock,	5
	STIRLINGSHIRE.	
	Carron Iron Co.,	4
		83

Those marked (s) have also steel works attached. In some other cases the same firm owns both blast furnaces and steel works, but they are not at the same place.

Historical Note.—For over a century the West of Scotland has held a prominent position as an iron producing district. At one time it stood first in the United Kingdom, and now, whether measured by number of furnaces or output, it is second only to Cleveland, where the number of furnaces in blast is 83.

The industry in the West of Scotland may be dated from 1759, when the Carron Iron Works was established, the site being selected because the river Carron supplied suitable water power for driving the blowing engines. The works were successful from the very first, and soon became "the most famous in Europe," among other things for the manufacture of cast-iron guns, called therefore carronades, the first of which was made in 1779. The furnaces were at first very small, and charcoal was used as a fuel; the blowing engines were worked by a water wheel, and in times of drought water to work it was pumped up by means of an engine. The water wheels and blowing plant were designed by Smeaton, and are thought by Dr. Percy to have been the first of their kind in the country. Coke soon replaced charcoal as a fuel, and Watt designed a steam blowing engine to take the place of the water machines.

In 1788 there were 8 blast furnaces in operation in Scotland—Carron, [redacted]Wilsontown, 2; and 1 in Argyleshire; the make of pig-iron being [redacted]6000 and 7000 tons a year. In 1796 there were 17 furnaces. In [redacted]to those at Wilsontown furnaces had been built at Muirkirk,

Omoa, 1787 (extinct); Clyde, 1788; Devon, 1792 (extinct); and Glenbuck (extinct). In 1830 there were 27 furnaces in blast at Balgonie, Fifeshire (extinct); Calder, 1801; Shotts, 1802; and Monkland, 1805, the total make being about 37,500 tons. Between 1830 and 1840 there were no fewer than 24 iron works established for the manufacture of pig-iron. The furnaces were very small, not more than 35 feet high, the weekly make was under 40 tons, and the coal consumed was about 8 tons per ton of iron.

Local Conditions.—The details of any industry are always largely determined by local conditions, and as the conditions in the West of Scotland are different from those elsewhere, the practice must also be different, and efficiency cannot be judged by comparison with other districts where very different conditions hold.

Ores.—In the early days of the Scotch iron industry local ores were used exclusively, and at first only the claybands. In 1801 David Mushet, of the Clyde Iron Works, discovered that the material which the miners were rejecting under the name of wild coal was a valuable iron ore, to which the name blackband ironstone was given, but the ironmasters were slow to take advantage of it, and it was not till about 1830 that it came into general use. With the rise of the mild steel industry, commencing about 1872, there arose a demand for suitable pig-iron, free from phosphorus, and as there were no local ores from which such an iron could be obtained, importation of ore from other places had to be commenced. Thus there grew up an enormous import trade in red and brown iron ores, to a small extent from England, but mainly from Bilbao, and as the supply from these districts is now quite insufficient, ores are imported from the Mediterranean, Algeria, Cuba, and many other localities. The ores are landed at either Glasgow or Ardrossan. The supply of local ores is insufficient, even for the manufacture of foundry pig, for which purpose, therefore, mixtures of local and imported ores have often to be used.

Scotch Iron.—Scotch foundry pig very early attained a high reputation, a reputation which it has held until the present time, and for many years this was the only variety of iron made in the district. As the mild steel industry developed more and more Bessemer pig was made, till now more than half the output is of this class. A small quantity of iron is made for the basic Bessemer, or Thomas-Gilchrist process. The output of iron for 1900 was—

Forge and foundry pig, - - -	680,000 tons.
Hematite, - - - - - -	418,896 tons.
Basic, - - - - - - -	55,000 tons.
Total, - - - - -	1,153,896 tons.

Fuel.—In the early days of the iron industry in Scotland as elsewhere the fuel used was charcoal, but this was soon replaced by coke; indeed, this replacement brought about the change of the centre of the industry from the woods to the coalfields, and thus determined the position of the iron-producing districts of the country. Raw coal was first used by Messrs. Dixon at the Calder Iron Works in 1831, and its use soon became general, a great saving of fuel being effected, as the coal was unsuited for coking, and the methods of coking in use were very wasteful. The coal used is of the variety known as splint coal. It is often hard and stony, and may be

brown or black in colour. On heating it gives off a very large quantity of volatile matter, and therefore burns with a long, bright flame, and leaves a residue of from 50 to 60 per cent. of coke, which is soft and friable and shows little sign of having softened or become semi-fused. The coal therefore does not swell up on heating—which is an essential character for blast furnace use—the fragments of coke retain the form of the original pieces of coal, and are friable and easily crushed. It must be remembered that only the coke or fixed carbon is of any use in the blast furnace, the volatile constituents being expelled at the upper part of the furnace, where there is no air for the combustion of them, and they pass away with the waste gases. The amount of fuel used is therefore much larger in the case of coal than of coke. The amount of coal consumed varies from 32 to 36 cwts. per ton of iron produced, according to the nature of the coal. This is equivalent to from 18 to 19 cwts. of coke, a practice that will compare not unfavourably with that of most other localities.

Furnaces.—The nature of the fuel used limits the height of the furnace which will give the best results, as, if the weight of the superincumbent charge be too great, the coke will crush, and this will interfere with the free passage of the gases.

The older furnaces were from 30 to 40 feet high, and were built of masonry forming massive square or circular blocks, four arches being left in the lower portion by which access could be obtained to the hearth, and the tuyeres inserted. These furnaces have now been almost completely replaced by those of more modern type—slim, nearly cylindrical, shells of masonry cased—or in the older furnaces only banded—with iron. The stack is carried on iron columns, so as to allow free access to the hearth all round, and six, eight, or ten tuyeres are used, spaced equally all round, one being over the slag-notch. The hearth is always closed.

The friability of the coke limits the height of the furnace, and from 55 to 60 feet external height has been generally adopted. Taller furnaces have been built, and some are still in use, but many of them have been lowered. The diameter of the bosh is about 16 feet, and of the hearth about 8 feet, though these dimensions vary in different cases. One furnace only in the district has been fitted with cooling blocks in the bosh, so as to allow of rapid driving. The tendency in the design of modern Scotch furnaces has been to increase the diameter somewhat, and also the size of the hearth, and to keep the bosh walls thin, so as to facilitate cooling, and the supporting columns high, so as to allow free access of air all round.

The material is lifted to the top of the furnace usually by vertical direct acting hoists, generally steam, but at one works hydraulic; and at one works inclined planes are used. The furnace tops are all closed, and the bell and cone is the almost universal type of charging apparatus; in one works the cone is provided with a cover, which can be lowered before the bell is dropped. Automatic charging has not yet been introduced.

The output of the furnaces is from 300 to 350 tons per week of foundry pig, and perhaps a little more of hematite, larger makes having occasionally been made.

Hot Blast.—The use of heated air for the blast was proposed in 1828 by Mr. J. Beaumont Neilson, then manager of the Glasgow Gasworks. Having no direct connection with the iron trade, he arranged with Messrs.

Dunlop of the Clyde Iron Works to try his invention. The experiments were made, the apparatus modified as defects were found, and the process soon proved a perfect success. In a very short time every furnace in Scotland and most furnaces in England were using the hot blast. At first the stoves were heated by separate fires, but about 1840 the waste gas of the blast furnaces began to be used for heating the blast, and its use soon became general. In 1860 Mr. Cowper, of Middlesborough, introduced the fire-brick regenerative stove, and this in various forms speedily replaced the old pipe stove.

Stoves of all types—Cowper, Whitwell, Massick and Crookes, and Ford & Moncur are in use in the district, but the last-named is the most popular, and is to a large extent replacing the others, as the stoves need rebuilding. The blast is used at a temperature of about 1400° Fahr.

By-Product Recovery.—The amount of slag produced is very large, say, 1·5 ton for each ton of iron, and at present no use has been found for it, except to a small extent for ballasting railway permanent way.

The amount of gas is very large, and since about 1850 this has been used for heating the blast and for firing boilers.

As the furnaces are fed with raw coal, the products of distillation will mix with the gas, and when it was seen that valuable products, such as tar and ammonia, could be obtained by condensing the condensible constituents in the manufacture of coal gas and in coking coal, it was suggested that similar valuable constituents might be obtained from coal-fed blast furnaces. It was, however, seen that to settle the question as to whether such recovery would be profitable or not, small scale experiments would be of little use, and to put up plant on a large scale would be very costly, and therefore for some time nothing was done.

In 1880 Messrs. W. Baird & Co. put up at their works at Gartsherrie a plant for the purpose. The plant was designed by Messrs. Alexander and M'Cosh, and was constructed to deal with eight of the sixteen furnaces then at work. This necessitated the treatment of about 56,000,000 cubic feet of gas per day.

The process was a success, and now every works in the district, with one exception, has either at work, or in course of erection, a plant for recovery of tar and ammonia, and the principles adopted by Messrs. Alexander and M'Cosh have been followed in all essentials in every successful type of plant, though it is hardly necessary to say that details have been modified as experience has been gained.

The gas is cooled by passing through atmospheric condensers, consisting of vertical tubes exposed to the air and cooled with water if necessary in hot weather, and is then washed, either by passing up scrubbers where it is met by a rain of descending water, or by passing through washers.

Three types of plant are in use—(1) The Alexander and M'Cosh, in which perfect cooling is obtained by atmospheric and water condensers and washing in scrubbers; (2) the Dempster, in which the gas is cooled by an atmospheric condenser, passed through washers, and then through scrubbers filled with a chequer work of wood; and (3) the Gillespie, in which the gas is cooled in atmospheric condensers, and is then passed through specially and ingeniously designed washers, the unwieldy and expensive scrubbers being dispensed with. In all cases suction is used to draw the gas through the apparatus, and pass it on to the furnaces.

The tar and ammonia liquors are separated by gravity, the tar, having a specific gravity of about ·90, floating on the top.

The Tar.—This is pumped into boilers and heated to expel water, and it leaves about 50 per cent. of its volume of boiled tar. This is then heated in retorts, when it breaks up into oils, which pass over, and pitch, which remains in the retort. The oils are often separated into two fractions —(1) *Lucigen oil*, specific gravity about ·970, which is used for burning in lucigen and similar blast lamps; and (2) *creosote oil*, having a specific gravity of about ·989, which contains considerable quantities of phenols, and is used for preserving timber, etc., and at one works is converted into a disinfectant known as Neosote.

The Pitch may be hard or soft, according to the point at which the distillation is stopped. The yield is usually about 50 per cent. of the anhydrous tar, and the pitch is used for briquette making and other purposes. As will be seen from the nature of the products obtained, the tar is very unlike that obtained from the gasworks, containing only very small quantities of the aromatic bodies that make the latter so valuable as a source of aniline and its derivatives. This is no doubt due to the low temperature at which the coal is distilled in the blast furnace.

Ammonia.—Splint coal contains from 1·2 to 1·6 per cent. of nitrogen, say, on an average, 1·4. When the coal is distilled in a blast furnace about 16 per cent. of the nitrogen comes off in the form of ammonia. This is about ·222 per cent. of nitrogen as ammonia, or about 4·97 lbs. of nitrogen as ammonia, per ton of coal, which will yield about 23·5 lbs. of ammonium sulphate. This seems a small amount, but as each furnace may consume 500 tons of coal a week, the total quantity obtainable is very large.

The water containing the ammonia is distilled with a little lime, and the gas passed into sulphuric acid. The sulphate crystals are separated and dried. Automatic stills and apparatus for discharging the crystals and centrifugal driers are used in some of the works.

The yield at the Glasgow Iron Company's works at Wishaw was stated to be on a consumption of 2000 tons of coal per week.

Pitch, - - -	100 tons	= 1 cwt. per ton of coal.
Oil, - - - -	20,000 gallons	= 10 galls. ,,
Sulphate of ammonia,	20½ tons	= 22·96 lbs. ,,

The Gas.—The heating power of the gas is, of course, reduced by the removal of the tar, but not to any serious extent. The gas is much drier, as its temperature is reduced, and being quite free from dust or tarry matters it is much cleaner to use. It is quite suitable for fuel purposes. At the Wishaw works a gas engine is driven direct by the washed gas for the electric lighting of the works.

Blowing Engines.—The blowing engines used are almost all of the beam type, and are of large size, many of them erected many years ago; but in one or two works more modern direct acting engines have been introduced.

Most of the works have been in existence and in active work for many years. If in some respects they seem old-fashioned, it must be remembered that the replacement of old plant by new is not only costly but very troublesome, and often impossible without a

complete stoppage. Most of the works have undergone, or are undergoing, reconstruction, so as to bring them well up-to-date, and whilst much of the plant is such that it would not be put into a newly designed works to-day, there is no reason why it should be discarded if it is doing its work well. Scotch ironmasters have, as a rule, been wise in the slowness with which they have revolutionised the works. "Hasten slowly" is always a good motto in such cases.

A brief note is given of the more important works, especially those in the neighbourhood of the city.

Govan Iron Works (William Dixon, Limited). Electric car from High Street.—This is the only blast furnace works in the city. It was started about 1837. There are six blast furnaces about 65 feet high, of which five are in blast. The ammonia plant is of the Dempster type.

The Clyde Iron Works (Messrs. J. Dunlop & Co., Tollcross). Tollcross Station, C.R.—The works was established in 1786. It was here David Mushet, who entered the works as accountant in 1792, did the experimental work which made him famous, most of which is recorded in his "Papers on Iron and Steel." It was here also that Neilson made the experiments which led to the success of the hot blast. There are five furnaces of modern type—three 72 feet high and two 60 feet—of which four are in blast. The original blowing engine was erected by Watt early in the century, and one now at work was built in 1847. The ammonia plant is of the Gillespie type.

Langloan (The Langloan Iron Co.), Coatbridge. Langloan Station, C.R.—This works was established by Messrs. Addie & Sons. Some years ago it was put out of blast, and the works underwent complete reconstruction, but was not re-started till December, 1900. There are five furnaces about 60 feet high, of which only three are at present in blast. Messrs. Addie erected a plant for the recovery of ammonia by an ingenious process, which consisted in mixing sulphur dioxide with the gas and oxidising the ammonium sulphite to sulphate. It did not prove satisfactory, partly because the tar was not completely recovered, and a new plant has just been erected by Messrs. Dempster, which is therefore the latest of their plants in this district.

Gartsherrie (Messrs. W. Baird & Co.), Coatbridge. Coatbridge (Sunnyside Station), N.B.R.—This works was started about 1830. Messrs. Baird were the first ironmasters to take out a licence for the use of the hot blast, which was at once put into use at this works. It was here also the first plant for the recovery of the by-products from the gases was erected in 1880. The first plant is still at work, and another similar one has been erected to deal with the other half of the furnaces. The furnaces are arranged in two rows; originally there were eight on each side, but the works has been reconstructed, the size of the furnaces increased, and the number reduced to twelve, all of which are in blast.

Carnbroe (Merry & Cuninghame, Limited). Calder Station, C.R.—This works was erected in 1838. There are five furnaces, of which four are in blast. The ammonia plant is Dempster's.

Calder (William Dixon, Limited). Calder Station, C.R.—This works was commenced in 1899. It was here Condie, who was experimenting with the hot blast, invented the water tuyere, without which the hot blast could never have become a success. The tuyere is used to-day exactly as designed by Condie. There are six furnaces all in blast, one making silicon iron. The ammonia plant is Dempster's.

Coltness (Coltness Iron Co.). Newmains Station, C.R.—This works was commenced in 1837 by Messrs. Houldsworth. It originally consisted of twelve furnaces, but the number has now been reduced to nine, which are of modern type, and larger than the old furnaces. Attached to the furnaces is a foundry for the casting of moulds for the steel works direct from the blast furnaces, and there are also a steel furnace, briquette plant, and brick works.

Summerlee (The Summerlee and Mossend Iron and Steel Co., Ltd.). Coatbridge, C.R., nearest.—This works was started in 1836 by Mr. Neilson of Oakbank, a brother of the Neilson who invented the hot blast. There are seven furnaces, of which six are in blast. Three are 55 feet high and four 68 feet. The output is about 90,000 tons a year. The blowing engine which was erected when the works were started still stands and blows two furnaces. Iron of all kinds is made, the foundry pig being still made entirely from blackband ore raised from the company's pits. Mr. Gillespie is now putting up ammonia plant, which, therefore, will be the latest in the district. This replaces an earlier form of plant designed by Mr. Neilson, in which the gas was treated directly with sulphuric acid for the production of sulphate, and which was abandoned because, though the recovery of ammonia was good, the tar was not obtained.

Wishaw (Glasgow Iron and Steel Co.). Wishaw, C.R., either station.—This works consists of four furnaces about 60 feet high—two modern and two of older type. The iron made is all hematite for the steel works. The metal is partly cast in the sand bed as usual, and partly run into a ladle to be used direct in the steel works. The ammonia plant is Gillespie's.

Shotts (Shotts Iron Co.). Shotts Station, C.R.—This works was started in 1802. There are six furnaces 62 feet 6 inches high and 16 feet in diameter, of which four are in blast. Both hematite and foundry pig are made. The ammonia plant is Dempster's. There is a large foundry attached to the works.

Glengarnock (Glengarnock Iron and Steel Co.). Kilbirnie, G. & S.-W. R., or Glengarnock, C.R.—This works was started about seventy years ago. There were nine blast furnaces, much smaller than those now in use. There are seven furnaces, six of which are usually in blast; at present five are in blast and one is being rebuilt. The furnaces are 61 feet 6 inches high, 16 feet in diameter, and the well is 9 feet in diameter and 6 feet deep. Three of the furnaces are making basic iron, and two hematite. The iron is either cast as usual, or run into a ladle for direct use in the converters. There are eighteen stoves—sixteen Massick and Crookes, 18 feet in diameter and 52 feet high, and two Cowper, 82 feet high and 18 feet in diameter. The blast is supplied by three engines. The ammonia plant is Dempster's.

The other Ayrshire works do not require description. They are—

Eglinton (Messrs. W. Baird & Co.). Dalry Station, G. & S.-W. R.—Six furnaces, of which five are in blast.

Lugar (Messrs. W. Baird & Co.). Lugar Station, G. & S.-W. R.—Five furnaces, all in blast; also briquette making plant.

Dalmellington (Dalmellington Iron Co.).—Six furnaces, five in blast.

Muirkirk (Eglinton Iron Co.). Muirkirk, G. & S.-W. R.—Three furnaces, of which two are in blast.

Ardeer (Glengarnock Iron and Steel Co.). Stevenston, G. & S.-W. R.—Five furnaces, of which three are in blast.

Carron (The Carron Iron Co.), Stirlingshire. Grahamston, C.R., or N.B.R.—The history of this works has already been mentioned. At present there are four furnaces, and all are in blast, making foundry pig. This is made from blackband ore from the company's mines, and is the same as has been in use since the starting of the works. There is no by-product recovery plant. There are very extensive foundries in connection.

MALLEABLE IRON.

The malleable iron industry in the West of Scotland followed close on the manufacture of pig-iron, the first forges for its preparation being put down at Carron soon after the works were started. In many cases malleable iron works were established in connection with blast furnaces, as at Govan, etc., but these have been almost entirely abandoned, and some of the old malleable iron works have developed into steel works. The plant required for the preparation of malleable iron is so much less costly than that required for pig-iron, that works are much more easily abandoned in one locality and started elsewhere.

There is very little variation in the methods of producing malleable iron. Puddling is universal, and the details differ but little in different places. Twenty years ago it looked as if the malleable iron industry was becoming extinct, but threatened industries often live long, and as the amount of finished malleable iron made last year was 147,904 tons, it is evident that the malleable iron industry is not yet dead. The introduction of mild steel has, of course, largely restricted the number of purposes for which malleable iron is used. The large forgings, which used to be the pride of the forges, have completely disappeared, and the mills now mainly roll small sections of various kinds.

The puddling furnaces in this district are of the usual type, a charge of about 5½ cwts. being puddled at once, the time taken being two to three hours, so that five or six charges can be worked in twelve hours. The furnaces are all worked with a closed ashpit, air and steam being blown under the fire. The hot gases are utilised for steam raising by passing them through boilers placed above the furnaces, usually one for each two furnaces. No slag is tapped out, but a large quantity comes over the sill of the door, and the remainder is left in the furnace to form a bath for the next charge of metal. Hand puddling is generally used, but in a few works mechanical rabbles are in use, the furnaces in that case being larger than for hand puddling.

Steam hammers are universally used for shingling.

The mills are of the usual type, each works, as a rule, confining itself to the rolling of more or less definite sections. For reheating, gas furnaces have been largely introduced in several works. They are of what is called the Siemens new type, in which the air only is heated in a regenerator, part of the products of combustion being passed into the gas producer, and the gas being used hot.

The following is a list of the works in the district, with the number of furnaces and the materials they produce: —

COATBRIDGE.

At the head of the malleable iron producing firms of the district stands **The Waverley Iron and Steel Co.,** with its two works, **The Waverley**

and **Rochsalloch.** The former has twenty-five puddling furnaces, and the latter twenty-six. Both works are arranged for the production of bars, angles, tees, hoops, and many other special sections. In 1890 the output of the combined works was—Crude iron, 51,000 tons, and 40,000 tons of finished bars.

The North British Iron Works (Thomas Ellis, Limited).—This is probably the largest individual works in the district, as it is one of the oldest. It stands on a portion of the Dundyvan estate. There are thirty-four puddling furnaces and five rolling mills, and the works is arranged for the production of all varieties of bar iron.

Tin Plate Works (Coatbridge Tin Plate Co.).—This works was started for the manufacture of tin plates, and this industry was carried on for some years. It was, however, abandoned many years ago, and the work is now confined to the manufacture of malleable iron.

Crown Iron Works (W. Tudhope & Son).—This works was established in 1874. It has twelve puddling furnaces and is capable of turning out 200 tons of finished iron per week.

Clifton Iron Works (Wylie & Co.).—This works has twenty-eight puddling and scrap furnaces, and manufactures bars, hoops, and strips in great variety of sizes and sections.

Coats Iron Works (Messrs. Paterson, Downs & Jardine).—This is one of the oldest works in the district, and the brand Coats is well known. It has now fourteen puddling furnaces, and produces higher-class bar rod, tee angle rivet, horse-shoe and wheel-shoeing iron, for home and export.

The Victoria Iron Works (The Victoria Iron and Steel Co.).—Fourteen furnaces, producing bars and hoops.

The Phœnix Iron Works and the Drumpellier Iron Works, both belonging to John Spencer (Coatbridge), Limited.—The former has twenty-two, the latter has eighteen furnaces, and two mills making bars, hoops, strips, and plates.

Dundyvan Iron Works (Mr. William Martin).—Fourteen furnaces, making bars only.

Coatbridge Iron Works (H. F. Martin).—Ten furnaces, producing bar iron.

Woodside Works (Woodside Steel and Iron Co.).—Eleven puddling furnaces, making strips and plates.

MOTHERWELL.

In this district there are several important iron works—

Etna Iron Works (Etna Iron and Steel Co.). Flemington Station, C.R.—This is a well arranged works, with nineteen puddling furnaces. There is a Siemens (new form) ball furnace, for working all sorts of scrap, two finishing mills, one 12 inches and one 9 inches, turning out about 40 tons of bar per twelve hours. Bars and hoops are made.

Dalzell Steel Works (David Colville & Sons, Limited).—This forms a part of the great steel works (*q.v.*).

Motherwell Iron Works (Glasgow Iron and Steel Co., Limited).—This is the largest works in the district. There are thirty-three furnaces, and bars, strips, hoops, and sheets are made, steel from the steel works (*q.v.*) being rolled also for small sections.

The Globe Iron Works (A. & T. Miller).—This works has twenty-one furnaces: Bar iron is made, and steel bars are rolled from billets.

Messrs. Smith & M'Lean, Ltd., own the **Milnwood Works,** Mossend, with nine furnaces, and the **Gartcosh Works,** at Gartcosh, with seven furnaces. Sheets, both iron and steel, are rolled, and there is also a bar mill.

WISHAW.

Excelsior Iron Works (John Williams & Co.).—This works has twenty furnaces, rolling sheets, hoops, etc. Steel sheets are also rolled.

Pather Works (The Pather Iron and Steel Co., Limited).—Thirteen furnaces. Roll plates, strips, and sheets both from iron and steel, large sheets being a speciality.

Stentor Iron Works (C. F. M'Laren & Co.).—Has eighteen puddling furnaces, and make bars.

Carntyne Iron Works (Carntyne Iron Co.). Parkhead Station, N.B.R.—This is the only remaining works of the kind in the Glasgow district. There are ten puddling furnaces. Strips, plates, and sheets are rolled from iron and steel.

Muirkirk Iron Works (W. Baird & Co., Limited). Muirkirk Station, G. & S.-W. R.—A small works in connection with the blast furnace plant. There are nine puddling furnaces, and bars only are rolled.

STEEL.

Scotland has now become a very prominent steel making centre, the make being, however, confined almost entirely to the production of acid open hearth steel, and of this the output is almost, if not quite, equal to that of Cleveland. In the first half of 1900 the output was 501,214 tons of acid, and 1677 tons of basic open hearth steel.

The Bessemer Process.—Experiments were made with the Bessemer process by Mr. Jackson, of the Coats Iron Works, as soon as particulars of the process were published, but they were not attended with success. About 1857 Messrs. W. Dixon took out a licence to work the process, and an experimental plant was erected at the Govan Iron Works. The process was not a success as applied to Scotch pig-iron, so the experiments were abandoned. The right of using the process in Scotland was repurchased by Bessemer. In 1861 the late Mr. Rowan obtained a licence, and put up a plant consisting of two 3-ton converters. These works were carried on till 1875, when they were dismantled. About 1884 a plant, consisting of four 8-ton converters, was put up by Messrs. Merry & Cuninghame at Glengarnock, and this is still in use, the converters having basic linings; and in 1885 the Glasgow Iron Co. put up three 7-ton converters at Wishaw, but these have now been removed. The Glengarnock is the only Bessemer plant now at work in Scotland.

Siemens.—In 1871 the Steel Company of Scotland was formed to work the Siemens or open hearth processes, the intention being apparently to use the purple ore, the residue left from the extraction of copper by the wet process at the Tharsis Works, and a Siemens revolving furnace for the direct production of malleable iron was put up, but was soon abandoned, and the ordinary open hearth process substituted. Until 1879 the Steel Company was the only maker of open hearth steel in Scotland, and in that year furnaces were put down by Mr. Beardmore at the Parkhead Works.

The Steel Company of Scotland.—This company, as the pioneer of the industry, naturally calls for first mention. It owns two works—

Hallside Works. Newton Station, C.R.—This works was originally designed for the manufacture of steel rails, but this was soon abandoned in favour of the manufacture of steel for structural purposes and shipbuilding. The first furnaces were of 6 tons capacity, and these were followed by others of 10 tons. There are at present five furnaces of from 35 to 40 tons, nine of 25 tons, and two of 23 tons capacity. The producers are of the Siemens type. The varieties of steel made are steel castings of the heaviest character, used either for shipbuilding purposes, such as sterns, sternposts, rudder frames, etc., or in the construction of marine engines, such as engine seatings, bearer frames, etc. Forgings for all kinds of engineering work—axles, sectional bars of all descriptions, and also rounds, squares, flats, and nail strips. The work done is therefore extensive and varied. A considerable quantity of yolla steel, which contains nickel, is made, and has been used in the construction of torpedo boats and high-class yachts.

Blochairn Works.—This works, which is situated at St. Rollox, in the north-eastern corner of Glasgow, was originally established for the preparation of malleable iron, and was purchased by the Steel Company in 1880, and eight steel furnaces were erected. There are now four 50-ton furnaces, six 40-ton, and six 25-ton, the output of ingot steel being about 250,000 tons, which, in case of push, could be considerably increased. The principal manufactures at Blochairn are plates of all kinds for shipbuilding, boilermaking, and structural purposes, and sheets for building torpedo boats, destroyers, and similar purposes, also tyres and rivet bars.

The Glasgow Iron and Steel Company. Wishaw, C.R., either station.—This works was started in 1879, when three furnaces were erected, and, as already mentioned, a set of Bessemer converters was put up. The works was completely rearranged a few years ago. There are now sixteen furnaces, two of them being supplied with molten pig-iron direct from the blast furnaces (the others not being conveniently situated for this, are charged in the usual way). The products are plates for boilers, bridges, ships, etc., also angles, channels, and tees. Having been recently rearranged, the plant is all of the most modern type.

The Lanarkshire Works (The Lanarkshire Steel Co.). Flemington Station, C.R.—This works was established in 1890, and is the latest addition to the Scotch steel works. Everything, therefore, is of the latest type, and the works is so laid out as to allow ample room for expansion. There are five 50-ton and five 25-ton furnaces. The cogging mill and its engine are probably the largest in Scotland, and are capable of dealing with the heaviest ingots, and are so arranged that all parts can be worked from the bridge, no one being needed on the floor. The overhead cranes and other appliances are worked by electricity, generated in a well-arranged power house. Water bottom gas producers are used, one set being provided with electrically-operated automatic charging. The output is at present confined entirely to bars, angles, and similar articles.

The Clyde Bridge (The Clyde Bridge Steel Company, Limited). Cambuslang Station, C.R.—This works was established in 1888. There are nine 35-ton furnaces. The producers are about one-half Wilson (modified), the other half water bottom. The cogging mill is capable of dealing with 5-ton ingots, and there are two plate mills. The make is mainly ship

plates, with a small percentage of boiler plates. The output is about 65,000 tons a year.

Mossend (The Summerlee and Mossend Iron and Steel Company). Mossend Station, C.R.—This works was established in 1839, and in 1880 commenced to make steel by the Siemens process, when five furnaces were built. There are now twelve furnaces of from 20 to 40 tons capacity. The gas producers are of the Siemens and Wilson types. The manufactures consist of ship plates, boiler plates, plates for structural work, and sections for shipbuilders.

Calderbank Steel Works (J. Dunlop & Co., Limited). Calderbank Station.—This is a comparatively recent works. There are two 50-ton, one 40-ton, and two 25-ton furnaces, and boiler and ship plates are made.

Coltness (The Coltness Iron Company).—Mention has already been made of this works, under the pig-iron works (*q.v.*). There is one furnace of about 25 tons capacity, and the output is entirely of steel castings, such as locomotive wheels, etc. At one time the steel furnace was worked with blast furnace gas, but auxiliary gas producers are now in use.

Dalzell Steel and Iron Works (David Colville & Sons, Limited), Motherwell.—This works was started as malleable iron works (*q.v.*) by the late Mr. David Colville in 1872, and the putting down of steel plant was commenced in 1880. The works has the largest steel producing plant in Scotland, having an output of 4000 to 5000 tons of ingots per week. There are five 50-ton and fifteen smaller steel furnaces, the 50-ton furnaces holding the record in Great Britain for output, as does also the slab cogging mill. The plate mills are capable of producing the largest plates required for shipbuilding and boilermaking. There are three bar mills, and all standard sections of bars, angles, bulb angles, tees, bulb-trees, plain bulbs, channels, zeds, etc., and many special sections, are made. Ingots for forging up to 50 tons weight, rolled blooms or slabs up to 30 tons weight, heavy steel castings and steel rolls, turned and finished complete, are made. Over 2000 men are employed.

The Glengarnock Steel Works (The Glengarnock Iron and Steel Company). Kilbirnie Station, G. & S.-W. R.—The blast furnaces have been already mentioned. The steel works was laid down in 1884, and was designed for the manufacture of ships' plates and angles from basic steel. There are four basic-Bessemer converters, having a capacity of 8 tons. Three 30-ton acid-lined open hearth steel furnaces were added about 1891. At the same time a girder mill was erected. Later large stock banks and cranes for handling and loading girders were added. The metal for the converters is partly melted in cupolas and partly used direct from the blast furnaces. Later extensions of the works comprise plant for the manufacture of permanent way rails and a large workshop for the building of compound girders, stanchions, etc., from rolled joists, etc. Various sections are rolled. Phosphate manure is made by grinding the slag from the Bessemer converters.

Clydesdale Iron and Steel Works (A. & J. Stewart & Menzies Limited). Mossend and Holytown Stations, C.R.—This works has nine 40-ton Siemens-Martin smelting furnaces, twenty-six puddling furnaces, and six rolling mills. Tie products are steel boiler, ship, and bridge plates, steel and iron strips and hoops for tube making, and steel ingots and slabs for forgings.

The Parkhead Iron and Steel Works (W. Beardmore & Co.).

Parkhead Station, N.B.R., or Parkhead Car Terminus.—This works, familiarly known as Parkhead Forge, dates back to the early years of last century. From a comparatively small beginning it has gradually advanced, ever developing with the requirements of the times, until now it covers an area of over 45 acres of ground, and occupies a position as a steel works, forge, and armour manufacturing establishment second to none in this country.

The plant includes—Siemens furnaces, ranging in capacity from 20 to 50 tons; mills for rolling light plates, ship and boiler plates, and armour plates; also mills for rolling tyres, etc., ordinary steam hammers, hammers for forging axles, a 12,000-ton hydraulic press—the largest and most fully equipped tool of its kind in existence; and five hydraulic forging and bending presses; a plant for carbonising (Harveyising) armour plates, and large machine shops.

As is well known, the manufacture of armour plates has now become the leading branch at Parkhead; and these huge plates in all stages of production and completion are always to be found under manipulation by powerful machines in the various machine shops.

The manufacture of heavy ordnance and projectiles is also in course of preparation.

Shafts, both crank and straight, for marine and land engines, for which the works have long been famous, are still produced in large numbers; and hollow crank and straight shafting for Government cruisers and battleships are quite a speciality. At the present time the shafts, both crank and straight, for the first-class cruisers H.M.S. "Berwick" and H.M.S. "Suffolk" are in hand, as well as those for the battleship H.M.S. "Queen."

Railway tyres and axles are made. The second tyre mill, which is just completing and will be in operation shortly, is designed for turning out the largest type of tyres. In axles, the Parkhead make is well and favourably known for excellence of finish and material.

Parkhead boiler and ship plates are well known.

It may be mentioned that Messrs. Beardmore have lately acquired the old-established business of R. Napier & Sons, shipbuilders and engineers, at Govan and Lancefield, and thus have associated themselves with the concern founded by the famous shipbuilder, Mr. Robert Napier, who himself was associated with the Parkhead Works in the beginning of their history. This is one of the remarkable coincidences which sometimes occur in business circles in the course of years.

This shipbuilding and engineering business Messrs. Beardmore intend to transfer to Dalmuir, where over 70 acres of ground have been purchased for the purpose of laying down a shipyard and engine works of the most modern type, and capable of building warships and mail steamers of the largest size.

Of the smaller works may be mentioned—

Springfield Works (The Springfield Steel Co.), London Road, Glasgow.—Castings of all kinds are made for electrical, marine, bridge, mills, and other purposes of Siemens acid steel. There is one 17-ton furnace, and the output is about 2500 tons a year. About 500 tons of malleable iron castings are also made.

The Acme Steel Works (Shettleston), **The Mount Vernon Steel Works** (Shettleston Station, N.B.R.), have each one open hearth

furnace for the preparation of steel castings, and there is one at Dumbarton.

COPPER.

The copper industry of the West of Scotland is of but little importance, there being only one works.

Garngad Works (The Tharsis Sulphur & Copper Company, Ltd.). Car to Garngad Road.—This works is situated in the north-east of Glasgow, not far from the Blochairn Steel Works. The Tharsis Sulphur and Copper Company import pyrites from their mines at Huelva. The ore is burnt for the preparation of sulphuric acid at various alkali works, and the "burnt ore" is sent to the Garngad Works for treatment. The process used is the ordinary wet copper process, with Claudet's process for the separation of silver.

The burnt ore is ground with salt and roasted at a moderate temperature; the roasted mass is washed with water, which dissolves the copper salts, and the silver chloride, which dissolves in the solution of salt. The silver is precipitated as iodide by means of sodium or zinc iodide, and the silver iodide is decomposed by zinc. In the solution from which the silver has been precipitated the copper is thrown down by scrap iron. The copper precipitate is refined in a reverberatory furnace in the usual way.

The firm has similar works on the Tyne, at Oldbury, near Birmingham, and at Cardiff.

LEAD.

Lead ores are not worked in the immediate neighbourhood of Glasgow.

Messrs. Alexander Fergusson & Co., Ruchill Works, Maryhill (car from Glassford Street), smelt lead residues and, occasionally, ore, and desilverise by the Pattinson process and cupellation. At their works in M'Alpine Street, Glasgow, they have machinery for rolling lead into sheets and for the manufacture of lead pipe of all sizes.

The Leadhills. Abington Station, C.R., six miles; or Elvanfoot Station, C.R., seven miles; from the latter a coach runs.—This district, though somewhat far from Glasgow, yet belongs to the Clyde valley, as the streams flow down into the Clyde. It is the only rich mineral district near Glasgow, and so valuable was it deemed that it was called "God's treasure-house in Scotland," and the mines have been worked for hundreds of years. At one time gold was found in the gravels of the Elvan, Shortcleugh, and Glengonnar, but these have long since been exhausted and now the district yields only lead.

Two sets of mines are at work—those at Leadhills (The Leadhills Silver Lead Mining and Smelting Company) and at Wanlockhead.

At Leadhills lead ore is smelted in the old Scotch ore hearth, now nearly extinct. In some years as much as 1800 tons of lead has been smelted. There are three hearths, each capable of turning out about 12 to 15 tons of lead per week, but at present only two are at work. There is also a slag hearth for the reduction of the slags. The lead contains but little silver, which, however, is extracted by the purchasers.

The Queensberry Works, Wanlockhead, belonging to the Duke of Buccleuch, are about two miles beyond Leadhills village, and have been at work for over two hundred years. There are two ore hearths and a slag hearth. The silver is extracted from the lead by the Pattinson

process and cupellation. The output of the mines is about 1550 tons of ore per year, all of which is smelted at the works.

A light railway is in course of construction to the Leadhills.

NICKEL.

Kirkintilloch Works (The Nickel Co.). Kirkintilloch Station, N.B.R.—This works was founded in 1880. The company has its head office in Paris, and owns mines in New Caledonia, from which the European works derive their supply of nickel and cobalt ores. The nickel ore is a double silicate of nickel and magnesia, and contains on an average about 8 per cent. metallic nickel. Besides the works at Kirkintilloch, the company also own refineries at Birmingham, at Havre in France, and Iserlohn in Germany. At Kirkintilloch the nickel ore is smelted in blast furnaces, and the refined mattes are finished at its Birmingham works, where it is sent out into the market in the state of pure nickel of 98-99 per cent. purity. The cobalt ores, which contain about 3 per cent. of metal, are also smelted in blast furnaces, and the refined metal converted into oxide, and sent out in this condition to the market. Since the formation of the company the production of nickel has increased enormously. In 1880 the production was 400 tons per annum, which has steadily increased, until now the production is 4000 tons per annum.

GALVANISING.

The process of coating iron materials with zinc by dipping in molten zinc, or galvanising, is largely carried on in the district, all kinds of articles, from nails to the largest tanks, being galvanised. A short time ago plant for the deposition of zinc by an electric current, or electro-galvanising, was put up, but the process has now been abandoned.

The principal galvanisers in the district are—

Eclipse Works, Petershill Road (F. Braby & Co.).—A very extensive works, capable of dealing with the largest size of articles. The firm are also galvanisers of sheet iron, and makers of corrugated galvanised iron plates.

Messrs. Smith & M'Lean, Lower Mavisbank.

Porteous & Crawford, Elliot Street.

Messrs. M'Hutcheon & Co, Lancefield Street.

The Whiteinch Galvanising Co., Ltd., Whiteinch.

TUBE MAKING.

The making of iron tubes is an old-established industry in the West of Scotland. The butt-welded process for making gas, water, and steam tubes was introduced into the district about 1835 by Mr. Andrew Liddle, of the Globe Foundry, Washington Street, and was subsequently carried on by him and by Mr. John Crichton at 36 London Street.

About 1844 the late Mr. Joseph Baker established the **Caledonian Tube Works** at Coatbridge for the manufacture of lap-welded or boiler tubes, and in 1850 the firm of **Crichton & Eadie,** who up to that time had been makers of butt-welded tubes only, started the manufacture of lap-welded tubes at the **Clydesdale Tube Works,** Rutherglen. These two original works still hold a prominent position in the tube trade. Later on in the year the **Glasgow Tube Works** was erected by **Messrs. Marshall &**

Wylie, and a year or so later the firm of **A. & J. Stewart** began work in Glasgow and at Coatbridge. This firm rapidly progressed, and a few years ago took over the works of Messrs. James Menzies & Co., and now, as **A. & J. Stewart & Menzies, Ltd.,** it is the largest makers of butt and lap-welded tubes in Great Britain. The largest, and at the same time the oldest, of its works is the **Clyde Tube Works,** Coatbridge. There every variety of tube except gas tube is made, both lap-welded and butt-welded, up to the largest size, and the firm makes gas tubing at its other works.

The manufacture of butt-welded and lap-welded tubes is now an important industry in the Glasgow district. There are eleven firms, employing some thousands of workmen, and turning out thousands of tons of tubes yearly.

ALUMINIUM.

The British Aluminium Co., Foyers. Foyers Pier, Caledonian Canal Steamers.—This hardly belongs to the Glasgow district, though it certainly is one of the industries of the West of Scotland. The buxite is treated for the preparation of pure alumina at Larne, and the product is shipped to Foyers. The carbons for the electric furnaces are made at Greenock. The aluminium is separated by an electric current, the dynamos for the production of the current being driven by turbines, the power for which is obtained from the celebrated Falls of Foyers. A dam has been constructed to retain the water, which is brought to the turbines by means of iron pipes.

MECHANICAL ENGINEERING,

BY

HENRY DYER, C.E., D.Sc., M.A.

MECHANICAL ENGINEERING.

INTRODUCTION.

The following notes on the Mechanical Engineering industries of Glasgow and the West of Scotland are not intended to supply a complete directory for all the existing establishments, nor to enter into a history or detailed description of such as have been mentioned. The space allotted to this section of the work only allowed some representative works in the various departments of mechanical engineering to be mentioned, and a few particulars given of their most important features and recent developments. The history of mechanical engineering in Glasgow and the West of Scotland is a very interesting subject, but it has scarcely been touched upon, and the readers are referred to special books and papers for detailed information regarding it. The handbook issued on the occasion of the last visit of the British Association to Glasgow contained a considerable amount of interesting historical matter, which, however, it has not been thought necessary to repeat. Only such points are mentioned as are necessary to indicate the changes which have taken place during the past quarter of a century, and only such information is given as seems necessary to guide the members of the British Association to some of the most representative mechanical engineering establishments in Glasgow and the West of Scotland.

It is impossible to arrange such notes in a perfectly systematic manner or under special headings, as many of the establishments undertake different departments of engineering. As a rule they have been arranged under the class which seemed to indicate the most important part of their work, and occasional cross references have been made from one section to another where it was desirable to direct attention to special kinds of work undertaken by firms previously mentioned.

Iron and Brass Founding naturally are mentioned first, as supplying the materials for a large part of mechanical engineering, and mention has been made of establishments which turn out different kinds of work. **Boilermaking** next claims attention as supplying the motive power in ordinary use. A few representative firms are mentioned which make the ordinary form of band boilers, those for marine engines being noticed under "Marine Engineering and Shipbuilding." A short notice is given of some of the modern types of water-tube boilers and of the appliances which are used for economising steam. It has been thought sufficient to give the names of the most important bolt and rivet makers, as these are now incorporated under one company.

The first department of Mechanical Engineering proper which is

mentioned is that of **Machine Tools**, and the miscellaneous appliances which are to be found in all well-equipped engineering establishments. No attempt has been made at strict classification, it being considered sufficient to group together representative firms which supply engineers with tools and appliances. As electricity is now being largely applied to machine tools, under the heading of **Electrical Engineering** are mentioned the chief firms employed in that department of industry. The chief applications of electricity as a motive power and for lighting are to be found in the Glasgow Corporation tramway and lighting departments, and these are briefly described under the municipal activities of Glasgow.

Under the heading of **General Mechanical Engineering** are given notes on some of the most important mechanical engineering establishments in Glasgow and the West of Scotland. Some of these specialise to a considerable extent, but it has not been thought necessary to subdivide the section. However, as the making of **Sugar Machinery** was at one time a very important industry in the district, and although it has been depressed for some time on account of the special conditions of sugar production on the Continent, it is still of sufficient importance to justify a separate heading. **Locomotive Engineering** is now one of the most important mechanical industries in the district, and an account is given, not only of the private firms which are engaged in it, but also of the establishments belonging to the railway companies, which turn out a considerable amount of work both in the way of locomotives and railway plant generally. Following on that is a short account of some of the establishments which construct **Roofs and Bridges and Railway Appliances** generally.

The spinning and weaving industries have declined much in recent years in the West of Scotland, and consequently the construction of spinning and weaving machinery has fallen off, although a few establishments still maintain some of their trade in these departments. The sewing thread industry, however, has developed very much, chiefly in Paisley, and several firms now devote themselves largely to the production of the machinery required. In connection with this the making of sewing machines has also attained large dimensions, and some notes are given of the establishments which manufacture them, of which by far the most important is that of the Singer Manufacturing Company. The notes on this department are given under the heading of **Textile Machinery and Sewing Machines.**

Glasgow is now an important centre for the production of large cast-iron pipes for the water supply of cities, and some of the most important **Pipe Foundries** are noted, together with some establishments which are connected with hydraulic works. For the production of **Sanitary, Lighting and Heating Appliances** there are many important establishments in the district, and of these a few have been noted, but reference must be made to the illustrated catalogues which these establishments usually publish for an adequate idea of the variety and extent of the work which they turn out.

Although the manufacture of **Agricultural Implements and Machinery** has not attained, in the West of Scotland, the importance it has in some parts of England, still there are a few firms which do an extensive business, and which have obtained a good reputation for

the excellence of their work, and of the most important of these a few particulars are given.

Under the heading, **Instruments and Miscellaneous Appliances,** are given some particulars of the productions of some firms which could not be strictly classed as engineering establishments, but which still are of great interest from a scientific point of view or on account of their practical applications in different departments of engineering. The list, however, is by no means exhaustive; to have made it so would have taken up more space than could have been spared, and therefore only a few representative establishments have been mentioned.

GENERAL IRONFOUNDING.

Hyde Park Foundry Company.—These works were established upwards of half a century ago, and make a speciality of marine engine castings up to the heaviest class. The engine castings of some of the most celebrated steamers built on the Clyde and elsewhere have been manufactured here, including small cylinders for torpedo craft up to those for first-class cruisers, battleships, and mail steamers, weighing upwards of 36 tons each.

The works cover over two acres, and employ about 400 men. The ground and buildings belong to the trustees of the late Mr. Walter Montgomerie Neilson, who was senior partner of the firm until his death in 1889. Mr. Alexander Wilson is now senior partner, and associated with him are Mr. Thomas C. Campbell and Mr. Thomas Downie.

Messrs. James M'Ewan & Sons, Cyclops Works, Whiteinch.—These works had their origin in the firm of Messrs. Sheriff & Anderson, which was started in 1847, in the East End of Glasgow. Mr. M'Ewan, the present senior partner, joined the firm in 1871, in Peel Street, London Road. On account of the increase of business the works were removed to Whiteinch in 1898, where new buildings were erected and fitted with the most improved appliances. They occupy fully two acres of ground, and the work which is done is very similar in its nature to that done in Hyde Park Foundry above mentioned, namely, marine engine castings, from the largest to the smallest sizes. The firm supplies the engineers on the Clyde, but does also a good business with those of Belfast, and occasionally sends some of its castings to Germany and other continental countries.

Messrs. William Moses & Co., Plantation Foundry, off Paisley Road.—This firm also supplies castings of the same kind as those of the above-mentioned establishments.

Cumberland Foundry, 168 Gallowgate.—These works were established more than a century ago, and have, during their long existence, been the nursery of many men who have become distinguished in the iron trade. The proprietors, Messrs. Moses M'Culloch & Co., have the reputation of turning out first-class work. Special attention is given to all kinds of structural castings, such as columns and beams, which are now so extensively used in the construction of warehouses, etc. Lamp pillars for street lighting are also made in great quantities, many hundreds of which may be seen in use in the streets of Glasgow and of the suburbs, the Corporation having got their supply at these

works for many years. Various other castings are also made, such as stable fittings, cast-iron windows, etc. Mountings for bakers' ovens are a speciality of the firm, so that their name has been long and closely associated with the baking industry all over the country. Although the productions of the firm are principally for the home markets, still many export orders are executed for the colonies and foreign countries.

William Ure, Crown Point Foundry.—This firm is specially distinguished for the excellence of its castings for machine tools and wheel gearing, which have a reputation second to none in the kingdom.

Messrs. Fullerton, Hodgart & Barclay, Limited, Vulcan Works, Paisley.—These works are situated in the Renfrew Road, Paisley, close to the Abercorn Station of the Glasgow and South-Western Railway Company. Founded in 1838 by Messrs. Craig & Donald, the firm later became Craig & Fullerton, and finally assumed its present designation. The works are divided into two departments, the engineering department and the foundry department. The engineering department is employed in the construction and manufacture of high-class engine work of every description, and for all powers. The class of engines made is chiefly for driving mills, electric lighting, and traction, winding engines for mines, engines for driving stamps, hydraulic and other pumping machinery, etc. For upwards of thirty years a speciality has been made of hydraulic machinery for railways, docks, steel works, etc., and the firm has supplied this type of hydraulic machinery to a large number of the principal docks, harbour boards, and railways in Great Britain and on the Continent. The foundry department is capable of turning out the largest castings, and has a considerable trade in supplying the firms of marine engineers on the Clyde, besides executing other general work. Both foundry and engineering shops are equipped in the most modern manner, and finished with the usual steam and hydraulic power and electrical appliances as are customary in up-to-date works. The average number of men employed in these works is between seven and eight hundred.

The British Hydraulic Foundry Co., Ltd.—The works of this company are situated at Whiteinch, near Glasgow, and were erected in 1891 to work certain patents in connection with hydraulic moulding. In addition to small repeat castings suitable for machine moulding, the company commenced in 1892 the manufacture of cast-iron tunnel lining in segments, of which it has since made a speciality. These segments are used for the lining of tunnels, and are specially suitable for tunnels made by means of a shield and compressed air, as was done in the case of the Blackwall Tunnell and the Central London Railway and the Glasgow District Subway. The works cover an area of over eleven acres, and are well placed, having not only direct communication with the Caledonian and North British Railways, but also with a private wharf, at which can be loaded or discharged steamers of from 700 to 800 tons capacity.

Messrs. J. & R. Houston, Cartsburn Foundry, and Glenburn Ironworks, Greenock.—These works were started about thirty years ago as a foundry and engineering shop, and in the course of years the growing colonial trade of the firm developed to such an extent along with their present home trade, it became necessary to acquire another site,

and a large portion of the late Messrs. R. Steel & Co.'s works in Ingleston Street, and which are now known as the Glenburn Iron Works, was acquired about eight years ago, when the engineering part of the work at Cartsburn was removed and refitted up in the newly acquired premises, and at the same time a large number of new tools, with hydraulic plant, were introduced, and the whole shop and offices fitted up with electric light.

The works at Cartsburn were entirely converted into a large moulding shop, and fitted up with steam and travelling cranes, lines of rails, with turntable running through the shop. Although the foundry can turn out from 25 to 30 tons per day, it is already found to be much too small. The firm turns out castings of all dimensions, made in loam, dry sand, and green sand. It also makes structural work, iron roofing, and fire-proof buildings. In the more strictly mechanical engineering department it undertakes plants for sugar estates and refineries, and for breweries, distilleries, and gasworks, as well as high-speed engines, and all the usual mechanical fittings of manufactories. The chief markets to which the firm exports its productions are Australia, India, China, and Japan.

There are numerous other foundries in Glasgow and the West of Scotland, both independent and attached to engineering establishments, but the above-mentioned illustrate the chief varieties of work done. For pipe foundries and foundries for sanitary and ornamental work see pp. 80-84.

BRASSFOUNDING AND COPPERSMITH WORK.

Messrs. John Broadfoot & Sons, Inchholm Works, Whiteinch.—This firm was started about fifty years ago in M'Alpine Street, Glasgow, by Mr. John Broadfoot, and it soon obtained a good share of the brass-founding work required by the marine engineers of the Clyde. Mr. Broadfoot was trusted as a sub-contractor by the firm of Robert Napier & Sons and others, and his business increased so much that he found his premises too restricted to meet all the requirements, and accordingly he removed to what was then the extreme west of the Clyde wharfage, viz., Lancefield Quay, in close proximity to the Lancefield Dock, where the ships built by Robert Napier & Sons were engined after being launched at Govan.

At this time some of his friends thought that he had gone too far west, but business here increased so rapidly that in 1868 he found it necessary to erect more commodious premises, and for this purpose ground was bought at the top of Finnieston Street and workshops erected thereon. The removal took place in 1869. In the years 1872 and 1873 Mr. Broadfoot was joined by his two sons, and in 1875 they were assumed as partners.

Up till this time Mr. Broadfoot had done much work for the British Admiralty as a sub-contractor, but in 1875 the firm had an opportunity of tendering direct for an important Government contract comprising a large variety of the brass fittings customarily required in warships, and were successful in securing a five years' contract. Since that time this contract has been repeatedly thrown open to public competition, but Messrs. Broadfoot have up till the present been successful in securing it, so that the firm has held it continuously for twenty-six

years. Along with this the Admiralty connection with the firm has been very much extended, and it is now entrusted with a great variety of very important work that calls for the highest skill and exactness. The manufactures of the firm are so varied that it is difficult to enumerate each particular. A glance at the illustrated catalogue issued by the firm shows that it includes every variety of brass work and ships' fittings, and general brass castings. The firm has several specialities, among which may be mentioned improved patent pumps, improved patent Admiralty Downton pump, improved patent automatic valve, and patent combination hinged and pivot side lights.

In 1881 Mr. John Broadfoot retired from any active part in the business, which, since then, has been carried on by his two sons, largely extended in many directions, so much so that about four years ago they found it necessary to build extensive new works at Whiteinch, and at the same time to secure sufficient ground for considerable extensions when these are required.

At present the firm carries on in an extensive way brassfounding, brassfinishing, smith work, plumber work, tinsmith work, and much engineering work of a varied character. In the brass foundry, which is fully 200 feet long, the largest gun metal and bronze castings required by modern warships can be cast, and the machinery workshop is equipped with the most modern plant to produce with economy and speed the many fittings that go to make up the business. While the principal outlet of the manufactures of the firm remains with the British Admiralty, it has a good general home trade as well as a connection in all the ports of Europe, and in the far East.

Messrs. Steven & Struthers, Anderston Brass Foundry.—These works, situated in Eastvale Place, Kelvinhaugh, were erected in 1898, as the accommodation at Elliot Street, where this firm was so long located, had become quite inadequate for the extent of the work now taken in hand. The buildings comprise large and small brass foundries, iron foundry, machine and pattern shops, and are capable of turning out over 80 tons of castings per month, and single castings up to 20 tons in weight. A speciality is made of stern and sternpost, etc., casting for battleships and cruisers for the British Admiralty and foreign Governments, and of propellers, propeller blades, and liners for tail-end shafts of the largest dimensions, the latter being turned out finished complete. The small iron foundry has been recently added for the work required in connection with the other business of the firm. The tools in the machine shop are specially adapted to the manufacture of all kinds of fittings required by engineers and boilermakers. Syrens, fog-signalling machinery, lanterns, revolving apparatus and machinery for lighthouses and specialities of the firm, which is also the sole maker of Lyall's patent corrugated shaft liners, Bevis and Gibson's patent equilibrium valves, Grigg's automatic ventilation valve, etc. Direct connection by means of a private siding with the North British Railway Company gives the firm every facility for prompt despatch. The number of men employed is about 200.

Among other representative brassfounders who do considerable business in the various departments of the work may be mentioned Messrs. Thomas Jack & Co., Woodville Street, Govan; Messrs. France & Morgan, Whitefield Brass Works; and Messrs. John & William

Young, Stoboross. Many of the larger engineering establishments make a good many of the brass castings which they require, but, as a rule, the special fittings are supplied by outside makers.

Messrs. Blair, Campbell & Maclean, Scotland Street Copper Works, Glasgow.—This firm, which is the largest of its kind in Scotland, may be taken as representative of the coppersmith trade, in which it undertakes work of all descriptions. In addition to all the ordinary branches, they are specialists in the manufacture of distilling, sugar making, and refining plants, and make various patent appliances. Vacuum pans and evaporators, in iron, copper, or aluminium, and all the apparatus in which the use of copper is required for sugar refineries, breweries, and distilleries, are supplied, as well as a large number of miscellaneous appliances for heating, refrigerating, and refining, in all their departments.

In Glasgow there is a large number of coppersmiths, but their work does not call for special mention.

BOILERMAKING AND BOILER APPLIANCES.

Many of the engineering establishments have boiler shops attached to them in which the boilers are made for the engines which they construct, and it is not necessary to mention them specially. In what follows a few typical boilermaking establishments are briefly described, and some details are given of others where special forms or appliances are made.

Messrs. Lindsay Burnet & Co., Moore Park Boiler Works, Govan. —These works were established in 1883 for the production of high-class boiler work. The buildings comprise one large central erecting shop 190 feet long, with machine shops on each side, and other sheds extending from the main blocks into the yard. There is a railway siding into the works from the Glasgow and Paisley Joint Lines, and from it branches are led into the various shops. It is interesting to note that the works have been lighted by electricity ever since their establishment eighteen years ago. The shops are equipped with special machine tools of modern description, including hydraulic flanging plant capable of dealing with the heaviest plates used in the construction of steam boilers. This plant is used not only for the flanging of the plates required for all the boilers made in the works, but is also employed in turning out a large quantity of flanged work for customers.

The firm is engaged in the manufacture of boilers of all types suitable for use on board ships. The manufacture of dry-back boilers and other multitubular types has also been a speciality with this firm since its foundation, and great numbers have been made for electric and other installations on land, both in this country and abroad. Feed heaters and all the other accessories in connection with steam plant also form a large part of the business done by the firm.

Messrs. Mariott & Graham, Plantation Boiler Works, Govan.— This establishment is one of the most interesting of its kind in Glasgow and neighbourhood. While it turns out boilers of all the ordinary types, special attention is paid to those which from their design require to be welded instead of riveted, and some of the work done is of a wonderfully skilful nature. Boilers for heating apparatus and for cooking and laundry purposes are specialities of the firm, and many of

its designs are well known and highly appreciated all over the country. A visit to the works is most instructive, and shows some of the possibilities of working in iron and steel and their applications to boilers and heating apparatus, which are known to many in the engineering trade.

Messrs. Penman & Co., Caledonian Iron Works, Dalmarnock Road, Glasgow.—Among the many great works in Glasgow, the Caledonian Boiler Works of Messrs. Penman & Co. have an exceptional reputation for efficiency. The firm started business thirty years ago, and in the interval has made great developments.

At the present time the average turnout is four Lancashire steam boilers per week, and as the whole of the work is executed on the premises the works are necessarily of great extent, covering fully 3 acres of ground. The main buildings are of brick and substantially constructed; the principal shed is in three bays, and measures 420 feet long by 120 feet wide. In the centre bay is a 35-ton travelling crane, and in the side bays there is a number of small travelling cranes. The works are fitted up with the most improved tools and appliances, and the firm has spared no effort to bring their resources up to the highest point of efficiency. It sends its boilers to all parts of the world.

Messrs. William Wilson & Co., Lilybank Boiler Works, Glasgow.—This firm was founded by the late Mr. William Wilson in 1852, and since his death in 1893 it has been carried on by two of his sons, who had been partners with him for several years before that event.

The works are situated in the South Side of Glasgow, about a mile from the Royal Exchange, have frontages to Eglinton Street, Pollokshaws Road, and Lilybank Street, and are equipped with modern machinery for the production of land boilers, to which class of work Messrs. Wm. Wilson & Co. devote their whole attention. The type of boiler chiefly built by this firm is the Lancashire or double-flued boiler, up to the largest sizes and for the heaviest pressures. They also make various smaller types of boilers, such as Cornish or single-flued, multitubular, vertical, etc.

Messrs. Wilson's boilers not only find a market in the mills, collieries, public works, and institutions throughout the United Kingdom, but are also largely exported to India, China, Australia, South America, and other foreign markets.

Water-tube Boilers.—During recent years water-tube boilers have been very largely adopted for the generation of steam for almost all kinds of purposes, and especially for electric light and electric tramway stations, iron and steel works, and for all the new ships of the royal navy. This type of boiler has not yet been largely adopted in the mercantile marine, but there are indications that, as experience is gained in the management of these boilers, they will gradually supersede the ordinary marine type in most of the important vessels in the mercantile marine.

The main reasons in favour of the adoption of water-tube boilers are—(*a*) The ease with which they can be got into confined boiler rooms; (*b*) the smaller floor space required for a given power; (*c*) the greater rapidity with which steam can be raised, owing to the much smaller quantity of water contained in these boilers; (*d*) the facility with

which repairs can be effected and the fact that when a repair has been effected the boiler is practically as good as a new one—on this account the safe working pressure does not require to be reduced as it does in shell boilers after they have been in use a number of years; (*e*) owing to the circulation of the water within these boilers being more rapid and systematic than in ordinary boilers there is less deposit of scale on the heating surfaces, and this tends to the maintenance of the efficiency of the boilers during longer periods; (*f*) the greater ease with which these boilers can be constructed for the higher steam pressures which are now being adopted; (*g*) the greater safety under all conditions of working. With these boilers disastrous and widespread explosions are practically impossible, owing mainly to the small quantity of water and steam which they contain. In warships their main advantages are due to the rapidity with which they can be got into action, and the ease with which the parts can be got into and out of the boiler rooms. Without the water-tube type of boiler the modern high-speed torpedo boat destroyer would have been impossible.

Water-tube boilers for warships of the Belleville and other types are constructed in the Clyde district by the Fairfield Shipbuilding and Engineering Co., Ltd., Govan; the London and Glasgow Shipbuilding and Engineering Co., Ltd., Glasgow; Messrs. John Brown & Co., Ltd., Clydebank; and by Messrs. Babcock & Wilcox, Ltd., Renfrew.

Water-tube boilers for land purposes are constructed by Messrs. Babcock & Wilcox, Ltd., Renfrew; the Stirling Boiler Co., Ltd., Flemington, near Motherwell; Messrs. Lindsay Burnet & Co., Govan; and Messrs. Duncan Stewart & Co., London Road Works, Glasgow. By far the largest work in Britain for the construction of water-tube boilers are those of Messrs. Babcock & Wilcox, Ltd., Renfrew. These works cover 32 acres of ground, and are equipped with special machinery of great interest for the rapid and economical production of boilers on a large scale. About 1400 workmen are employed, and the present output of land boilers is about 1500 per annum. Besides these, the firm makes a considerable number of marine boilers, superheaters, mechanical stokers, and other accessories. The latest development in these boilers is their construction entirely of wrought steel, and the adaptation of the marine type to all kinds of marine work, both naval and mercantile.

The "Stirling" Boiler Co. have recently erected new works, covering 10 acres, at Flemington, near Motherwell. These works are constructed to turn out six boilers per week, and extensions in view will enable this output to be doubled. The works are supplied with steam by two "Stirling" boilers, one of which is arranged for hand-firing, and the other is provided with a chain grate mechanical stoker. The main driving gear of the works is actuated by two of Parson's improved steam turbines and dynamos, running at 4000 revolutions per minute. British-made boilers of this type now generate 110,000 horse power, and the output is rapidly increasing.

Messrs. G. & J. Weir, Ltd., Holm Foundry, Cathcart.—These works have been built for the manufacture solely of the firm's specialities in marine feed-water heaters, land and marine independent direct-acting feed pumps, general pumps, marine evaporators and distilling plant, direct-acting circulating pumps, independent air pumps, etc.

The works are situated at Cathcart, and are reached by the Cathcart District Railway from the Central Station. They extend over an area of 9¼ acres, and comprise pattern shop, iron foundry, brass foundry, machine testing and erecting shops. A portion of the works is driven electrically from a central power station, the power being supplied by a Weir water-tube boiler, triple expansion marine engine, and 160 h.p. dynamo. The entire works are electrically lit throughout. The firm's new machine shop, however, is driven by Crossley's gas engines. The machine shop covers 57,000 square feet, and is equipped throughout with the latest British and American and continental machine tools, and with English and American electric cranes. The fitting and erecting shop covers 18,600 square feet, and is provided with a very complete equipment for the expeditious erection and carrying out of work. The whole establishment is planned and organised in the most up-to-date manner for the rapid and economical production of accurate and high-grade work.

The firm's specialities are extensively used by the mercantile marine, by the British Admiralty, and by the leading foreign navies. Their standard feed pump for land purposes have been widely adopted for electric light stations, mills, factories, etc., and their compound feed pumps, tandem type, are also largely adopted. The commercial and drawing offices of the works are well got up and lighted, and the establishment generally is a good example of the modern up-to-date engineering works.

Makers of Bolts and Rivets.—The rivet, bolt, and nut makers of Glasgow and neighbourhood were recently formed into a united company, of which the registered offices are 121 St. Vincent Street, Glasgow. The following were the firms from which the combination was formed:—John Bilsland & Co., Cranstonhill, Glasgow; The Clyde Iron Co., Port-Glasgow; The Clyde Rivet Works Co., Glasgow; Edward Crosher, Kinning Park, Glasgow; Wm. Crosher & Co., Kinning Park, Glasgow; Walter Donald & Co., Easterhouse; The Dundee Rivet Works Co., Ltd., Dundee; Hunter, Hardin & Wilson, Germiston Works, Glasgow; James Kennedy, Dundyvan Rivet Works, Coatbridge; James Miller & Co., Ltd., Stobcross Works, Coatbridge; Macfarlane Bros., Hydepark Street, Glasgow; Alex. Pillans, Caledonian Works, Motherwell; James Rose & Sons, Govan Rivet Works, Govan; James Smith & Co., Scotia Bolt Works, Rutherglen; The Sunnyside Rivet Co., Ltd., Coatbridge.

MACHINE TOOLS, HOISTING APPARATUS, Etc.

Messrs. James Bennie & Sons, Clyde Engine Works, Glasgow.—This firm was established in 1837, and carried on business in the Caledonian Foundry, West Street. For about twenty years the business of the firm was solely ironfounding, and they were chiefly engaged in the production of marine engine castings of the largest and heaviest type then made. About 1857 the firm added to their business the making of machine tools for shipyards and bridge building, and in 1867 the business of ironfounding was discontinued, and the firm devoted itself solely to machine tool making. In 1879 new works were erected at Polmadie, and last year the firm removed from there to new and thoroughly modern buildings which they have erected at Cardonald, near Govan.

The main portion of the works is the fitting and machine shop, which is a

long building, 50 feet wide and 40 feet high, and is supplied with two travelling cranes, each of 25 tons capacity. The shop is fitted with powerful machine tools of most modern character, and specially adapted for the work carried on. The ground extends to 2½ acres, and includes smith shops, pattern shops, pattern stores, counting-house, and drawing office. A railway siding connected with the Caledonian and Glasgow and South-Western Railways runs into the works.

Heavy machine tools for shipyards, boiler shops, and bridge building works are the specialities to which the firm devote their attention. These consist chiefly of punching and shearing machines, plate bending rolls, plate edging planing machines, beam bending machines, manhole punching machines, cold iron and steel sawing machines, etc. The machinery manufactured by the firm is supplied to the shipyards and bridge building works in this country, and also very largely to Germany, France, Holland, Denmark, Norway, Sweden, Russia, Italy, Austria, India, China, Japan, and South Africa.

Messrs. Craig & Donald, Machine Tool Makers, Johnstone.—This firm has been in existence for sixty years, and was the first to supply the machine tools required in the construction of ships' hulls when iron superseded wood. Its chief productions are punching and shearing machines, angle cutting and bending machines, plate bending and planing machines, plate flanging and shearing machines, and bar cutting machines. These machines are chiefly used in shipbuilding, bridge building, boiler making, tank and gas-holder making, and in connection with plate and bar mills in iron and steel works.

Twenty-five years ago the firm introduced the multiple punch. Some of the larger machines punch a great many holes at a stroke, and accuracy of pitch is ensured. These machines have been introduced into fence makers' works, and have punched at one stroke all the holes in a 9-inch bar. The firm was the first to make the manhole punch when the system of continuous water ballast was first introduced. A hydraulic machine has been made to punch a hole 36-inch diam. through ¾-inch steel plate. The machines have been sent to all the chief shipbuilding countries in the world.

Messrs. Caldwell & Co. (late Muir & Caldwell), Engineers, 130 Elliot Street, Glasgow.—This firm has had a long-established reputation for the excellence of its productions, which may be described generally as ship auxiliary machinery of all kinds. Their well-known steering gear is supplied to many shipbuilders, and is found to be thoroughly efficient and reliable. They also do a large business in capstans, winches, and coal-hoisting machinery, all of which are to be found not only in the ships of the merchant service, but also in those of the British and foreign Admiralties.

Messrs. David Carlaw & Sons, Finnieston Street, Glasgow.—Probably of all the mechanical workshops in Glasgow no one is of so much interest to the inventive genius as that of Messrs. Carlaw, where work of all kinds requiring the greatest exactitude can be done with the intelligent aid of the members of the firm. Mr. Carlaw, senior, has long been known as an ingenious inventor, whose models of machinery have won the admiration of engineers in all parts of the world. At the last Glasgow International Exhibition Mr. Carlaw had a model of triple expansion engines made at Fairfield, and another of quadruple expansion engines by Messrs. Denny, of Dumbarton, which attracted much attention and received much praise. In the present Exhibition he has a model of a locomotive by Messrs. Neilson, Reid & Co., which is a marvel of exactitude in construction.

In recent years the business of Messrs. Carlaw has very much developed, and in their fine new premises in Finnieston Street they have a splendid collection of special tools of the latest design and best construction, which are used for turning out a great variety of work. They, however, make a speciality of printers' and stationers' machinery, to which for many years Mr. Carlaw has devoted much attention. Some specimens of these machines are to be seen in the present Glasgow Exhibition, so that members of the British Association will have an opportunity of inspecting them. Mr. Carlaw is the patentee of special machines for printing, numbering, and cutting tramway and other similar tickets, and which represent an evolution which he has been carrying out for many years. They are most ingenious in their design and perfect in their performance. The firm, however, undertakes the construction of all kinds of machine tools for special purposes, and of high-speed engines for electric work. Any inventor with a good idea and sufficient money will find that the Messrs. Carlaw are able to render him effective assistance in carrying it into practice.

Messrs. Dron & Lawson, Cranstonhill Tool Works, Glasgow.—This firm has long held a high reputation for its machine tools, and especially for everything connected with screwing apparatus. Long before machinery attained its present development, the taps and dies made by Dron & Lawson were known in almost every workshop in Scotland. Mr. Dron, one of the founders of the firm, and the grandfather of the present partners, made the tempering of the taps and dies his special work, and so careful was he about it that his name became a household word among engineers. His reputation was worthily maintained by his son, and now his grandsons are in possession, and they seem determined that no effort shall be wanting on their part to keep up the family name for excellence of workmanship.

Screwing apparatus still forms the speciality of the firm, and while great attention is paid to the making of taps and dies for hand work, they now turn out a great variety of screwing machines of all sorts and sizes, from ordinary machines for screwing bolts and nuts to those which screw both ends of a 15-inch steel tube at the same time, and to the special apparatus required in connection with the making of water-tube boilers. Patent roller tube expanders have long been specialities of the firm, and these have been of much use in aiding in the development of modern marine boilers. They also make excellent lathes of large size and other similar tools, and there are few engineering establishments in Scotland where the machine tools of Messrs. Dron & Lawson are not to be found in use.

Messrs. G. & A. Harvey, Albion Works, Woodville Street, Govan.—Another purely Glasgow firm which has long had a very high reputation for the excellence of its productions is that of Messrs. G. & A. Harvey, engineers, millwrights, and machine tool makers. Their productions include machine tools of all sizes, and for almost every purpose which is required in mechanical engineering, and there are few establishments in Scotland which have not some specimens of their work. Their self-acting lathes, railway wheel lathes, axle lathes, and slotting, planing, boring, and screwing machines are well known for the excellence of their design and workmanship. The firm is by no means resting on its reputation, but is keeping all its productions up to date with the latest improvements, and to meet the changing conditions of engineering. This is specially true of the large screwing machines, which are designed for screwing the ends of tubes of water-tube boilers, and of the boring and shaping machines required to machine the complicated castings of modern engines and appliances.

Messrs. John Hastie & Co., Ltd., Kilblain Engine Works, Greenock.—This firm was started in 1850 by Mr. John Hastie, formerly managing engineer to Messrs. Scott, Sinclair & Co. (the predecessors of Messrs. Scott & Co., of the present Greenock Foundry), and was continued by him till his death in 1860, when his two sons, William and John, took over the business, which was then at East End of Greenock. In 1875 they removed to their present premises, to which a considerable addition was made two years ago.

During the first thirty years the business of the firm was of a miscellaneous character, including considerable repairing work to marine and other engines, and a large trade in the construction of gunpowder machinery. Another speciality was a patent hydraulic engine, which automatically regulated the consumption of water according to the work it had to do. The introduction of gas engines, however, did away, in great measure, with the demand for hydraulic engines. For the last twenty years the firm has paid special attention to the construction of deck machinery for both steam and sailing vessels, having patented steam steering gear, hand steering gear, rudder brakes, and halyard winches, which now keep them fully employed. The chief markets to which the productions of the firm are sent are the chief shipbuilding yards in Great Britain and the Continent, and also to shipbuilders in China, Japan, and Australia.

Messrs. Loudon Brothers, Clyde Engineering Works, Johnstone.—Messrs. Loudon Brothers are makers of special and general machine tools for engineers, boiler makers, shipbuilders, and railway companies, both for home and export. They are also contractors to the Admiralty. About fifteen years ago they purchased the works and business of Messrs. A. Macarthur & Son, Johnstone, and these have been greatly extended to meet the increasing demand for their manufactures. Amongst their specialities are horizontal boring, tapping, and studding machines, vertical and horizontal planing machines, slotting machines, radial drilling and tapping machines, special surfacing and boring lathes, and other machines suitable for the heaviest class of engineering work.

They have recently built commodious premises in Glasgow (corner of West Campbell Street and Cadogan Street), consisting of offices, warehouse, and showrooms, where they exhibit a large number of machine tools and labour-saving appliances.

Messrs. John Lang & Sons, Johnstone.—This firm was established in 1874. A few years' trial was given to the existing condition of the trade under which toolmakers undertook to make lathes, planes, drills, shapers, as well as specially designed tools to suit customers' requirements. Realising, after five years' experience, the disadvantages of the system, the firm decided to concentrate their energy and attention on the systematic manufacture of lathes as their leading speciality.

Among the first special machines put down to perfect their lathes was a universal automatic gem cutter. Machine cut wheels were found to be so advantageous that they decided to cut every wheel and rack which left their works. They claim to be the first firm of toolmakers in this country which adopted this as a system. At present the firm has over two dozen machines cutting spur, bevel, worm wheels, and racks for the trade generally, as well as for their own requirements. Owing to the steady growth of their business the Messrs. Lang have found it necessary to secure about fifteen acres of ground adjacent to their present works. A railway siding is in progress for convenience in handling raw materials. A new foundry, 250 feet by 150 feet, has

recently been erected. It is fitted with electric cranes, electric light, gas furnace for stoves, moulding machines, and all up-to-date appliances. About 450 men are employed in the works. The Messrs. Lang find their chief market at home, where first-class lathes have been in demand for many years, but they also send a good many of their specialities to the Continent and the colonies. The members of the firm take pleasure in showing visitors around their works at all times, and to engineers the visit is generally an interesting one, as their works are fitted throughout with the most modern machine tools available.

Messrs. John M'Dowall & Sons, Walkinshaw Foundry, Johnstone. —Amongst the pioneers of wood working engineers this firm occupies a prominent position. The business was established in 1823 by the late Mr. John M'Dowall, father of the present senior partner, Colonel H. I. M'Dowall, and since then has taken a leading part in the development of this branch of engineering industry.

The late Mr. M'Dowall was born in Johnstone in 1796, and served his apprenticeship as a mechanic in one of the spinning mills in his native town. He commenced business on his own account in 1823, and by his great abilities as an engineer and inventor soon took a prominent position in the trade. One of Mr. M'Dowall's inventions—the steam saw frame—earned a great reputation, and in the early fifties it was largely adopted by the Government for the various arsenals and dockyards. Mr. M'Dowall died in 1857, and from that time till 1875 the business was carried on by trustees and managers. In that year the late Mr. Daniel M'Dowall became proprietor, and was joined a few years afterwards by his brother, Colonel H. I. M'Dowall, and later on by Mr. James Barr in 1885. Mr. Daniel M'Dowall died in 1892, and since then the business has been carried on by Colonel M'Dowall and Mr. Barr.

To give an idea of the great variety of the work carried on by the firm, it is sufficient to mention that it manufactures over three hundred distinct types of machines, many of which are made in quite a number of sizes. We must refer to the illustrated catalogue issued by the firm for details of the different kinds of machines. It contains machines which are capable of reducing the largest logs or trees to any size of scantling required.

The manufactures of the firm have been, and are continually being, sent to all parts of the world, with the exception of the United States of America, the excessive tariff of which is quite prohibitive. Machines of the larger type are sent to the timber producing countries of Burmah, Siam, Borneo, Straits Settlements, Queensland, Western Australia, New Zealand, etc., from which countries the firm continually receives orders for large plants, including engines, boilers, gearing, etc. The firm has generally orders on hand for the British and foreign Governments, while in the home trade its name has a reputation second to none amongst the leading shipbuilders, sawmillers, and wood workers of all classes.

The works, which afford employment to over two hundred men, cover two acres of ground, almost every portion of which is occupied by buildings of two or three floors. The firm has twelve machines in the present Glasgow Exhibition, and no doubt a visit to their stall will

prove of great interest to engineers, as well as to those directly connected with the wood working industry.

Messrs. Alex. Matheson & Sons, Ltd., Saracen Tool Works, East Campbell Street, Glasgow.—This well-known Glasgow firm has been distinguished for three generations for the excellence of its hand tools of all kinds which are used in the mechanical trades and for the smaller sizes of machine tools.

Messrs. A. & P. M'Onie, Cessnock Engine Works, Govan.—This is a new firm which has undertaken the manufacture of shipyard and hydraulic plant of all kinds, and already its productions are favourably known. It seems likely to sustain worthily the well-known engineering Glasgow name which it bears.

Messrs. G. & S. M'Onie, Ladyburn Foundry, Greenock.—This firm was started in 1870 by the present partners, and their present premises, which are most commodious, were built in 1885. They carry on the business of ironfounders and general engineers. For the past twenty-two years they have made a speciality of anchor windlasses and warping capstans, both hand and steam power, and they supply them to shipbuilders all over this country and on the Continent. They are also makers of watertight bulkhead doors. A noteworthy fact in the history of this firm is that during the thirty years of its existence no employee has ever lost life or limb, and no fire has ever occurred in the premises.

Messrs. Hugh Smith & Co., Possil Engine Works, Glasgow, manufacture machine tools of all kinds for boilermakers and shipbuilders, including bending, punching, shearing, planing, riveting, and drilling machines. Also hydraulic plant for docks, railways, etc., and heavy plant for iron and steel works.

Messrs. Smith Brothers & Co., Kingston Engine Works, Glasgow, are makers of shipbuilders' and boilermakers' machinery, and produce all that is required for the heaviest work. They are on the Admiralty list, and are contractors to the British and foreign Governments.

Messrs. Sharp, Stewart & Co., Ltd., Atlas Works, Springburn.—In addition to locomotives, this firm manufactures all kinds of high-class machine tools. (See page 68.)

Messrs. L. Sterne & Co., Ltd., The Crown Iron Works, North Woodside Road, Glasgow.—This business was established in 1860 for the manufacture of spiral and railway buffer springs, and this department is still continued. Thereafter the business of emery wheel and emery grinding machines was added, the firm being the sole makers of the famed "Consolidated" emery wheel, "Crown" brand. The firm is the sole makers in Great Britain of the well-known De La Vergne refrigerating machines, and its productions in this department are at work all over the globe.

The spiral springs and emery wheels made by the firm are used in almost all the engineering and railway works in this country, and it also manufactures largely for continental arsenals, as well as for Australian colonies and foreign countries.

Messrs. Alex. Chaplin & Co., Cranstonhill Engine Works, Govan, is a firm of long standing and well known in the engineering world for its steam cranes, excavators, launch engines, etc.

Messrs. Napier Brothers, Ltd., Hydepark Street, Glasgow, are patentees and manufacturers of high-class windlasses, capstans, and

steering gears, which have been fitted to many of the ships of the British and foreign navies, as well as to those of the most important lines in the mercantile service. They also manufacture a number of other specialities, and among them devote great attention to the accurate cutting of teeth in spur, bevel, and worm wheels.

Messrs. George Russell & Co., Motherwell.—The works of Messrs. George Russell & Co. were founded in 1865, and their principal manufacture has always been cranes of all types and sizes, which have been supplied to harbours and docks in all parts of the world. On the quays of the river Clyde, from Glasgow to Ardrossan, there are upwards of sixty steam travelling cranes, built by this firm, varying in size from three tons at 25 feet to twenty-five tons at 74 feet radius of jib, the latter being twenty-five times the size of the former, so that there is a great range in dimensions and weight. Quite recently they have constructed for the Mersey Dock Board two very notable and powerful cranes. One is at the Cunarder Graving Dock, and is self-propelling, on rails of 25 feet gauge, with a derricking jib 84 feet long. It lifts forty tons at a radius of 78 feet, and is fitted with two pairs of their patent hydraulic double acting engines. Its total weight is three hundred tons. The other crane is afloat, carried on a twin screw barge. It lifts fifty tons at 64 feet radius through a vertical height of 105 feet. The radius of jib is variable from 40 to 75 feet, and it revolves the complete circle.

They have also made for various foreign Governments a number of sets of their patent sheer legs, in which the main screw is inside the back leg. Some of these have been fitted in steamers for lifting guns and heavy material up to sixty tons from the quay or a vessel alongside to the main hold and *vice versa*. Overhead travelling cranes operated by steam, electricity, or hand power are also designed and constructed in these works. The firm has patented an arrangement of rope driver for overhead cranes, which obviates reverse bends in the rope, lessens the power required, and makes the driving rope last much longer.

Messrs. Thomas Shanks & Co., Johnstone.—This firm has long been known for the manufacture of the heaviest class of machine tools used chiefly by marine engineers, armour plate makers, and in steel works.

It was founded about seventy years ago by the late Mr. Thomas Shanks. Thirty-six years ago the present head of the firm, Mr. William Shanks, joined his father, and in 1883, when the latter retired from the business, Mr. Joseph Barrow joined Mr. Shanks. These are the present partners.

The principal manufactures of the firm are large lathes and planing machines, horizontal and vertical planers for marine engines, and armour plate planing machines for steel works. Specimens of these are to be found in almost all the large establishments in this country, and in the large steel works both in this country and on the Continent. The firm has also been largely patronised by the British and continental Governments and by those of China and Japan.

Messrs. John Wilson & Sons, Vulcan Works, Johnstone, successors to Messrs. J. & W. Weems, make machinery for covering cables with lead, hydraulic pipe presses, rolling machinery for sheet lead, steam heated air-drying machinery, etc.

ELECTRICAL ENGINEERING.

Messrs. Kelvin & White, 16, 18, and 20 Cambridge Street, Glasgow, Instrument Makers and Electrical Engineers.—This business was founded in 1849 by the late Mr. James White. The work at that time consisted principally in the manufacture of philosophical, mathematical, and optical instruments, and the care and ingenuity with which these were made very soon brought Mr. White to the front rank of instrument makers. It was not till about the year 1854 that electrical instrument making was entered on, and then only in the form of experimental apparatus for class demonstration. It is in this capacity that Professor Sir William Thomson, now Lord Kelvin, came to be associated with Mr. White, and got to know of his special aptitude for carrying out work of this class. It was very natural, therefore, that when Lord Kelvin, as adviser to the Atlantic Telegraph Co., found that the ordinary land instruments were quite useless for submarine cable work, and having designed the mirror galvanometer to overcome the difficulty, he should go to Mr. White to have this instrument made. The first two instruments made were a perfect success, and by their aid speaking across the Atlantic was rendered possible. From that time may be dated Lord Kelvin's permanent attachment to Mr. White, and from then till the present time Mr. White and his successors have been the mechanicians who have constructed the various instruments and apparatus devised by Lord Kelvin.

From February, 1858, till November, 1900, Lord Kelvin has taken out no less than fifty-one patents, and a glance at the classified list of these, as arranged by Dr. Magnus Maclean, and published in the Proceedings of the Philosophical Society of Glasgow, 1897-98, shows the extent of this work carried out by James White; and the rate at which the business has extended. In 1884 the works were removed to the present premises in Cambridge Street, and in 1892, and again this year, the works had to be extended. At present there are over four hundred persons employed.

The various kinds of instruments and apparatus manufactured are as follows:—Optical and mathematical apparatus, instruments for submarine telegraphy, instruments for electric lighting and tramways, standard electric balances and electrostatic voltmeters for laboratory use, switchboards and switch gear for electric lighting and tramways, navigational instruments.

Messrs. Mavor & Coulson, Ltd., 47 King Street, Mile-End, Glasgow.—The works of this firm have been erected on ground purchased from Messrs. Clark & Co., Limited, who formerly used the site for their Mile-End Thread Works, and are easily accessible both by rail and tramcar. The company's manufacturing business was formerly carried on in their premises in Orr Street, Bridgeton, which premises, together with the machine tools there, were held on lease. During the company's tenancy of these works patterns were developed and standardised, and methods of production systematised. On the expiry of their lease the company was therefore in a singularly favourable position to undertake the design and equipment of a new factory for their specialities in electrical engineering and accessories. The directors have combined with this an intimate knowledge of the most recent American and

continental practice, and the result has been the building and equipping of a factory which is the most important of its kind in Scotland, and in facilities for the rapid, economical, and accurate production of high-class electrical machinery is not surpassed by the best and most recent factories in the country. A special feature of interest in the establishment is the method of administration and supervision of the factory, and the record of the cost of production. This and the American tools employed bring a great many visitors to see the place.

An excellent illustrated catalogue is published by the firm which fully describes the works, the appliances, and productions, and reference must be made to that for details. It may be noted, however, that the machine and erecting shops are 160 feet long by 75 feet wide, covered by a single span steel roof, glazed all over, and that the other departments of the works are carried on in suitable buildings driven by electric motors from the generating station in the north-east corner of the works. A special feature of the factory is the equipment of a tool room, where special tools, jigs, and other appliances for accurate and rapid production are manufactured by a staff specially devoted to this work.

While the excellence of the company's manufactures have secured for it a large share of English and foreign work and important contracts for Government departments, municipalities, and public bodies, the directors, in the design and equipment of the new factory, have kept prominently in view the large and increasing demand for electric machinery, especially for power purposes in this district, and they believe that there is no more promising field in the whole world for the introduction of the applications of electricity to industrial purposes than that embraced by a circle of ten miles' radius round the city of Glasgow; and they hope that the existence of their works will give an important stimulus to the adoption of electrical plant in Scottish industries, and bring them more in line with those of America and the Continent.

Holland House Electrical Manufacturing Co., Ltd.—The offices and works of this firm are at 9 Holland Place, Glasgow. They are designers and manufacturers of artistic electric light fittings and of switchboard apparatus for municipal and other supply stations, as well as for private plants. The company uses almost exclusively hand-hammered ornamental metal work in the manufacture of their electroliers and other decorative fittings, and employ a number of local artisans who are trained to this class of work.

In the switch department main and branch switches and switchboards of all sizes are made, one of the longest being sets of feeder panel switchboards to the design of the Corporation engineer, Mr. W. A. Chamen, for the electric supply stations at Port-Dundas and St. Andrew's Cross, Glasgow. The company has extensive showrooms, where a good selection of their manufactures is on view.

Messrs. Mechan & Sons, Scotstoun Iron Works, Glasgow.—This firm was established in 1862 by ex-Councillor Arthur Mechan, and until recently carried on business at Cranstonhill, Glasgow.

Though originally contractors for the fitting out of merchant ships, their business has undergone considerable change, and, in keeping abreast of the times, has been almost entirely transformed. With the

advance in the application of electricity to uses on board ship, Messrs. Mechan have laid themselves out to meet the demand. They started by making electrical apparatus, such as electric call bells, etc., for ships' use in 1886, but in the spring of 1899 a separate department was constituted to undertake solely the electrical work of the business.

During their fourteen years of electrical experience Messrs. Mechan have fitted out for the British, Japanese, American, and other navies ships with electric call bells, voice pipes, telephones, electric lighting, telegraphs, ventilation, watertight doors, ash ejectors, searchlights, etc. In connection with ventilation they have recently completed the Japanese battleship "Mikasa," in which electrically driven fans of the firm's own special design and manufacture were used in conjunction with the usual trunk system. The firm is at present engaged on the ventilation of H.M.S. "Russell," the first ship to use one hundred volts in His Majesty's service. For the Admiralty alone the firm makes some thousands of switches, distributing and section boxes for electric lighting, firing keys, etc. They are also makers of switchboards for public supply companies, and have recently completed the bus bar work for the Electricity and Tramway Departments of the Glasgow Corporation, also street service boxes for electric lighting and telephone supply use.

For a notice of the general engineering work done by Messrs. Mechan see page 56. There is a considerable number of electrical engineers in Glasgow who contract for lighting and supply of motive power, but, for the most part, they do not make the appliances and machines, but purchase them from manufacturers in different parts of this country or on the Continent and America. Several of the mechanical engineering firms are directing their attention to the production of high-speed engines of different types suitable for purposes connected with electrical engineering.

GENERAL MECHANICAL ENGINEERING.

Messrs. Alley & Maclellan, Sentinel Works, Polmadie Road, Glasgow.—This firm, which has special claims to notice on account of the excellence and variety of its productions, was established over thirty-two years ago in London Road, but five years later, on account of the development of its business, it was transferred to its present quarters at Polmadie. By a gradual process of extension the works now cover nearly 12 acres of ground, every part of which is utilised to the greatest possible advantage.

The various departments are arranged in methodical order, and are made to follow one another in natural sequence, so that time is economised and efficiency ensured. The general and drawing offices are commodious and well equipped, and have connections by telephone not only with the different parts of the works, but also with the Exchange system of Glasgow. Well equipped pattern shops and brass and iron foundries give all the necessary facilities for casting required by the firm, while the large machine shop is fitted with all the latest appliances for economical production of work. The erecting shop is a lofty building 80 feet in height and 150 feet in length, and is furnished with all the necessary machinery and lifting apparatus. A spacious

gallery at the north end accommodates the tinsmiths and iron plate workers. The testing shop, where under the most exacting conditions and the highest mechanical skill, high-speed engines, steering gears, safety valves, and the other productions of the firm are tested previous to being passed for delivery, is a most interesting part of the establishment.

Among these productions special prominence must be given to the "Sentinel" high-speed engine, which is made in many sizes, both of simple and compound design. These engines are compact, easily dismantled for repair, and remarkably free from vibration, and are much used for central electric supply stations, as well as for other high-class and economical installations. The "Sentinel" patent horizontal steam steering engine, manufactured by the firm, has enjoyed a gratifying measure of support from the leading Scottish and North of England shipbuilders. The ash hoists of the firm are much used both in the British and foreign navies. Messrs. Alley & MacLellan have always made the manufacture of valves a leading feature of their business. They are made for all purposes and for all pressures up to 200 lbs. per square inch. A curious feature in the establishment is the shipbuilding establishment, from which, notwithstanding all the work that has been done, no launch has ever taken place, as the vessels built are for foreign river navigation, and are sent out in pieces to their destinations. They include side-paddle steamers, tugs, water boats, salvage boats, steam lighters and hoppers, horse ferries, cargo barges, crane barges, pontoons, and various other forms. Messrs. Alley & MacLellan have also built several floating piers and floating docks, a class of work for which they have received high commendation from eminent marine authorities. Altogether the establishment is one of the most interesting, from an engineering point of view, in the district.

Messrs. Andrew Barclay, Sons, & Co., Ltd., Caledonia Works, Kilmarnock. The works of this company are old-established, having been started in 1840 by the late Mr. Andrew Barclay, and have been carried on for the manufacture of locomotives, steam engines, pumping machinery, etc., up to the present date. They give employment to about five hundred men, and cover an area of about 4½ acres, the latest extension being a boilermaking shop, 200 feet long by 52 feet wide, and a boiler smithy and locomotive tank shop 140 feet long by 40 feet wide. A general erecting shop, 210 feet long by 52½ feet wide, is also in course of completion. The present company, in whose hands the works have been since 1892, have modernised the works and added new plant during the past five years, and they have especially developed the locomotive department. The works have been fitted throughout with the most improved modern appliances. Electricity has been adopted throughout the works for driving and lighting purposes, and a central station with triple-expansion engine and 200 h.p. in dynamos has been equipped to generate and distribute power at 210 volts pressure to the various overhead cranes, shafting, &c. Hydraulic and compressed air power on the newest lines are used in the boiler department.

The principal output of the firm during the last few years has been locomotives, chiefly with side and saddle tanks, with cylinders up to 18 inches diameter, and for working steam pressures up to 180 lbs. per

square inch. The engines are, for the most part, of the usual British design, with the "Stephenson" link motion, but are occasionally fitted with "Walchaerts" or "Joy's" valve gear. The company has a long standing and good reputation for locomotives of both tank and tender types. They are chiefly for home markets, but a good many are sent to South America, the West Indies, China, Egypt, and other countries. Locomotives with cranes supported over their centre, direct from the frames, and free from the boiler, are a special product of this firm, and a large number are turned out for works, shipyards, and other purposes.

The manufacture of winding engines is an important feature of the works, and they are to be found in many of the most important collieries in England and Scotland. Large pumping engines have always been a speciality of the firm, and some of the recent large sizes of pumps turned out have 30-inch rams with 13 feet strokes. Waterworks plant of all sizes is made by the company. Another speciality is the "Capell" fan, of which the firm is the sole manufacturers for Scotland and Ireland, and it has established itself as an excellent mine ventilator. Steam excavators for heavy earth cuttings are built at Caledonia Works, and some of the larger sizes, weighing as much as eighty tons each, did some record work in excavating and loading the heavy boulder clay at the north end of the Forth Bridge during its construction. Many blowing engines and air compressors have been built by this firm. A number of the iron works in Cumberland have been fitted with blowing engines, and some have also been erected, and are working in India and other countries.

Messrs. Crow, Harvey & Co., Park Grove Iron Works, Glasgow (successors to Robert Harvey & Co.), manufacture steel and iron works plant, reversing mill engines, hydraulic machine tools, as well as general engineering work, and worthily maintain the reputation of the well-known firm it succeeded.

Messrs. John Cochrane & Co., Grahamston Engine Works, Barrhead.—These works were established in 1850 by the father of the present partners, and fourteen years ago the present new works were erected to meet the increasing demand for their manufactures. The works adjoin the Barrhead Railway Station, and they cover about 4½ acres. The shops have a floor area of 35,000 square feet, and are equipped with all the modern tools best suited for the work produced.

The principal manufactures of the firm are land engines, simple, compound, tandem, and quadruple, fitted with Corliss valve gears, and every equipment for economical working; winding engines for deep levels, steam or hydraulic reversing engines, steam or hydraulic brakes; pumping plants of every design to meet all classes of specifications; centrifugal pumping engines of large sizes for docks, sewage, and surface water; condensing plants (independent) to deal with any given quantity of steam, steam hammers with single or double standards from 1 cwt. to 10 tons, feed pumps of different designs, direct acting, duplex, flywheel, and geared.

The firm has recently executed work for the following:—The British Admiralty, dockyard engines; East London Waterworks, pumping engines, with all the necessary gear; West Ham Corporation, large centrifugal pumps, with direct acting compound engines; London

County Council, triple expansion pumping engines for sewage works; and large orders for mines in South Africa and West Australia.

Messrs. A. F. Craig & Co., Ltd., Caledonia Engine Works and Snowdown Works, Paisley.—These works were founded in 1868 by Mr. A. F. Craig, and are now one of the most important establishments in the West of Scotland. They are splendidly equipped and organised, and their productions are very varied. They include steam engines of all kinds, shafting, pulleys, and gearing, sugar refining machinery, oil refining machinery, oil plant, gas plant, hoists, paint, and chemical machinery, hydro-extractors and centrifugal machinery, and bleaching and dyeing machinery. The firm also makes portable and stationary cranes, air-compressing machines, hydraulic and screw presses, starch-making machines, and calendars.

A large business is also done in textile machinery of various kinds, especially those connected with the thread industry, of which Paisley is such an important centre. The firm specialises in the following:—Cropping machines of all types for woollen cloth, clipping machines, large Axminster shearing machines, velvet and rug shearing machines, and cloth finishing machinery. It also makes looms for tapestry.

The firm is also developing the manufacture of gas plant into an extensive trade. It has a branch in France and a London correspondent, and it sends its productions to all parts of the world.

Messrs. Fleming & Ferguson, Ltd., Phœnix Works, Paisley.—This firm is well known for its dredgers and marine engines, but it also makes a speciality of high-class pumping engines of the most powerful and economical type for water supply, irrigation, docks, sewage, drainage, etc., which are made in any size up to a duty of 600,000 foot-tons per hour. It has recently made triple expansion engines for the London County Council for Crossness Pumping Station, each engine being capable of pumping 2½ million gallons per hour.

Messrs. Bow, M'Lachlan & Co., Limited, Thistle Works, Paisley, chiefly manufacture marine engines, and make a speciality of steam steering gear and electrical engineering plant. Messrs. Hannah, Donald & Wilson, Abbey Works, Paisley, make a speciality of gas plant. Messrs. Campbell, Calderwood & Co., Soho Engine Works, Paisley, manufacture chiefly marine engines and sugar mill machinery. Messrs. Walter M'Gee & Sons, Paisley, devote themselves chiefly to textile machinery; and Messrs. Thomas Reid & Son, Paisley, to windlasses and steering gear.

Messrs. Mechan & Sons, Scotstoun Iron Works.—In addition to the special electrical work mentioned at page 52, Messrs. Mechan do a considerable amount of general engineering work, their new establishment at Scotstoun being fitted with a great variety of tools, all driven by electricity.

A special branch of their business is that of riveted steel pipes for water mains, etc. They have recently completed several miles for the Johannesburg water supply, their average output in this way being about thirty miles per annum. Tanks and other plant for gold extraction purposes are also specialities of the firm. A considerable number, averaging 30 to 40 feet diameter by 10 feet deep, has just been shipped to the Rand, and others are awaiting shipment. The firm has recently completed the steel flues for the tramway power station for the Glasgow Corporation.

A complete equipment of hydraulic and pneumatic riveting, caulking, and drilling tools is installed throughout the works, whieh, besides the electrical department, consist of departments for mechanical engineering, structural ironwork, brass foundry, copper work, etc. The number of men employed is not less than one thousand.

Messrs. Lamberton & Co., Coatbridge.—This firm is well known by iron and steel makers for the excellence of its productions in all that is requisite for the largest sizes of iron and steel plant. They are makers of the largest and most modern installations of machinery for the manufacture of steel, including plate, bar and rail mills, bloom and plate shears, hydraulic plant of all kinds. Their reversing bar and rail mill engines are first-class specimens of design and construction, and are highly efficient in their working. They also manufacture all kinds of colliery engines and machinery.

Messrs. Murray & Paterson, Ltd., Coatbank Engine Works, Coatbridge.—This firm was founded in 1868 for general engineering purposes. On Mr. Murray's decease in 1897 Mr. M'Gregor joined Mr. Paterson, and carried on the business under the firm's name. In 1899 it was formed into a limited liability company. In 1900 new works were built on the most modern lines, on a site close to the Whifflet Station on the Caledonian Railway, and are so designed that they can be gradually extended as the requirements of the business demand.

From the beginning the demands of surrounding works were such that the requirements of iron and steel works and collieries soon became the principal trade, and the number of guide mill engines, forge engines, large shingling steam hammers, shearing machines, and hot bar saws bearing their names bears ample testimony to the quality of their work.

Tube works plant has also been turned out, engines both for main driving and for hydraulic work, accumulators, tapping and screwing machines being almost always on hand, as well as winding and pumping engines for collieries. Tank locomotives for collieries and iron works are also made, and are always under construction or repair.

The home market has been the principal customer of the firm, but China, India, Burmah, Australia, Chili, and San Domingo have all contributed their share to the firm's prosperity.

The other mechanical engineering firms in the Coatbridge and Airdrie district doing work of the same kind for the most part as the two last named are Messrs. W. V. V. Legerwood & Co., Speedwell Iron Works, Coatbridge; Messrs. Gibb & Hogg, Messrs. Inglis & Hossock, Messrs. Martyn & Co., and the Airdrie Iron Company, Airdrie, all of which turn out large quantities of machinery of a very varied nature, chiefly, however, for collieries and iron and steel works. Messrs. Shearer & Pettigrew, Wishaw, are also well and favourably known for their colliery engines and machinery.

The Mirrlees Watson Company, Ltd., Glasgow.—This business was founded in 1840 by three brothers—Peter, William, and Andrew M'Onie—the original title of the firm being P. & W. M'Onie, Mr. Andrew M'Onie being engaged as works manager. Mr. William M'Onie retired from the firm in 1848, and Mr. James Buchanan Mirrlees joined with Mr. Peter M'Onie, the title of the firm becoming M'Onie & Mirrlees. Two years later Mr. Peter M'Onie died, and Mr. Mirrlees

took into partnership Mr. William Tait—although the firm still continued as M'Onie & Mirrlees until 1858, when the title was changed to Mirrlees & Tait. Under this title the firm continued for ten years, when, on the failing health of Mr. Tait, Mr. W. Renny Watson was taken into partnership, and the firm became Mirrlees, Tait & Watson. Soon after this Mr. Tait died, but the title of the firm remained the same until 1882. In this year Mr. R. A. Robertson and Mr. J. G. Hudson, who had been connected with the management for some time, were admitted as partners, and a change was then made, the title of the firm becoming Mirrlees, Watson & Co. Mr. Hudson retired in 1888, and Mr. W. J. Mirrlees, eldest son of Mr. J. B. Mirrlees, became a member of the firm.

In 1889 the business of the firm was amalgamated with the Yaryan Company (whose patent rights in their evaporators for the United Kingdom and British colonies the firm had secured two years previously). The new organisation under the Companies Act assumed the title of Mirrlees, Watson & Yaryan Company, Limited. In 1900 it was thought advisable to reconstruct the company, and this having been carried through, advantage was taken to adopt the shorter and more convenient title of the Mirrlees, Watson Company, Limited, under which name it now carries on its extensive home and foreign business. The management of the present company is in the hands of a board of directors, Mr. William Littlejohn Philip being managing director.

The general works of the company are situated in Scotland Street, South Side, and are substantially built, compact, and well lighted, the frontage to Scotland Street being about 350 feet. The ground area of the premises is about 17,400 square yards and the upper floors of the buildings give an additional area of about 7200 square yards.

The general offices, board room, and drawing office are large and commodious, the latter being exceptionally well lighted and fitted up with every convenience, including plant for photographing drawings by electric light, etc. The pattern shop, foundry, boiler shop, and joiners' shop are all fitted with the most improved appliances. The erecting shop is 200 feet by 82 feet and is divided into two bays, the roof, etc., being supported by a row of cast-iron columns down the centre. There are two overhead cranes with rope drive, each capable of lifting fifteen tons. The machine shop is supplied with a great variety of tools of all kinds, and many of the latest design, and the whole establishment is well designed for carrying out work economically.

Up to the year 1885 the output of the works consisted almost exclusively of machinery for the production, manufacture, and refining of sugar, of which they were the largest manufacturers in the country, and had a world-wide reputation. Since that date, however, this industry has been, through various causes, on the decline, and the company, although still largely engaged in the industry, have turned their attention to other branches of engineering, among which may be mentioned the following:—Evaporating machines for all purposes, distilling plants for fresh-water supply, condensing plants, evaporative condensers, air and circulating pumps, steam, electric, or belt driven; high-speed engines for electric lighting, etc.; conveyers and elevators for coal, etc. In this connection it may be mentioned that this com- is at the present time supplying the whole of the condensing

plant and coal conveyers for the Glasgow Corporation Tramway Electric Generating Station at Pinkston.

With regard to distilling plants, a large number of these have been erected at various points on the Red Sea, and one at Mombasa for the Uganda Railway. Evaporators for all sorts of purposes have been supplied to various clients in North and South Russia, also France and Germany, for a variety of purposes too numerous to mention here, not excepting a considerable number to paper mills in this country in connection with soda recovery.

For some remarks on the markets to which this firm sends its sugar machinery see under the heading "Sugar Machinery," page 63.

Messrs. R. G. Ross & Son, Greenhead Engine Works, Glasgow. —This firm was long known under the designation of Messrs. Glen & Ross. It was founded in 1856, when Mr. Rigby, the inventor of the well-known steam hammer, transferred to it all his rights under his patent. From that date till 1890 the business was carried on by the two partners. At the latter date Mr. Glen retired from business, and Mr. Ross assumed as partner his son, James MacEwan Ross, and the firm took the designation of R. G. Ross & Son. It still continues the manufacture of steam hammers, of which over fifteen hundred which have been made by the firm are in use. They have been awarded the highest award wherever exhibited, and are too well known to engineers in all parts of the world to require any detailed description.

While the manufacture of steam hammers has been the staple trade of the firm since it was founded, during recent years it has added that of many special tools and appliances, the majority of which are the inventions of the junior partner. Among those may be mentioned pneumatic or steam caulking, chipping, dressing, and planishing tools, which supersede all other processes in every essential point, and deliver from 8000 to 10,000 strokes per minute, with a pressure of air or steam from 40 to 60 lbs. per square inch; a machine for dressing granite, which will do the work of fifteen to twenty men working by hand; a patent drill and patent speed reducing and increasing gear. This latter is specially adapted for coupling to electric motors or other type of high-speed machinery, from which the speed can be reduced practically without limit. With worm gear the loss from friction is enormous, while the same ratio of reduction may be attained by this gear with a loss of about 5 per cent. in transmission. The firm also manufactures the pneumatic stay riveter, designed and patented by Mr. H. D. Earle, works manager, L. and N.-W. Railway, Crewe, who, having in use some of the patent caulking tools made by the firm, devised an ingenious application of one of them for riveting the copper stays of locomotive fire boxes. This tool has now been in use for a considerable time, and has given the greatest satisfaction, both as regards efficiency and durability. Each tool is capable of doing the work of five or six men when closing the stays by hand, and the work done is of the highest character. The firm purchased the patent rights from Mr. Earle, and have supplied a number of these tools to railway companies and locomotive firms both at home and abroad.

The productions of the firm go to all parts of the world, and "Rigby's Patent" steam hammers have been supplied to the British Admiralty and to many foreign and colonial Governments, in addition to many of the chief engineering establishments at home.

Messrs. A. & W. Smith & Co., Ltd., Eglinton Engine Works, Glasgow.—This is an old-established Glasgow firm which does general engineering work, including shipyard machinery. It makes a speciality of sugar making machinery. (See page 66.)

Messrs. D. Stewart & Co., London Road Works, Glasgow.—The present firm of D. Stewart & Co., Ltd., engineers and boilermakers, was founded by Mr. Duncan Stewart, the present managing director, in 1864, under the style of Duncan Stewart & Co. Like the majority of old established works in Glasgow, its beginnings were small, the number of men employed during the first year being about 80, and the works covering an area of 3600 square feet. The firm now gives employment to from 700 to 800 men, and the premises have lengthy frontages to Summer Street, London Road, and William Street, and cover an area of 60,000 square feet. The buildings include a suite of offices for private, commercial, and drawing purposes, lofty and well-lit pattern shop, heavy machine shop, smiths' shop, boiler shop, brass foundry, and a large erecting shop. The light machine work is done in galleries overlooking the heavy machine shop and fitting shop.

The principal classes of work produced by this firm are slow speed steam engines, sugar mills, sugar factory and refining plant, bleaching, dyeing, printing, and finishing plant, hydraulic machinery, steel works plant, gold dredging plant.

The chief purposes for which the slow speed engines are made by this firm are driving jute and cotton spinning factories in this country and in India, electric lighting, and traction work at home and abroad. The types most recommended for spinning factories are horizontal or vertical triple-expansion, of which this firm has made several capable of indicating up to 3000 horse power. Among others may be mentioned the engines for Chandernagore Mills, of Messrs. Ogilvy, Gillanders & Co., and those for Messrs. W. Duncan & Co., and the Anglo-Indian Jute Mills, Ltd. The new engines of the Glasgow Cotton Spinning Co. were also supplied by Messrs. D. Stewart & Co., and are capable of indicating 1400 horse power.

For electric lighting and traction work the side by side compound or cross compound type is most in favour, as these engines have the largest range of economical working, and this firm has recently completed two cross compound engines to indicate up to 1000 horse power for the new electric tramway station of the Glasgow Corporation. Four similar engines have recently been despatched to Western Australia, and others of different sizes to Barcelona, Kingstown, Jamaica, and Brazil. The firm is at present executing an important contract for the electric lighting department of the Corporation of Dublin.

Rolling mill engines up to 12,000 indicated horse power have been constructed by this firm for several of the most important steel works in the country, including Messrs. William Beardmore & Co., Parkhead; Messrs. David Colville & Sons, Motherwell; Glasgow Iron and Steel Co., Wishaw; Lanarkshire Steel Co., Motherwell; and the Weardale Steel Co., Sunderland. These engines are of the high pressure two-cylinder type, suitable for rapid starting and reversing.

In the department devoted to hydraulic machinery Messrs. D. Stewart & Co. have designed a large forging press of 12,500 tons

capacity for Messrs. William Beardmore & Co., of Parkhead Forge, and have made two others of 6000 and 3000 tons respectively for the ordnance and armour plate departments of the same firm. Hydraulic machinery of different kinds has been made for firms in this country and abroad. The steel works plant made by this firm comprises rolling mills, shearing machines, roller racks, and, in short, all the complicated gear required for the equipment of large steel works. They have recently completed one of the largest plants of this kind for the Lanarkshire Steel Co. A comparatively new development has been the manufacture of gold dredging machinery for use in the rivers of New Zealand, several plants having been constructed within the last few months.

The most important contracts this firm has on hand are the Dublin engines already mentioned, and the complete pumping plant for the Partick Pumping Station of the Glasgow Corporation Sewage Works. For other work done by this firm see p. 65.

Messrs. D. & J. Tullis, Ltd., Kilbowie Iron Works, near Glasgow.—The original firm of D. & J. Tullis, consisting of two partners, started business as engineers in 1891, the works being then situated in Parkhead. They devoted themselves to the manufacture of laundry machinery more particularly, and by dint of much study and thoroughly practical and up-to-date appliances, they are now known as among the largest and best known manufacturers of that class of machinery.

In 1894 it was found that the old works at Parkhead could not meet the ever increasing demand for machinery, and the establishment was removed to new buildings at Kilbowie, and again to enable these premises to be considerably increased the partners decided to reconstitute the company and open the share list to the public. This was done in 1898.

The present works, offices, foundry, and stores, etc., cover an area of about 4 acres. The arrangement of the shops has been altered periodically, and at present the equipment and arrangement of tools are admirably adapted to the class of work done by the firm. In the foundry, which is quite a new building, the arrangement is all that could be desired. In addition to supplying the requirements of the firm, high-class castings of all kinds are made for the engineers and machine makers of Glasgow and neighbourhood. Branch offices have been established, and permanent staffs appointed, in Manchester, London, Bombay, Cape Town, Spain, Russia, and Australia.

Among the principal manufactures of Messrs. Tullis are their well-known and appreciated Corliss valve engines, a large number of which have been built for manufacturers throughout the country. These engines, on account of their perfect cut-off, are well adapted for electric power generation, or for use in factories where the power required varies considerably through machines being used intermittently.

The firm still pays special attention to laundry machinery, for a notice of which see p. 85. Among its other specialities are leather tanning and dressing machinery, belt stretchers, water tanks, boilers, etc., in connection with which they have recently established a large continental and colonial connection.

Messrs. Watson, Laidlaw & Co., Dundas Street (South), Glasgow.—This business was originated in 1883 to carry on primarily the manu-

facture of the "Weston" centrifugal, previously in the hands of Messrs. Mirrlees, Watson & Co., who possessed the sole British and colonial rights of the "Weston" patents. Messrs. Watson, Laidlaw & Co. arranged with Mirrlees, Watson & Co. to take over all drawings, patterns, patent rights, etc., relating to the "Weston" centrifugal, and, while carrying on a general engineering business, they have made this machine a special article of manufacture.

The buildings are arranged for the convenient manufacture of medium and light work, the main building consisting of two large open bays surrounded by two storeys of wide galleries, light turning and finishing being done in the galleries, heavy turning below them, and erecting in the open bays. The boilers, pattern shop, and pattern store are in a separate building of modern fireproof construction, and the drawing office and counting-house are in another building conveniently situated in relation to the works. Besides the department mentioned above, the works include a blacksmith shop, brass foundry, tinsmith shop, and joiner shop, as well as suitable stores for raw material and finished work.

As already mentioned, the "Weston" centrifugal in its many forms is the principal production of the firm. This machine consists of a perforated cylinder and drum which is rapidly rotated so as to subject its contents to considerable centrifugal force. It is largely used for drying crystals, the centrifugal force throwing off the mother liquor, which escapes through the perforated shell of the cylinder (or basket, as it is generally called). These machines are principally used in the drying of sugar, but also find an important place in all manufacturing processes where crystals or other granular substances have to be washed or dried, replacing the older process of draining in a cheap and efficient manner. (See under heading "Sugar Machinery," p. 64.)

The same machines, but of slightly different construction, are used for the drying of all kinds of textile or fibrous material, and are of the greatest value in bleach houses, dye houses, laundries, etc. Another variety is made with a solid basket or drum, and is used for depositing solids held in liquid suspension, such as starch or yeast, or for separating liquids of different specific gravities.

From this last Messrs. Watson, Laidlaw & Co. have developed their "Princess" and "Victoria" cream separators, which separate cream from milk mechanically and efficiently. These vary in size from the 10 gallon per hour hand power domestic machine to the 150 gallon per hour steam turbine-driver machine for factory use. They are light and small, calling for considerable skill and care in their manufacture, owing to the very high speed at which they have to run, and are made in large numbers on the most modern factory system, thus ensuring great accuracy and perfect interchangeability of parts.

The chief interest in the modern "Weston" centrifugal is the method employed in driving it, and Messrs. Watson, Laidlaw & Co. draw special attention to their patent water-driven centrifugals, which dispense with belting or gearing—a Pelton wheel fastened direct on the spindle, and a pressure pump with suitable piping forming a ready and convenient means of driving which possesses many advantages.

Besides the foregoing specialities this firm makes all the accessory machinery required in the use of centrifugals. They also manufacture

engines or any light work which demands repetition of many pieces, all their arrangements being made for the economical reproduction of individual pieces such as, for instance, are entailed in the manufacture of projectiles. Those interested in centrifugals or hydro-extractors are recommended to visit the complete exhibit which this firm has in the Machinery Hall of the Glasgow International Exhibition, and also any of the modern public wash-houses which the Glasgow Corporation have fitted with their patent water-driven hydro-extractors.

The centrifugals made by this firm find their way into every country where sugar is grown or refined, and are largely used for chemicals, etc., in Great Britain. Their hydro-extractors are used all over Great Britain, and considerable numbers are sent to the Continent of Europe. Their cream separators have a comparatively small sale in England, and a smaller in Scotland, but find a good market in Germany and other continental countries, as well as in Australasia.

SUGAR MACHINERY.

Some of the establishments mentioned in the preceding section devote considerable attention to sugar machinery. For convenience of reference they are again mentioned in the present section, along with a few others which make sugar machinery the chief part of their work.

Messrs. Blake, Barclay & Co., Victoria Works, Greenock.—This firm was established in 1858, in the premises formerly occupied George Oughterson & Co., Hillend Works, and some years subsequently the business was transferred to more commodious and new premises adjacent, which have since been known by the name of Victoria Works.

The works comprise turning, fitting, pattern, and smith shops, with all the accessories of an engineering establishment, and there has lately been added a wrought-iron department, with the installation of the necessary rolls and other machines for the economical handling of structural and light girder work, and under ordinary conditions 150 men can find employment therein.

Since the founding of the firm sugar refining machinery has been the staple product, and continues to be, but since the gradual extinction of the sugar trade the firm has taken up the manufacture of all kinds of elevating and conveying plant and all kinds of transport appliances and machinery, especially for gasworks. In addition to the home market the firm has sent its productions to Australia, New Zealand, China, and Japan, with an occasional excursion into other countries where sugar refining machinery was in demand.

Messrs. Blair, Campbell & Maclean, Scotland Street Copper Works, Glasgow, are makers of all the copper work required for sugar refineries. (See p. 41.)

The Mirrlees Watson Company, Limited, Scotland Street, Glasgow. —For a description of the works of this firm and a sketch of their chief productions see under heading "General Mechanical Engineering," p. 57.

With regard to the markets to which their sugar machinery is sent it is well known that through causes into which we cannot at present enter the West Indian market for sugar machinery, which at one time was the principal, has now practically ceased, and only a small proportion of the machinery manufactured by this company finds its way

to what was at one time its best market. To counterbalance this, however, a very large quantity of sugar machinery is now sent to Mexico and the Argentine Republic. At the present time these may be said to be the principal markets in the West. There is also a fairly good market in the Central American States, Columbian States, and Peru. Cuba, also, is showing signs of revival, and may yet prove a fairly good market if it is not turned into an American preserve in a similar way to Honolulu. In the East, Java offers a good field; also Natal, Mauritius, Southern India, and, to go further afield, Queensland and the Fiji Islands. Honolulu, once a good market, is now practically closed to British manufactures. Coming nearer home, some large factories are found in the south of Spain, with which business is done, and it is to be expected that the Egyptian market may yet prove a lucrative one for the sugar machinery industry.

Messrs. Watson, Laidlaw & Co., Dundas Street (South), Glasgow.—The works of this firm, which may be considered an offshoot of the preceding one, have been described at p. 61, and some of their productions have been noted.

As explained, the most important of these is the "Weston" centrifugal in its many forms. These are so numerous that we can only refer to the illustrated catalogue published by the firm with special reference to the sugar industry. It contains a great variety of designs not only for centrifugals, but also for many other of the appliances used in the manufacture of sugar, and all interested will find its perusal very instructive. In addition to the very complete exhibit in the Machinery Hall of the Glasgow Exhibition, the firm also undertakes to introduce visitors, by arrangement, to a sugar refinery in Greenock where their patent water-driven centrifugals can be seen curing sugar.

Messrs. M'Onie, Harvey & Co., Ltd., Scotland Street Engine Works, Glasgow.—The history of this firm, and of those who have been connected with it, takes us back to the early days of the making of sugar machinery in Glasgow. About the year 1785 James Cook started a small workshop near St. Enoch's Square (now about the centre of Glasgow) as blacksmith, millwright, and engineer. In the face of many disadvantages the business prospered, and in a few years James Cook became known as a good engineer, the manufacture of sugar mills being included amongst the other branches of his trade. The business so increased that new and larger premises had to be provided, and about the year 1800 he removed to what was then open country, on the south side of the river Clyde, where he built what was in these days considered very large works, which went by the name of "Cook's Works," and in the trade were known as the "College," from the fact that many of the best workmen and engineers got their training there in these early days.

The introduction of steam engines to drive sugar mills, the motive power having hitherto for the most part been wind or water power, gave a great impetus to the sugar industry in the West Indies; and as a great number of the plantations there belonged to old Scotch families, the supply of machinery naturally centred in Glasgow, and was practically in the hands of James Cook. About the year 1835 James Cook died, when the works were offered for sale, and bought by the manager of the works, David Cook. The firm was then changed

to David Cook & Co., engineers and boilermakers, and was carried on successfully, the principal work being sugar making machinery, supplied to all parts of the world where sugar cane was cultivated. The chief and only draughtsman in D. Cook & Co.'s works was Robert Harvey, who had risen to that position from being a workman in the shops, and continued draughtsman for a number of years. About the year 1852 Mr. David Cook retired from active business, and a new co-partnery was formed, with Robert Harvey as managing partner, and was carried on very successfully until 1870, when the other partners retired from business and the works were sold. Mr. Robert Harvey bought all the patterns and drawings, acquired ground in Kinning Park, on which he built new works, the firm being Robert Harvey & Co., successors to D. Cook & Co., and carried on the business of sugar machinery and general engineering. Mr. Harvey, senior, retired in 1880, and the business was continued by his sons Robert and William, and under their management the business continued to increase.

In 1888 an amalgamation was made with the firm of Messrs. W. & W. M'Onie, successors to the well-known firm of Messrs. W. & A. M'Onie (as to the origin of which see p. 57), by which the sugar machinery business of Robert Harvey & Co. was transferred to the new firm of M'Onie, Harvey & Co., now M'Onie, Harvey & Co., Ltd., so that the firm represents two important streams of engineering in Glasgow. Mr. Robert Harvey is the chairman and managing director of the concern, and the work is carried on with all the vigour of youth combined with the experience of age.

The company recently erected large new works on the south side of Scotland Street, fitted up with all the latest improvements in heavy steam travelling cranes and new tools designed for their special work, and here the largest sugar mills and triple Effets are erected, the smaller and lighter work being done in the old works.

The company devotes itself almost exclusively to the production of sugar making and refining machinery, and makes a speciality of the manufacture of triple and quadruple Effet evaporators for the treatment of cane juice. These evaporators are of a special construction, patented by Mr. Harvey, and in operation combine great economy of fuel and increased production of sugar. They are very simple in construction, automatic in working, moderate in price, and are now at work in most of the sugar growing countries, where they are giving the greatest satisfaction to planters. A glance at the catalogue of the firm shows that it is prepared to supply every requisite for sugar plantations and sugar refiners, including engines and cane mills of all sizes, vacuum pans, vacuum pumping engines, juice heaters, clarifiers, defecutors, eliminators, Aspinall, Wetzel, and Bour pans, centrifugal machines, improved filter presses, and water wheels. They are also licensees and makers of the patent Lillie evaporators, which are made from drawings furnished by the Sugar Apparatus Manufacturing Company, of Philadelphia, U.S.A. (Mr. Lillie's company in America), so that the firm is able to supply the Lillie apparatus in its most approved form.

Messrs. D. Stewart & Co., London Road Iron Works, Glasgow.—In addition to the general mechanical engineering work done by this firm (see p. 60) it has for many years made a speciality of sugar mills,

sugar factories, and refinery plant. A special feature of the sugar mills is Stewart's patent hydraulic attachment, whereby a hydraulic pressure of 3000 lbs. per square inch intensity is brought to bear on the roller, and an enormous crushing effect is produced.

Messrs. D. Stewart & Co. have equipped several of the largest cane sugar factories in the world with complete plants, including triple crushing, evaporation and vacuum, crystallisation in motion, and extraction of the crystals by continuous process. Among several of the more important factories may be mentioned those of Rio Fundo and Iguape, Brazil; Narcissa and San Jose, Cuba Rijo, Rabaso, Tatetla and Atenerngo, Mexico; Balianu, Egypt; Mozambique, East Africa; Sanskotte and Cawnpore, India; The Colonial Sugar Co., Sydney and Queensland; the Natal Sugar Estates, and many smaller factories in the British West Indies, Honduras, Japan, Straits Settlements, etc.

Messrs. A. & W. Smith & Co., Eglinton Engine Works, Glasgow.—This is one of the old established Glasgow firms, well known for its sugar machinery, which it still continues to manufacture with all the improvements introduced in recent years.

Messrs. Pott, Cassels & Williamson, Motherwell.—This is a comparatively new firm, which has erected very complete works with all the most modern appliances, and it has made a speciality of crystallisation in motion plant. Centrifugal machinery of all kinds, including these mentioned in the preceding notices, elevators, conveyers, etc., are among its chief productions.

LOCOMOTIVE ENGINEERING.

Messrs. Neilson, Reid & Co., Hyde Park Locomotive Works.—The history of locomotive engineering in the Glasgow district, as a separate branch of business, dates from the time when Messrs. Neilson & Co. commenced the construction of such engines, for although several firms had previously attempted to include this branch of engineering among the industries of Glasgow, none of them succeeded. The firm of Messrs. Neilson & Co. dates from 1837, and for a good many years it undertook several branches of general mechanical engineering work, into the details of which we cannot now enter, as we are concerned now with its development in the manufacture of locomotives. From small beginnings, it has gradually developed until it has attained the proud position of being the leading house engaged in the locomotive trade in Great Britain; indeed, the Hyde Park Locomotive Works have probably the largest capacity of any similar establishment in Europe. Progression is the keynote to the firm's action, and so keenly alive are they to the necessities of the times that their works are fitted with every contrivance that has for its object increase or economy of production.

In the year 1860 Messrs. Neilson & Co. laid out at Springburn entirely new works upon a large scale, and exclusively for the manufacture of locomotive engines, and since then they have carried on a very extensive and constantly increasing business, and the greatest advances have been associated with the name of the late Mr. James Reid, who joined the firm as manager in 1853. In 1872 Mr. Walter Neilson withdrew entirely from active management, and Mr. Reid assumed the full direction of affairs, both commercial and practical. At the end of 1876 Mr. Neilson retired altogether from the firm, and the business then belonged solely to Mr. Reid until

the beginning of 1893, when he assumed as partner four of his sons—Hugh, John, Andrew, and Walter. Up till his death in 1894 Mr. James Reid retained the active control of affairs. What strikes every visitor to Hyde Park Works is the system on which business is conducted, and the order observable throughout. Orderliness was one of the most striking characteristics of the late Mr. James Reid, and it was a point he insisted upon being observed by every one under his control. While every square foot of space is occupied, there is no crowding, and it is to this fact that may be ascribed that immunity from accidents which has all along been the good fortune of the workmen.

The visitor to the works is most favourably impressed with the first view he gets of them. The handsome range of offices gratifies the eye, and leaves little more to be desired in the way of architecture suitable for the purposes; a handsome gateway divides the offices into two sections, the commercial staff occupying one half and the technical staff of draughtsmen occupying the other. Inter-communication between these departments is direct, and by means of electric bells, speaking tubes, and telephones, the heads of departments can be called together at any moment. These offices, as the inscription over the doorway shows, were rebuilt in the year of Her Britannic Majesty's Jubilee, 1887, with which the Jubilee of the firm coincides; and as the long period of 50 years fully demonstrated what were the requirements of the business, both present and prospective, in respect to office accommodation, no expense or useful contrivance has been spared to render them in every way fitted for their purpose.

The shops are arranged so that the work may pass through in systematic progression. From the commercial department the wheels are put in motion, and the drawing office prepares the first of the technical work. On the one hand the drawings are sent down to the pattern shop, where the patterns are prepared for all castings; and on the other to the template shop, where templates are made for the malleable iron and steel work. The rough work from the foundries, forge, and smithy passes on in regular succession through the machine shop, until everything is congregated in the erecting shop, ready to be built into a complete engine. No description of Hyde Park Works would be complete without a reference to the engine and tender erecting shop. This is a new structure, a previously existing open space having been covered in with a strong roof of glass and steel, constructed on the newest system by Sir Wm. Arrol & Co., Ltd. This roof is supported on 48 columns, weighing about 10 tons each. The length of the structure is over 700 feet, and the breadth 40 feet. It is served by four electric cranes, one of 70 tons, one of 40 tons, and two of 15 tons each, and engines, complete or in parts, can be shifted with the greatest facility over the tops of the others, and deposited at any place within the length of the shop.

The firm now employs about 3500 hands, and that exclusively in the manufacture of locomotives. From a maximum annual output of 200 main-line engines, it is expected that the recent remodelling of the works, with the attendant installation of new tools and plant of the most modern description, will lead to the output being increased to 300 engines per annum, and this is now practically assured by actual fact.

Messrs. Dubs & Co., Glasgow Locomotive Works.—These works were founded in 1864 by Mr. Henry Dubs, formerly managing partner at the Hyde Park Locomotive Works, and are situated on the south side of the river, and alongside the Caledonian Railway Company's main line to

Edinburgh and the South. The arrangement and equipment of the works were planned by Mr. Dubs himself, and with the assistance of an able staff he had the gratification of seeing the first locomotive leave his yard early in 1865. Since that date the firm has built some 4000 engines, an indication that the energy which characterised the inception of the business has in no way diminished. Mr. Dubs died in 1876, but the control of the business has always been in able hands, and its reputation has never been allowed to suffer.

To-day the works present much the same appearance externally as they did when first completed, but their capacity for turning out work has greatly increased. New buildings have been added, old ones extended, and the plant increased and renewed, and to-day the works are among the largest of their kind in the kingdom. They give employment to more than 2000 men, and can turn out seven locomotives a fortnight.

For many years after the works were opened, Messrs. Dubs built exclusively for home railways, but this outlet was gradually closed to them through the railway companies building shops of their own to supply their requirements in respect of rolling stock. Messrs. Dubs had perforce, therefore, to go further afield with their engines, and buyers were readily forthcoming in all parts of the world. India is still, perhaps, the largest purchaser of locomotives, and throughout the various systems of railways—Government, guaranteed, and private lines—Dubs & Co. have hundreds of engines at work, and with the constant additions to the mileage of existing lines, and the construction of new ones, the connection with the East is more than maintained. With the colonies the Messrs. Dubs have always done a large amount of business, and have sent their share of locomotives to assist in the development of Greater Britain, and although some of these fields are gradually being closed through the adoption of protective measures, the foreign connection of the firm is still extensive. They have supplied, and still supply, engines for the Cape, Natal, Egypt, and the Transvaal; for Ceylon, Burma, Siam, and Straits Settlements; for Mexico and the various Republics in South America; for China and Japan; for Finland and Norway.

Within the last few years the home railways have bought largely from contractors, and the Glasgow locomotive works have recently been busy with orders for the Glasgow and South-Western, the Caledonian, and Highland Railways in Scotland, and for the Midland, Great Northern, and London and South-Western Railways in England. Not quite so recently they have also found customers in the various Irish railways.

Messrs. Dubs are manufacturers of a patent combined locomotive and crane, for which there has always been a large demand, and in their own yard they have always had one of these machines at work. The firm also manufactures the Abt Combination Locomotive for rack railways, and have several at work in Tasmania and Queensland. Within the past twelve months Messrs. Dubs have made several developments in their works in order to keep up with the demands of their increasing trade, and have equipped their establishment with the most modern tools and plant, so that it keeps in line with the progress which is every year being made in every department of the engineering industry.

Messrs. Sharp, Stewart & Co., Ltd., Atlas Works, Springburn (formerly of Manchester).—The original style of this firm was Sharp, Roberts & Co., and it was founded in 1828 for the purpose of manufacturing cotton spinning machinery, the works being situated in Falkner Street, Manchester.

Between 1830 and 1840 the demand for machine tools led to the inclusion of this class of machinery among their manufactures. The manufacture of locomotives was commenced in 1834, the first engine (with vertical cylinders driving through bell cranks) being supplied to the Liverpool and Manchester Railway, and the second, third, and fourth, of similar type, to the Dublin and Kingston Railway.

The various departments of the work of the firm were carried on in Manchester. When, towards the end of 1887, arrangements were completed for an amalgamation with the Clyde Locomotive Company, Limited, which had been incorporated in 1884, the late Mr. W. Montgomerie Neilson (formerly of the Hyde Park Locomotive Works) and some other Glasgow gentlemen being the founders. Work was started at the Glasgow works under the new condition of things in the beginning of 1888, Mr. John Robinson remaining for one year as chairman of the new company, Mr. J. F. Robinson being managing director, which position he still continues to hold.

The works are situated close to the Barnhill and Springburn Stations of the North British Railway, on the north-east side of the city. They have been considerably extended from time to time, and the following is a general description of them as they now stand:—The offices are situated near the eastern angle of the ground, and extending from them round the angle and along the north-east side come the pattern store, pattern and joiners' shops, brass foundry, iron foundry, forge and smithy, all fitted with the latest appliances and connected by narrow-gauge tramway, so that the rough material can be brought into the drawing-in department, which is close to the entrance, in the main machinery building. On the outside of the latter, in a small separate bay, are the main brassfinishing and grinding shops; and the adjoining main building itself consists of six bays, and occupies the whole of the south-western portion of the works.

The first three bays form the fitting and light tool shop. The other three bays form the heavy tool shop, the boiler mounting and frame fitting shop, and the erecting shop. The total width of the six bays is 280 feet, and the average length is about 400 feet. The narrow-gauge tramway traverses the different departments, and the larger bays are served by rope-driven overhead cranes, of which there are two in the erecting shop, and by a travelling jib crane. Hydraulic jib cranes are also placed in other convenient positions throughout the works, especially in the erecting shop and the cylinder fitting shop. At the other end of the yard, opposite the end of the erecting shop, is the paint and packing shop, occupying the southern angle; and in the middle of the south-eastern side is the boiler and tender shop, consisting of four bays, 220 feet long and together 160 feet wide. This shop is fitted with the most approved modern machinery, including special drilling machines and hydraulic riveters and suitable cranes. Parallel with the boiler shop is the furnace and flanging shed, with the necessary plate furnaces and a hydraulic flanging press. Parallel again with this are the main boiler-house, case-hardening furnaces, annealing furnace, and coppersmiths' shop.

The power throughout is transmitted electrically, being generated by special high-speed compound engines and dynamos in a separate power-house in the centre of the works, the motors being connected to the various line shafts. The steam is supplied by two high-pressure "Stirling" water-tube boilers.

The machine tool shop lies on the north-western side of the works, close

to the stores and main machinery building. It consists of three bays, a large one in the middle, and a small one on either side. The centre bay is served by a 25-ton overhead travelling crane, and at one side is a 5-ton rope travelling jib crane. The shop is fitted for dealing with all classes of work, up to the heaviest tools required in connection with marine and ordnance work, and during recent years considerable numbers of such special heavy machines have been manufactured for steel works and marine shops, principally lathes for shafting and gun work, boring machines and planing machines of the heaviest class, reaching up to 12 feet wide and over 100 tons weight, for dealing with armour plates.

The locomotive department is capable of turning out 150 engines a year. In addition to the work done for home railways, which has been of an extensive nature during the last few years, the firm continues to manufacture engines for the Continent of Europe (particularly for Holland, Sweden, and Spain), for India and for the colonies, and also for Brazil, the Argentine Republic, etc. The total number of men employed is from 1800 to 1900.

The Caledonian Railway Company's Works, St. Rollox.—These works are situated in the St. Rollox district of Glasgow, adjoining the Caledonian Main line between Glasgow, Oban, Perth, and the North. They employ 3130 workmen, and together with the yard and sidings occupy an area of 24 acres, fully 13 of which are covered, and are for the manufacture and repair of the locomotives, carriages, and waggons comprising the company's rolling stock, and the execution of work for the canals and docks, telegraph, signal, and other departments.

The shops have been so planned as to facilitate the passage of material from one department to another during the course of manufacture, thus minimising labour and consequently lessening the cost, and with this object there is a system of narrow-gauge railway connecting the different departments. Throughout the premises there are 3¼ miles of ordinary 4 feet 8½ inch gauge railway for the accommodation of rolling stock in course of construction, as well as under and awaiting repair.

The yearly working capacity of the workshops embraces the building of 52 new locomotives, 104 new carriages, and 3000 new waggons, and the repairing here and at the outside stations of 1050 locomotives, 10,720 carriages, and 103,920 waggons. In the adjoining running sheds are stabled 70 locomotives, there being 17 similar sheds located throughout the line.

The various departments of the workshops comprise forge, smithy, spring shop, boiler shop, iron foundry, brass foundry, copper and tinsmith shop, erecting shop, machine shop, brassfinishing shop, fitting shop, wheel shop, paint shop, trimming shop, waggon shop, carriage shop, and sawmill, besides smaller departments, all of which are fitted with the most improved appliances. The drawing office accommodates 11 draughtsmen. In connection with the workshops there is a fire brigade, an ambulance corps, a dining establishment, and a yearly friendly society.

At 31st July, 1900, the company's rolling stock consisted of—

887 locomotives.
2,243 coaching vehicles, etc.
62,925 merchandise and mineral trucks.

The principal dimensions of the company's present standard express passenger engine—a step in advance of the "Improved Dunalastair" class—are as follows:—

Cylinders, 19 ins. diam. by 26 ins. stroke.
Wheels (driving), 6 ft. 6 ins. diam.

Tractive force, 17,320 lbs.
Heating surface, 1600 sq. ft.
Grate area, 23 sq. ft.
Total wheel base, 49 ft. by 3½ ins.
Working pressure, 180 lbs. per sq. in.
Tank capacity, 4125 gallons.
Fuel space, 4½ tons flush with coping.
Total weight in working order, 96 tons 14 cwt.

At the above-named date the Caledonian Railway had 935 miles of track in working order, and the total mileage run by the company's trains during the year 1899 was 17,588,770.

North British Railway Company's Cowlairs Works. — These works were erected in 1841, previous to the opening of the Edinburgh and Glasgow Railway in February, 1842. Since the amalgamation of that railway with the North British Railway in 1865, they have been the chief works for building and repairing engines, carriages, and waggons.

The works occupy an area of some 25 acres, and are planned to facilitate the progress of the numerous varieties of works. They consist of iron and brass foundry, forge, smithy, boiler and tender shop, machine shop, fitting shop, erecting shop, wheel and carriage fitting shop, waggon shop, and saw-mill, carriage shop, and paint shop. Owing to the development of the line, the workshops have been from time to time remodelled and enlarged, and considerable additions are at present in progress.

The principal developments in this company's locomotives have taken place in the passenger engine during the last year or two, they having larger boilers, higher steam pressure, and larger cylinders. This has been necessitated by the increased weight of the through passenger trains run between Scotland and England.

Glasgow and South Western Railway Company's Works, Kilmarnock.—These works were opened in 1856, and are situated a short distance from Kilmarnock passenger station, in an angle between the main line and the branch line to Troon and Ayr. The works have been extended from time to time, and at present upwards of 1200 hands are employed. Within recent years great additions have been made to the number of engines, carriages, and waggons owned by the company, and in order to deal with the continually growing requirements of the line, a large extension of the carriage and waggon works is at present in process of erection on a site between Barassie Junction and Troon Station. Near the main entrance to the Kilmarnock works is the paint shop, and a little further on is the erecting shop in three bays. The centre bay is occupied by a steam traverser, on which the engines are carried into or out of the shop at either end. The capstan was built by the company, and is a fine machine. It is fitted with a capstan gear for hauling engines across the traverser to and from the engine repairing pits or sidings. In each of the other two bays there is an overhead travelling crane, capable of lifting 50 tons. Next to the erecting shop is the machine shop, which is in three bays, where there are some first-class tools. Beyond this is the boiler shop, where there is a splendid hydraulic riveting plant. The other shops are the smithy and forge, carriage and waggon building shops, carriage and waggon repair shops, and a detached building for dealing with road vehicles, lorries, etc. All classes of rolling stock are built and repaired at the works, although from time to time orders for new stock are let to contractors, but the great proportion of the passenger locomotives have been built by the company,

and within recent years 75 express engines were put on the line. These are employed on the coast service between Glasgow and Ayr, Ardrossan, Fairlie Pier, and Largs, as well as on the south express trains between Glasgow and Carlisle in connection with the Midland route. The express passenger engines have all a leading bogie, so constructed that lateral movement is provided by a swing link arrangement, which gives the engine great flexibility with perfect steadiness. There are some special features in connection with the Glasgow and South-Western locomotives worthy of passing notice. For instance, instead of the old hand reversing lever or screw gear, a very large percentage of the stock is fitted with a steam reversing apparatus, which renders manual labour unnecessary in handling the engine, the whole operation being under perfect control by the movement of one small lever. All new engines built for the Glasgow and South-Western Railway are now fitted with metallic packing for the piston-rods, automatic vacuum brakes, sight feed lubricators, steam sounding apparatus, etc.

Messrs. Andrew Barclay, Sons & Co., Ltd., Caledonian Works, Kilmarnock.—This company has been long known as makers of locomotives, chiefly for colliery and works purposes, and during the past few years has devoted its chief attention to such engines. See under "General Mechanical Engineering," p. 54, for a notice of the general work done by this firm.

BRIDGES, ROOFS, AND RAILWAY APPLIANCES.

Sir William Arrol & Co., Ltd., Dalmarnock Ironworks, Bridgeton, Glasgow.—This firm has won renown all over the world through the distinguished ability of its founder, Sir William Arrol, in carrying out such undertakings as the Tay, Forth, and Tower Bridges. Sir William Arrol began, in a small way, making boilers, girders, and general structural work, and with all the difficulties attending the formation of an entirely new business with small means. Soon, however, the business began to grow, and then grew so rapidly that in 1871 he was compelled to remove to roomier premises. Then was founded the business which is now carried on by Sir William Arrol & Co., Limited, at the Dalmarnock Works, in the eastern outskirts of Glasgow. In these new and more extensive works Mr. Arrol was enabled to undertake larger contracts than previously in all kinds of structural work, railway bridges, etc. With the increasing size and importance of contracts, and consequently greater masses of material requiring to be handled, Mr. Arrol set about designing and making special drilling and riveting plant for the manipulation of material by the most improved and economical methods.

Some of the earlier works which brought Mr. Arrol's name before the engineering world were a bridge over the Clyde at Bothwell for the Caledonian Railway Company, the structural portion of the great Central Station at Carlisle, and the Caledonian Railway bridge over the Clyde to carry this railway to the new Central Station. It was this latter undertaking which led to the design of some of the special tools and appliances which were afterwards found so necessary in his larger works. Not only was special drilling plant made to carry out this contract, but Mr. Arrol, perceiving the great advantage that would be obtained by a system of economical riveting (as the rivets were so large and so long that it was practically impossible to have satisfactory work performed by hand), set [redacted] designing plant for the purpose, and the outcome was the introduction

of the hydraulic riveting machine, known under the title of Arrol's Patent, which has done so much to revolutionise riveting in the principal bridge building and shipbuilding yards of Great Britain.

Important as were these operations, however, they were small compared with the great undertakings which were destined to make his reputation and bring him honour and fame, namely, the Forth and the Tay Bridges. It would be out of place to enter into details of these structures, or of the numerous special appliances which were designed for their construction and erection. For these reference must be made to the numerous special publications which have appeared on the subject, but every competent observer recognised that the impress of Mr. Arrol's personality was to be seen in practically every stage of the great undertaking. At a banquet which followed the opening of the Forth Bridge, and which was attended by many men of note in the railway world, the Prince of Wales announced that the Queen had been pleased to confer the honour of knighthood upon William Arrol for the great ability he had shown in carrying out this great undertaking.

Shortly before the completion of the Forth Bridge, the firm of Sir William Arrol & Co. undertook the erection of all the main viaducts and a good many of the swing bridges for the Manchester Ship Canal Company. About the same time, also, they undertook the erection of the steelwork for the Tower Bridge across the Thames in London. Specimens of their work can be found in all parts of the country.

The firm of Sir William Arrol & Co. does not confine itself to the work of bridge building, but carries on a very large general business in mechanical engineering, and in all kinds of structural work. It manufactures to a very large extent the riveting machines patented by Sir William, which are adopted in most of the leading shipbuilding and iron centres throughout Great Britain, and also in other countries. In recent years it has also introduced and developed the Arrol-Foulis stoking plant, used in connection with gasworks, and which causes an immense saving in the working of such works. These machines are used very largely not only in Great Britain, but also in many of the principal gasworks in Europe, Australia, and the United States. Among other productions of the firm may be mentioned hydraulic pumping engines, cranes, and stamping presses; in fact, it would be difficult to name any department of mechanical work which the firm could not undertake.

Arrol's Bridge & Roof Coy, Ltd., Germiston Works.—These works were started in 1882 by the late J. Cameron Arrol and T. Arthur Arrol as Arrol Brothers, but in 1891 they were altered to their present designation.

The works cover an area of 8½ acres, which to a large extent is covered by roofs of varying heights suitable to the work to be done under them. The materials required for manufacture are principally brought in by the Caledonian and North British Railways and deposited at one side of the works, and gradually wrought across same, passing through the various machine tools on their way to the erecting shops, from which they are sent out either by rail or cart. An extensive system of light railway is carried through the works.

The chief productions are bridge and roof work, but a large amount of constructional work, such as the Edinburgh Exhibition, 1886; Glasgow Exhibition, 1888; and the present Glasgow Exhibition, has also been carried out. The gigantic wheels at Earl's Court, Blackpool, and Vienna were made by the company, and they were also the designers and builders of the first large overhead gauntree at Messrs. Harland & Wolff's, Belfast.

The company has a large connection in England and Ireland, as well as Scotland, and their chief foreign markets are Africa, China, Japan, Mexico, and South America. For the last three or four years they have been constantly employed in manufacturing bridges for the Cape to Cairo Railway, and the extent of this work may be judged by the fact that were the bridges supplied placed end to end they would cover a length of fully 2½ miles.

The Brandon Bridge-Building Co., Ltd., Motherwell.—The Brandon Works, which are situated in the centre of the steel and coal industries of Lanarkshire, extend over an area of 11 acres, and are one of the largest and most modern bridge-building establishments in the country.

The works also comprise large iron founding and engineering departments, capable of turning out all descriptions of castings, engine work, etc., for railway, colliery, and general purposes.

The company has executed numerous large contracts both at home and abroad. Among the more important may be mentioned bridge work on Glasgow Central Railway, Lanarkshire and Ayrshire Railway, Gateshead and Hurlford Branch Railway, and the Leith and Edinburgh lines, Blackpool Station, etc.; also bridge work for the Imperial Railways of North China, Buenos Ayres, and Great Southern Railway, Indian State Railways, etc., etc.

Messrs. Alexander Findlay & Co., Ltd., Steel Roof & Bridge Builders, Parkneuk Works, Motherwell.—These works were established in 1888, but have been extended several times to meet the demands of the business. They manufacture all kinds of iron and steel structural work.

The establishment extends to about 6 acres, with extensive covered-in workshops, fitted with excellent equipment of plant for drilling, riveting, etc., special hydraulic plant for pressing trough flooring, largely used in railway and road bridges, and for fireproof floors in warehouses. Troughs 36 feet long by 18 inches deep by ¼ inch thick can be pressed from one plate.

The finished products include bridges, roofs, tanks, pithead frames, and general structural work in iron and steel. They have been sent to India, China, South Africa, and South America, in addition to the chief home markets. Amongst the latter may be mentioned the steelwork for the Great Central Railway Terminal Station and Goods Yard at Marylebone Road, London, and steel work for the grand concert hall of Glasgow Exhibition, 1901.

Messrs. P. & W. MacLellan Ltd., Clutha Works, Glasgow.—These works have been in existence for fifty years, and for thirty years have occupied their present position in Plantation, Glasgow. The firm owning them was, in 1890, formed into a limited liability company, under the title of P. & W. MacLellan, Limited.

The works occupy a space of 14 acres, about half of which is covered by buildings, and the remainder is used for erection and storage purposes. The chief offices of the company are at 129 Trongate, where there is also a large warehouse, and an extensive business is done as iron and steel merchants, and in the sale of railway appliances, etc. The principal output of the works consists of bridges, roofs, screw pile jetties and wharves, railway waggons, steel permanent way sleepers, cyanide plant and tanks, bolts and nuts, and every description of structural work in iron and steel. The works are capable of turning out 3000 railway waggons and about 10,000 tons of bridges and roofwork annually.

The chief markets to which the manufactures are sent are India, China,

Siam, Afghanistan, Siberia, Egypt, South Africa, the Crown colonies, Australia, New Zealand, and South America. There is always a large amount of work on hand for home railways, amongst the recent contracts being the Waverley Station, Edinburgh. It may be interesting to note that of the Glasgow stations the Central and Bridge Street Stations of the Caledonian Railway, and the Queen Street passenger station of the North British Railway were made at the Clutha Works, and erected by the firm.

One of the most recent orders executed at the works was that of a jetty 591 feet long by 75 feet wide, which was erected by the firm at Vera Cruz, Mexico. The firm also makes a speciality of irrigation work, and is engaged at present on a contract for lock and regulator gates and sluices for Assiont Barrage on the Nile.

The Barrowfield Iron Works, Limited (late Laidlaw, Sons & Caine, Limited), manufacture all kinds of iron and steel structural work, including piers, bridges, roofs, lighthouses, markets, etc., and their productions are to be found in all parts of the world.

The Glasgow Railway Engineering Company, Govan, Glasgow, manufacture railway wheels and axles of every description, and do all kinds of smith work.

Messrs. Dick, Kerr & Co., Ltd., Kilmarnock (head office, 110 Cannon Street, London), are engineers and contractors for complete tramway and light railway equipment, and supply all the machinery and appliances required.

Messrs. Hurst, Nelson & Co., Ltd., Motherwell, are builders of railway carriages, waggons, tramway cars, and light railway rolling stock of every description; also makers of wheels and axles, railway plant, forgings, smith work, and iron and brass castings.

Messrs. A. & J. Main & Co., Clydesdale Iron Works, Possilpark, Glasgow.—The business of Messrs. A. & J. Main & Co., Limited, was founded about fifty years ago by the late Mr. James A. R. Main, and was the first of a new industry in Glasgow and the West of Scotland. The firm was originally Messrs. Hennilewich & Main, afterwards becoming Messrs. Main, Kemp & Co. Under the latter title larger works were opened in Scott Street, Port-Dundas, Glasgow, and to the manufacture of iron and wire fencing, railings, gates, etc., were added iron roofing, and bridges. On Mr. Kemp's retiral, which took place about the year 1870, Mr. Alex. Jas. Main, brother of the founder, was assumed as a partner, and the firm's name was changed to Messrs. A. & J. Main & Co. About this time a branch was opened in London, as also one in Edinburgh. With these extensions to the firm's field of operations, the growth of the business was very marked, and ere long it was found necessary to have increased manufacturing facilities. In 1873 a plot of ground 2½ acres in extent was acquired at Possilpark, Glasgow, on which new offices and workshops were erected, with railway siding accommodation. A branch was started in Dublin in 1878, while in 1885 one was opened in Calcutta. Bit by bit every corner of the new ground became filled, and in 1890 further extensions were found necessary, and an adjoining plot of 2½ acres was secured, and which was soon fully utilised.

The business was converted into a private limited company on 1st January, 1896, when all the branch managers, as well as several other of the employees, became shareholders. The chairman of the company was the late Mr. James A. R. Main. In 1897 a further extension of business was found necessary, and other three acres adjoining the previous holding were

acquired. The company's works now occupy 8 acres of ground, and are the largest of their kind in Scotland, with an output of 10,000 tons per annum. They manufacture all kinds of iron roofing, buildings, and bridges, as also every description of iron and wire fencing, hurdles, gates, etc. At home the company's business is carried on chiefly in connection with the principal industries throughout the country, as also with corporations, water-works, estates, farms, etc., and many large contracts have been executed by them. They have also carried out many extensive and important contracts for the home and colonial Governments, as also for home and foreign railways. In addition to these outlets, the company's manufactures are also shipped to many parts of the world, but their principal foreign markets are India, South Africa, East and West Indies, and Egypt.

Messrs. R. Y. Pickering & Co., Ltd., Railway Carriage and Waggon Builders, etc.—The Wishaw waggon and wheel works are the longest established of their kind north of the Tweed, and they have, in the course of their history, undergone many changes. Indeed, a very small portion of the original works now stands, the buildings having been either pulled down and replaced by newer and larger shops, or incorporated in the modern extensions, whilst the machinery has undergone a complete revolution in keeping abreast of the times, and is now capable of meeting the latest requirements in the production of all classes of railway waggons, wheels, etc. The erecting shop for oak-frame waggons and other similar vehicles, in which from 50 to 60 waggons can be laid down at a time, has been entirely rebuilt within the last two years. Connected with this shop is the timber mill, which has also been remodelled within the same period. Here all the preparatory milling of timber for the frames and bodies of waggons is done by machinery, no manual labour being needed except to put the waggons together.

Perhaps the most interesting part of the works is the wheel-making shop, where wrought-iron wheels are made by one of Messrs. Tannett Walker's hydraulic presses of 1000 tons pressure. The type of wheel produced here has now altogether superseded that of cast-iron for all ordinary goods, and mineral waggons in this country. The most important department, however, is the steel frame erecting shop, which is one of the additions made to the works within recent years. The superior advantages of the steel-frame waggon are now being more fully recognised both by railway companies and private traders. The shop is fitted with overhead travelling cranes, hydraulic riveters, and machinery for boring, punching, screwing, planing, and cold-sawing the steel channels and angles and plates used in the construction of the waggons. The other principal shops include the forge, smithy, turning, fitting, and general engineering and paint shops, all specially laid out to suit their respective purposes, and lighted throughout by electric light generated in the works.

The annual output to all parts of the United Kingdom, a number of foreign countries, and the colonies, varies somewhat, but may be averaged at about 3000 railway waggons and other vehicles, and 4000 sets (a set consisting of 4 wheels and 2 axles) of wheels and axles, besides quantities of miscellaneous colliery and railway plant and stores, repairs, etc. Between 500 and 600 men are employed. The firm has branch works and stations for repairing purposes in different parts of the country, the principal of which are at Airdrie and Thornton (Fife).

Messrs. Stevens & Sons, Railway Signal Engineers, New City Road, Glasgow.—Messrs. Stevens & Sons manufacture all kinds of railway signals,

with all the appliances connected with them. They also manufacture gas apparatus for towns, mansions, public buildings, as well as a considerable number of special appliances of different kinds.

Messrs. L. Sterne & Co., Ltd., the Crown Iron Works, North Woodside Road, manufacture, in addition to many other specialities, spiral and railway buffer springs, which are much used in the construction of railway plant. (See p. 49.)

TEXTILE MACHINERY AND SEWING MACHINES.

The Anderston Foundry Company.—When the weaving and spinning industries were more important in Glasgow and the West of Scotland than they are at present, the Anderston Foundry Company did a large business in every variety of power loom for all kinds of textile fabrics, as well as in the various subsidiary machines used in the manufacture. At the present time the firm still turns out a number of looms, but the changed conditions of the textile industries have led the proprietors to direct their attention to other classes of machinery, and notably, in recent years, to high-speed engines for electric lighting purposes, and which are obtaining a high reputation for design and workmanship. The looms made by the firm not only retain all the features which have made their productions so well known, but also incorporate all the most recent improvements, so that they maintain their position in the highest place among the appliances used in the textile industries.

The Carver Looms Company, Ltd., 33 Renfield Street, Glasgow.—The most recent development in connection with looms is the electrical Jacquard machine, which is patented and manufactured by this company. As is well known, for the reproduction of complex designs in fabrics, the method universally employed is that perfected by Jacquard early in last century, in accordance with which the position of the warp threads relatively to the weft when the shuttle is thrown is controlled by perforated cards, determining whether hooks, to which the warp threads are attached, engage or do not engage the knives of a vertically reciprocating griffe. As one card, measuring 16 inches by 3½ inches, is required in ordinary practice for each shot of the weft, it can be realised that for a design of any complexity the number becomes enormous, and in the manufacture of fabrics requiring this method the cost and inconvenience arising from the number and bulk of cards necessary is very great.

The machines of the Carver Looms Company, Limited, constitute a simple attachment to the present Jacquard machines, to which they can be clamped in a few hours to replace the card mechanism, and they electrically interpret the design from a single metallic sheet bearing the pattern. These pattern sheets are produced in any number from the original design so rapidly and at such a low cost that it is cheaper and more convenient not to preserve them, but simply to preserve the original design, and reproduce at any time they may be required any number of working plates from it, the pattern being removed after use from the metal, which can thus be used indefinitely. The electro-magnetic system employed is such that the machines effect their object with an exceedingly small expenditure of electrical energy—a single electrical horse-power will serve a large number of machines.

The metallic pattern sheet is arranged about 5 feet above the ground level, so that it is immediately under the eye of the attendant, and it can be taken out of the machine and another substituted for it in a few seconds. It is thus seen that the cost of the cards (the cost of the metallic sheet being infinitesimal compared with that of a corresponding set of cards), as well as the great time now expended upon the changes from one pattern to another in the loom, and the large amount of accommodation necessary for the card storage, are all practically eliminated.

The system is shown in operation at Stand No. 429 in the Machinery Hall of the Glasgow International Exhibition.

Messrs. J. & T. Boyd, Shettleston Iron Works.—This firm has been in existence for about thirty-seven years, originally as machine tool makers, but for more than thirty years as makers of textile machinery.

Their chief products are worsted spinning and doubling machines, cotton doubling for sewing thread and general manufacturing purposes, hemp and flax twine, and thread doubling and twisting, all of which are protected by patents in this country and abroad. Their manufactures are largely in use in Glasgow, Dundee, Paisley, and in Scotland generally, also in Yorkshire and Lancashire, whilst a considerable export business with the Continent and the United States and the colonies has been carried on for many years. Messrs. Boyd also carry on a large ironfounding business, chiefly in castings for machine tools for the local engineers.

Messrs. A. F. Craig & Co., Ltd., Paisley.—For a note of the textile machinery made by this firm see under heading of "General Mechanical Engineering," page 56.

Messrs. D. Stewart & Co., Ltd., London Road Iron Works, Glasgow.—For a description of the general work of this firm see page 60. It makes a speciality of engines for driving cotton and jute mills. It also turns out bleaching, dyeing, printing, and finishing machinery in large quantities, and it has supplied all the large firms engaged in this industry in the United Kingdom, also several in the United States, Canada, France, Germany, and Russia.

Messrs. Thomas White & Sons, Laigh Park, Paisley.—The firm of Thomas White & Sons was started in the year 1861 under the name of White & Hodgart, makers of machine tools, etc., which business was carried on successfully in works situated in Gordon's Lane, Paisley. In 1875 Mr. Hodgart left the firm, and the name was then changed to Thomas White & Sons.

At this time the thread industry was making rapid progress in Paisley, so the firm commenced making thread-making machinery, and also spool and bobbin-making machines, of which they were the original makers and designers. In 1890, in order to meet the demands of the increasing business, it was found necessary to erect new premises at Laigh Park, Paisley, where the business is still carried on.

Messrs. Thomas White & Sons have brought their thread, spool, bobbin, and other wood working machinery to such a perfection that they can supply machines for making any articles in wood from pen-holders to billiard table legs. Among the other productions may be [illegible]oned air compressors of all descriptions, with either belt or

power, and also high-class horizontal engines. The chief market for their machines are Scotland, England, France, Germany, Sweden, and Russia.

A number of the firms noticed under the heading of "General Mechanical Engineering" make textile machinery of different kinds, and reference should be made to these firms.

Messrs. Kimball & Morton, Ltd., Sewing Machine Manufacturers, 11 Bothwell Circus, Glasgow.—This firm was established in 1867, and incorporated in 1887. Their principal business has been the manufacture of special sewing machines for sail, sack, and tarpaulin work, and they are contractors to the British Admiralty, who use their sail and flag machines in all their dockyards. The machines made by the firm are used by the chief sail makers in the United Kingdom and the colonies and in several foreign countries.

The Grummet or Ring machine is in advance of any other sewing machine of its kind, and is giving the greatest satisfaction to the largest tent and tarpaulin or waggon and cover makers, as well as to the London and North-Western Railway Company and the Caledonian and other railway companies. The needle of this machine travels round the ring while the sail, tarpaulin, or tent is lying flat. Previous to the invention of this machine the whole cover had to be dragged through under the arm of the machine to sew in a Grummet.

In addition to their special machine, Messrs. Kimball & Morton make large numbers of up-to-date domestic sewing machines, as well as wringers. They also do a large trade in nickel-plating and enamelling, and have made many small machines for inventors. This branch of their business is steadily increasing, as are the other branches; so much so that their present factory is four times larger than it was in 1867.

The Singer Manufacturing Co., Kilbowie, by Clydebank.—This company is now the largest sewing machine manufacturing company in the world, and its large works at Kilbowie are among the sights of the West of Scotland. The "Singer" machine is of American origin, and in this respect it is on common ground with a large number of labour-saving mechanical appliances. The works at Kilbowie cover an area of 46 acres, and possess a total floorage of nearly one million square feet. No fewer than seven thousand persons are employed in the establishment, and the enormous value of the work accomplished may be gauged by the fact that the average output of 13,000 sewing machines per week is effected.

The Singer Manufacturing Co. commenced operations in Scotland, in Bridgeton, Glasgow, where the business increased very rapidly, and in 1882 the works at Kilbowie were commenced, and in 1884 they were completed and entered upon. They are of immense proportions, and contain within themselves all the appliances required for the production of all parts of the machines. The manufacturing or factory system is fully carried out in all details, with the result that the finished machines are put together with the greatest efficiency and economy possible. As an illustration of the mechanical ingenuity displayed in their design may be mentioned an important speciality known as the "oscillating shuttle." The design of this mechanism is almost perfect; there is but one simple conversion of motion—rotating to oscillating—and no differential motion or variable speed, and, not unreasonably,

the Singer Manufacturing Company claims for this mechanism a supremacy over all others in respect of ease, speed, capacity, and durability.

Among the more notable examples of useful domestic and manufacturers' machines made by the company may be mentioned the "vibrating shuttle," the "improved family," the "improved manufacturing," the "automatic chain stitch machine," the "Jacquard pattern card stitching machine," the "automatic carpet machine," the latter being specially adapted for all varieties of work requiring a zig-zag stitch or overedge seaming. Some idea of the vastness of the operations of the company and the multitudinous demands of the trade may be gathered from the fact that they have over seven hundred different classes and varieties of machines catalogued. The Singer Manufacturing Company, in addition to the enormous works at Kilbowie, possess large factories at Elizabethport, New Jersey, U.S.A.; Cairo, Illinois, U.S.A.; South Bend, Indiana, U.S.A.; Montreal, Canada; Vienna, Austria; and Russia.

The sales in Great Britain and Ireland amount to nearly 200,000 machines per year, while the total sales of the company throughout the world reach the enormous total of over one million machines per year, and over sixteen millions have been manufactured up to date. The two hundred medals awarded at all the leading exhibitions of the world, the fifty first awards at the Chicago Exhibition of 1893, and the Grand Prix of the Paris Exhibition of 1900, are in themselves sufficient testimony of the pre-eminence of the company in its own special department of industry; but, after all, they are not so significant as the recognition by the public of the great improvement in social conditions which has been brought about by the products of the Singer Manufacturing Company. The organisation of this great enterprise is practically perfect, and its past record and present prosperity constitute a splendid tribute to the energy and industry of its founder, and to the spirit of enterprise which prevails in the counsels of those who are now charged with the administration of its affairs and the preservation of its valuable interests and high commercial repute.

PIPEFOUNDING AND HYDRAULIC APPLIANCES.

Messrs. Robert Maclaren & Co., Eglinton Foundry, Canal Street, Port Eglinton.—The growth of cities and burghs in the nineteenth century has caused sanitation to advance by leaps and bounds. Sanitary experts are no longer content with wells which are liable to pollution, but insist that every dwelling should be provided with a supply of water, the purity of which is beyond suspicion. The increased wealth of our communities has called for more light and better light, and has led to a great development of gas and electric lighting works. These are some of the factors which have caused the manufacture of cast-iron pipes to become a special industry, and to be carried out on an enormous scale.

Glasgow has for half a century been a centre of this industry, and its present capacity is about 200,000 tons per annum. There are four large firms engaged in making large and small pipes, and about half a dozen firms engaged in making small pipes only. One of the large

firms is that of Messrs. Robert Maclaren & Co., Eglinton Foundry. It began work about fifty years ago, and is now producing 30,000 tons of pipes annually for water, gas, or electric purposes. Visiting the foundry, the visitor is first shown the power station, which consists of three large 180 I.H.P. gas engines, each driving a dynamo and a set of hydraulic pumps. Two of the engines are by Messrs. Tangyes, and one by Messrs. Crossley Brothers. The engines are supplied with gas by a range of five gas generators, two of which supply gas for heating purposes. The dynamos are coupled to the switchboard, and the power is distributed through Kelvin ammeters to the various parts of the foundry through concentric cables. These cables supply light or power as may be desired at any point. The hydraulic pumps connect with an accumulator, and have an automatic belt shifter. Passing from the power station, we find the cupolas, which are two in number, capable of 150 tons per day, and run on alternate days. The blast is supplied by a 50 H.P. motor, driving a set of Root's blowers. Next we come to the loam mills, which grind the core-making materials. In the department for large pipes we first see the special core-making machinery and collapsing bars which are used, then the large ovens into which the cores roll continuously. Next we come to the casting platform. Opposite us are the mould drying ovens, behind us a massive 10-ton hydraulic crane, while beneath us is an arrangement of chains and pulleys and an electric winch for shifting the heavy moulds. Passing to the other side of the mould stoves, we observe the process of making the mould. The turned iron patterns are suspended on powerful hydraulic cranes, with auxiliary cranes to carry the lighter bend pieces, and hydraulic rams below to carry the socket patterns. Alongside is a Jacob's ladder for lifting the sand, driven by a small motor.

Passing out to the yard, we see the moulding boxes opened by special cranes, and the sand fall into the pit, while the pipe is placed by another crane on the fettlers rail, where the core sand is removed and any fins chipped off. The pipe is next placed on a special electric driven lathe, where 10 inches to 12 inches of bend are cut off. To ensure absolute solidity the casting is next placed in a powerful hydraulic testing machine filled with water at a low pressure, and then a small quantity of high pressure water is admitted until the test pressure is reached, when the pipe is hammered all over. It is next weighed and stamped, and coated with Dr. Angus Smith's composition, and, if required, turned and bored in a special lathe.

The process of manufacture of small sizes is generally similar to that above described, although some of the details differ. The section of the foundry set apart for the manufacture of the usual connecting tees and bend pipes is equipped with a 20-ton electric travelling crane. The firm have made a speciality of reducing these branch and bend pipes to standard dimensions, and now find that engineers, who formerly specified their own dimensions for these castings, gladly accept the founders' standards. Vexatious delays in producing these castings are thus prevented, and the founders are enabled to employ economical plant and manufacture in a sensible fashion.

Before leaving the works it is quite worth the visitor's trouble to visit the shipping department. Here many thousand tons are usually in stock, indeed, quite an extensive waterworks can be furnished from stock. The

loading and stacking arrangements are worthy of notice, an iron shed, with a 5-ton electric travelling crane, running 200 feet per minute, spans the ends of all the pipe stacks, and a railway siding and a roadway, so that castings can be stored and shipped at the minimum risk and expense.

Messrs. Macfarlane, Strang & Co., Lochburn Iron Works, Glasgow.—This business, which was established in 1877, with all the most approved appliances for the manufacture of cast-iron pipes of all sizes, from 1½ inches to 48 inches diameter, for gas and waterworks, has earned for itself a world-wide reputation for its productive capacity, and for the quality of its manufactures.

The works cover an area of 16 acres, and are conveniently situated on the Forth and Clyde Canal, and in close proximity to the North British Railway, a siding from which runs into them. There is also a passenger station on the ground for the use of the workmen, and which is also of great advantage to all visitors to the works, trains calling every thirty minutes.

These works are capable of producing over 1000 tons of pipes weekly. Large contracts have been executed by the company, notably the following:—Bombay Waterworks, 50,000 tons of 48-inch pipes; Manchester Waterworks, 27,000 tons of 40-inch pipes; Sydney Waterworks, 20,000 tons of 42-inch and 48-inch pipes. In addition to these, large contracts have been executed for all sizes of pipes for water and gasworks in Glasgow, Edinburgh, Liverpool, Oldham, Paris, Boulogne, Oporto, Naples, Venice, Constantinople, Tokyo, etc. Within the last year they have delivered about 10,000 tons of 36-inch and 48-inch pipes for Obras de Sahskidad de la Capital, Buenos Ayres.

To maintain and extend their large connection with engineers in all parts of the world, and to meet the various wishes of their numerous clients, the directors have recently made an extensive addition to their works, and they are now in a position to supply pipes in 9 or 12 feet lengths, or, if required, in 3 or 4 metre lengths.

The other two firms which supply cast-iron pipes are Messrs. D. Y. Stewart & Co., St. Rollox, and Messrs. R. Laidlaw & Son, East Milton Street, and their productions are to be found in all parts of the world, and are distinguished for their excellence. The firms which have been mentioned also make the smaller sizes of pipes, but there are several works which only undertake these, such as Messrs. David King & Sons, Keppoch Iron Works; Messrs. John Shaw & Co., Maryhill Iron Works; Messrs. Shaw & M'Innes, Firhill Iron Works, Springbank; and Messrs. Watson, Gow, & Co., Limited, Etna Foundry, Lilybank Road, Glasgow.

Messrs. Glenfield & Kennedy, Ltd., Kilmarnock.—The extensive works of this firm are located in the town of Kilmarnock, about 20 miles from Glasgow. Although the firm is an old one its present title is quite new, and was brought about by the amalgamation of Glenfield Co., Limited, and Kennedy's Patent Water Meter Co., Limited. The latter is the older of the two, having been founded in 1853, at the Town Holm, by the late Mr. Thomas Kennedy, the inventor of the Kennedy water meter, from which the business took its title. In 1869 the works were moved to new and more commodious premises in the south end of Kilmarnock, specially built for the manufacture of the meters. The Glenfield Co., Limited, came into existence in 1865, and was famed for the manufacture of castings for meters, and of water fittings, and hydraulic machinery of every description. Four years later new premises were erected specially to meet the require-

ments of the growing trade. Extensions and alterations to the works have gone on almost unceasingly, until the full extent of ground available on the west side of the river Irvine has been taken up. Lately about 12 acres were acquired on the east side of the river, this additional purchase having been effected just at the time of the amalgamation of the two concerns.

When the present extensions are completed the works will cover a total superficial area of about 24 acres. The two portions separated by the river Irvine are connected by two bow-string girder bridges belonging to the company, while a third bridge, in course of erection, is provided by the Glasgow & South-Western Railway Company, and will connect the works with their new railway.

The workshops, which are all paved with wood, are equipped with modern machinery adapted to every process in the complex industry carried on, and they employ about 1400 persons, most of them being highly skilled and experienced workmen. The offices are spacious and well lighted, and those within the yards are supplied with electric light. There are ten steam boilers and eight engines, the combined power exceeding 300 horse-power, but to cope with the present extension of their works a large power station has just been built, where ultimately two sets of triple-expansion pumping engines (one set already at work) and two sets condensing steam engines with dynamos will be added to the existing plant, which includes, besides the engines and boilers mentioned, three dynamos driving four electric motors and lighting twenty-four arc lamps. There are also three sets of three-throw and one set of double-throw hydraulic pumps, pumping into four accumulators at 750 lbs. pressure per square inch. Throughout the works are twenty-two hydraulic cranes, six steam cranes, nineteen hand cranes, ten overhead cranes, and twenty-six Smith cranes. The new foundry will be equipped with a 60-ton overhead electric travelling crane, and to the pillars of the shop hydraulic cranes will be fixed. Testing appliances are fitted up in the various departments adaptable to the work produced.

This firm turns out enormous quantities of sluice valves, water meters, hydrants, taps, and fountains of every description, sanitary appliances, fire extinguishing apparatus, and everything in the shape of hydraulic machinery, steam pumping engines, pumps, cranes, hoists, capstans, presses, etc. Up to the present time 150,000 meters have been made and despatched to all parts of the world. Every meter is carefully tested before being sent out, and is correct within 1 per cent., and all sluice valves, hydrants, cocks, etc., are similarly tested before despatch.

This firm controls an extensive trade both in the home and export markets, and ship largely to India, Africa, China, Japan, South America, Australia, New Zealand, and France, in which latter they possess a branch works and offices in the city of Paris. It has an interesting exhibit in the Glasgow International Exhibition, and its fittings are to be seen in all parts of the buildings.

Many of the engineering firms mentioned under the heading "General Mechanical Engineering" manufacture pumping engines, hydraulic machinery and fittings of all kinds, as, for instance, Messrs. Andrew Barclay & Sons, Kilmarnock, and Messrs. Fleming & Ferguson, Paisley; Messrs. D. Stewart & Co., Glasgow; and reference should be made to the notices under that heading. Among special manufacturers of pumps and pumping machinery may be mentioned Messrs. Drysdale

& Co., Bon-Accord Engine Works, Glasgow; and Messrs. J. H. Carruthers & Co., Polmadie Iron Works, Glasgow; Messrs. Clarkson Brothers, City Engine Works, High John Street, Glasgow; and Messrs. A. & P. Steven, Provanside Engine Works, in addition to a general mechanical engineering trade, make a speciality of hydraulic and other hoists, both for goods and passengers, and in recent years such appliances have been very widely used.

SANITATION, LIGHTING, AND HEATING APPLIANCES, Etc.

Under this heading might be included a very large number of establishments of all sizes and varieties, but as they are, for the most part, not directly connected with what is usually understood as mechanical engineering, we shall only notice a few representative firms. The names of many others may be obtained by consulting the Glasgow Post Office Directory.

Messrs. Robert Boyle & Son, Ltd., 110 Bothwell Street, Glasgow, and 64 Holborn Viaduct, London, E.C.—The productions of this firm are so well known and so highly appreciated by all who understand their qualities that it is unnecessary to do more at present than refer to them. They are used in every part of the civilised world, the chief works of the firm being in Glasgow and London, with branches in the principal continental countries and British colonies, in the most of which the ventilating and sanitary appliances of the firm are manufactured, to save the expense of duty and carriage. The firm publishes elaborate catalogues, and keeps the public so well informed, by means of papers and circulars, of the work which it is doing, that any one who wishes to obtain information regarding it has no difficulty in doing so. A representative collection of its productions is shown at the Glasgow International Exhibition.

Messrs. David King & Sons, Keppoch Iron Works, Glasgow.—This firm of artistic, general, and sanitary ironfounders had its origin in 1874, when Mr. David King, sen., took his eldest son John to found the business in Keppoch Iron Works, Keppochhill. In 1875 Messrs. David King & Son bought the firm of Messrs. Blair & Miller, Saxon Foundry (formerly the Sun Foundry), with all the plant, patterns, and appliances connected therewith, which at once gave them a full equipment of plumbers' goods, as well as ornamental railing, structural ironwork, etc., and the work of the firm extended in several departments.

In 1885 other three sons of the founder joined the firm, and on account of the extended business the works were removed to Possilpark, where on an admirable site new workshops were erected and fitted with all the most improved appliances. In 1890 the whole of the patterns, plant, etc., of Budhill Iron Works, Shettleston, belonging to Messrs. Brown, Hendry, & Haddow, who manufactured high-class ranges, register and tiled grates, was also purchased by Messrs. David King & Sons, who transferred them to their own works, and erected grinding mills, etc., for this trade, which was added to the now numerous branches of business.

The works are now under the personal supervision of Mr. John King, who has been at the head of the firm since 1892. Among the productions may be mentioned electric pillars, bases and brackets, section boxes, finials, coltars, troughs, hot-water pipes, soil and drain pipes, bandstands, verandahs, balconies, stable fittings, school fittings, fountains, baths, lavatories, clock towers, railings and gates, ranges, registers, etc.

For the convenience of its customers, the firm has established warehouses and offices in Aberdeen and in Leeds, and every effort is made to meet the demands of those parts of the country as regards the design and make of the different classes of goods. Its export trade has largely developed in recent years, and besides sending goods to continental ports, the firm exports to Egypt, India, China, Australia, New Zealand, South Africa, North and South America, West Indies, etc. The firm's products have been used by all classes, from H.M. the King to the humblest cottager, and to every country in the world have its specialities been sent.

Messrs. Walter Macfarlane & Co., Saracen Foundry, Possilpark, Glasgow.—The productions of this well-known firm are to be found in every part of the civilised world, so that it is unnecessary to enter into a detailed description of them. The firm stands *facile princeps* in the exposition of foundry work pure and simple, and its productions mark the highest development and technique in the lighter branches of iron founding. It was founded in the year 1850 by Mr. Walter Macfarlane, in premises in Saracen Lane. Later a move was made to Washington Street, and at length, in 1871, the site of the mansion and grounds of Sheriff Alison, the historian, was acquired, and the present extensive works were erected thereon, subsequent extensions being made from time to time, until an area of nearly 24 acres is now occupied.

The construction of the foundry is artistic and elegant, and a striking demonstration not only of their own resources, but of the wonderful possibilities of the trade it represents; and the showrooms of the works contain numerous specimens of the productions of the firm, and they all show a very high standard of design and workmanship. A perusal of the general illustrated catalogue of castings indicates to a still greater extent the wide range of the firm's productions. We must refer to that publication for all details, which will be found to include every department of ornamental cast-iron work. The excellence of these productions have not only been recognised by the general public, but they have been awarded medals at all the most important International Exhibitions which have been held during the latter half of last century.

Messrs. D. & J. Tullis, Ltd., Kilbowie Iron Works.—For some notes on the general mechanical engineering work done by this firm see p. 61. The laundries of this country are indebted to Messrs. Tullis for several of the best-known inventions in the way of machinery. Especially is this the case with regard to asylum, hospital, union, and the laundries in connection with kindred institutions, and in this respect they have proved their ability to keep abreast of the times.

In connection with their laundry machinery branch may be mentioned their four-roller drying, ironing, and finishing machine, which has a capacity equal to any two single-roller machines. The merit of the machine is well-known to buyers, as is evidenced by the fact that 300 of them are now at work in the United Kingdom. The latest machine for institution purposes was introduced by Messrs. Tullis, and after a severe test at Guy's Hospital in London, it has been adopted by several of the largest institutions in the Metropolis. This machine is specially designed for cleansing and disinfecting foul bed linen, surgical dressings, etc., and is a valuable addition to an institution laundry. It is interesting to note that one of these machines, connected to a small portable boiler and engine, is now doing service with one of the field hospitals in South Africa.

Messrs. Smith & Wellstood, Ltd., Columbian Stove Works and

Bonnybridge Foundry.—The founders of this firm were Scotch by birth, but in their early years they emigrated to the United States, where they gained experience in American designs and methods of work. They recognised that in many respects these were superior to those of Scotland, and, after some years, they came back to their native country, got out their patterns, and contracted with local foundries for their castings, and soon thereafter opened a warehouse in Union Street, Glasgow, for the sale of American stoves.

As their business developed, they entered into partnership with Mr. George Ure, Bonnybridge, and established the "Columbian Stove Works and Foundry," although the sale of the stoves was entirely in the hands of the firm of Smith & Wellstood. The stove trade developed rapidly, and, moreover, the excellence of the castings of the firm brought a large founding trade. For a good many years the Singer Manufacturing Company obtained all their castings from this firm until they started a foundry of their own. After some time the two departments were separated into different firms, but in 1890 the two firms which had parted company under their founders became again united under the sons of the founders, and they maintain their reputation for the production of the most modern and improved types of ranges, registers, and all other heating, cooking, and architectural castings. The firm has large warehouses in Glasgow and London, and in addition to a large home trade it supplies many foreign markets, especially Australia, New Zealand, Tasmania, South Africa, South America, and several European ports.

There is a large number of other foundries in Glasgow and neighbourhood, and in the Falkirk and Kirkintilloch districts, which supply sanitary, heating, and lighting appliances; but for our present purpose it is not necessary to enter into details regarding them. The firm of Messrs. Shanks & Co., Limited, Barrhead, is one of the most important which devotes attention wholly to sanitary appliances such as are used in houses and ships. It has warehouses in Glasgow, Manchester, London, and Dublin.

AGRICULTURAL IMPLEMENTS AND MACHINERY.

Messrs. Alex. Jack & Sons, Maybole.—This firm was founded by the late Mr. Alexander Jack, who began business in 1835 as a wood merchant, occupying sawmills driven by water power about four miles from Maybole. The site is now merged in the demesne of the beautiful residence of James Coats, Esq., of Auchendrane. He afterwards turned his attention to the making of carts and agricultural implements, and this business developing in his hands, he removed, in 1852, to Maybole, erecting there large works, with suitable appliances for more extensive and systematic production. The business prospered, and on the decease of Mr. Jack in 1877 it passed into the hands of Mr. J. Marshall, his son-in-law, who is sole partner of the firm, and who has been associated with it for fully thirty years.

The works at Maybole occupy about five acres of ground, and employ 150 hands. The largest shop is the engineers' shop, which is 200 feet long and 100 feet broad, and is replete with the various kinds of tools necessary for speedy and economical production. Then there are the smithy, foundry, and wood working shops, all fitted with the latest appliances. The large woodyards filled with timber in all stages of preparation are indications of the nature and extent of the work done. Besides the Maybole works, the

firm has a branch establishment at 20 Graham Square, Glasgow, which includes a large showroom, in which are to be seen specimens of the firm's productions.

These include almost every kind of agricultural implements and machinery, together with carts, vans, lorries, etc., and timber for railway and pit purposes. The founder of the firm was one of the pioneers of the reaping machine trade in Great Britain, having started their manufacture in Maybole in 1856, and the firm has kept in line with all the developments which have taken place, and its machines are well known all over the country. The potato digger is, however, *the* speciality of the firm, and they claim for it that for perfection of work it is without an equal in the wide universe. At the last great field trials held at Leicester in 1896 under the auspices of the Royal Agricultural Society of England, it was awarded the first prize of £20, beating all comers; and in the following year it gained the first prize at the Norwegian Government's trials, defeating machines of the leading foreign and English makers. A new patent seat, fixed to the side of the machine, clear of the wheels and within easy reach of the lever, is a valuable addition to the machine. One of the most recent developments of the work of the firm is the making of manure distributors, and they have proved very successful.

The products of the firm find a ready market throughout the United Kingdom and Ireland. Their principal export trade is in potato diggers, which are sent in large quantities to Norway, also to Sweden, Denmark, Belgium, France, Natal, New Zealand, and other countries. Reapers and mowers are shipped to Natal in quantities, and also to South America. Manure distributors command a large market in South Africa, and several have been sent to the Continent. Harrows are also exported in large quantities.

Messrs. John Wallace & Sons, Ltd., Graham Square, Glasgow.—The business of this firm was founded about forty years ago by the late John Wallace, father of the two present managing directors, James and William Wallace. The firm is now a private limited company.

The principal manufactures are mowers and reapers, potato diggers, turnip sowers, land rollers, and various kinds of agricultural implements. They are mostly sold to British agriculturists, some of them being exported to the British colonies and South America. Chop making and horse provender machinery for grain merchants are also specialities of the firm, which also extensively imports Canadian and American agricultural implements and machines. The regular employees of the firm are fully one hundred.

Messrs. A. & J. Main & Co., 54 Gordon Street, Glasgow; P. & R. Fleming & Co., 29 Argyle Street, Glasgow; and Kemp & Nicholson, Stirling, also supply a considerable variety of implements and apparatus for agriculturists.

INSTRUMENTS AND MISCELLANEOUS APPLIANCES.

Messrs. Barr & Stroud, 250 Byres Road and 44 Ashton Lane, Hillhead.—These works are devoted to the manufacture of range finders and other scientific instruments. The attention of Professors Barr and Stroud was first drawn to the demand for an efficient range finder by an advertisement which appeared in the engineering journals in 1888, stating that the Secretary of State for War was prepared to receive proposals for a range finder that would meet certain specified requirements, and be suitable for use in the

field by infantry forces. Their consideration of the problem thus brought to their notice resulted in the invention of the single observer range finder now known by their names. A design embodying many of the essential features of the instrument now extensively in use, was submitted to the War Office authorities and accepted by them, along with several others, for preliminary trial. An instrument, having a base length of 3 feet, was accordingly constructed and entered for test, with the result that it was accepted for further trial along with two others, both of which were of the two observer type. Meantime, the preparation of a new instrument of 30 inch base was begun, and it was only finished on the eve of the final trials. It embodied several new and untried features, and, proving less satisfactory than the original one, it was rejected in favour of the Watkin Mekometer.

Professors Barr and Stroud then turned their attention to the design of range finders and telemeters of other types for military and surveying purposes, some of which are described in a paper published *in extenso* in the report of the British Association for the Leeds meeting of 1890. In 1891 they, along with a few others, received a special invitation to submit proposals for range finders for naval use to meet more stringent conditions than those specified by the War Office. The single observer type appeared to be the only one that could be successfully used on board ships, and accordingly it was re-designed on a larger scale than the one proposed for infantry use. The design was selected for trial. A range finder of 5-feet base was constructed, embodying many improvements in detail, and after preliminary and final trials in 1892 and 1893 against instruments of other types it was selected by the Admiralty as the one that should be practically tested at sea. The first trials under service conditions were carried out by Professor Barr on board H.M.S. "Blenheim" during the Naval Manœuvres of 1893 in the English Channel and the Irish Sea, and those were followed up by further tests by naval officers at gunnery practice and in cruising.

The range finder was adopted by the Admiralty, and up to the end of 1900 some 180 instruments have been supplied to H.M. navy. They are now fitted on all battleships and cruisers. They are also in use in nearly every other navy in the world, notably in that of Japan, which has 47 instruments. The total number supplied up to the end of last year was about 300. The same type of range finder has also been supplied for use in fortresses in this and other countries, and for use by the field artillery, the mountings being arranged to suit the different conditions of the various services.

At first the instruments were constructed by the inventors themselves from details manufactured for them by various firms, but as the demand rapidly increased it became necessary in 1895 to train a staff of men to carry out the very delicate optical and mechanical adjustments of the range finder, and to manufacture the more delicate and special details. A workshop was accordingly started at 250 Byres Road, with a staff numbering at first three or four in all, but the work rapidly increased beyond the capacity of the original premises and an additional workshop in Ashton Lane was acquired in 1899, and equipped with the most modern tools. This workshop again is already much too small. The number of men now employed by the firm is about one hundred, being limited to that number by the size of the premises, and a great deal of work on structural details is done by Messrs. Kelvin & White, Limited, and other firms.

Some years ago the Admiralty requested the firm to devise instruments for communicating information regarding ranges and orders from the conning towers of vessels to the various gun stations, and after many designs had been made and tested, a satisfactory system was arrived at. The instruments proved entirely satisfactory on trial, and already some 36 transmitting instruments and 300 receiving instruments have been supplied for use on war vessels and in fortresses. They can be modified for other purposes where information has to be sent from one station to one or more stations at a distance.

The other manufactures of the firm are the Barr & Stroud high vacuum pumps used in electric lamp works and laboratories for the evacuation of incandescent lamps and Röntgen bulbs, electrically controlled clocks on the Barr, Stroud & Becker patent, helm indicators for showing automatically on the bridge of a ship the exact position of the helm, and other like appliances. The firm undertakes no general manufacturing, but confines its attention to the production of its own patented specialities. The Byres Road premises, which are now used as offices, drawing office, pattern shop, and testing laboratory, are lighted by current from the Corporation mains, while the works in Ashton Lane are lighted from a dynamo driven by the gas engine, which also supplies the motive power for the workshop.

Messrs. T. S. M'Innes & Co., Ltd., Clyde Place, Glasgow. This firm, which manufactures engineering and mathematical instruments, is best known by the "M'Innes" patent steam-engine indicator, which has been before the engineering world for the past thirteen years, and which, judging from its extensive sale, especially for marine and high-speed steam and gas engine purposes, is evidently much appreciated. It has been adopted, and is very largely used by the British Admiralty.

The business was founded about fifteen years ago by the late Mr. T. S. M'Innes, and was acquired by Mr. John C. Dobbie in 1893, who formed it into the present company. Since that date the demand for the productions of the firm has steadily increased. Recent exhaustive improvements have resulted in an improved form of their indicator, which has been kept up to the exacting demands of present-day engineering practice, and the firm is now in a position to supply no less than four different types of the instrument, and so adapt it to every purpose, speed, and pressure for which indicators are employed.

Special mention may be made of the external pressure spring type, in which the spring is not enclosed in the steam cylinder, and is thus kept comparatively cool when in use, so that not only are the results obtained more accurate, but the spring is kept in better preservation, and can be confidently depended upon for a much longer period. This type of indicator is recommended for high pressures, for engines using superheated steam, and for gas and oil engines. It is made in two sizes for maximum speeds of 250 and 800 revolutions per minute respectively. The enclosed pressure spring type of the instrument is free from complications of any nature, of strong construction, and capable of giving large sized cards. It is specially made for marine engines, and is very largely specified by superintending engineers. Other types include an indicator made entirely of steel for use on ammonia compression machines. To ensure comfort in manipulation all these indicators have the handling parts sheathed with vulcanite.

They are further fitted with case-hardened steel pistons of an entirely novel design, and have many other minor but important advantages, which have been secured by patents.

In addition to indicators, the following articles are manufactured in large quantities:—Steam pressure vacuum and hydraulic gauges, revolution counters and speed indicators, calorimeters, clocks for ship and engine room use, and general engine and boiler fittings.

Agents represent the firm in various parts of the world, and the goods, especially indicators, are regularly shipped to Norway, Denmark, France, Italy, Russia, South Africa, India, China, Japan, Australia, South America, and Canada, and they are gradually being adopted by foreign Admiralties.

Messrs. Kelvin & White, Cambridge Street, Glasgow, make a great variety of instruments and appliances used by engineers. (See page 51.)

Messrs. David Carlaw & Sons, Finnieston Street, Glasgow, make high-class engineering models of all kinds, and a great variety of special appliances. (See page 45.)

Messrs. Kelso & Company, 47 to 57 Oxford Street, Glasgow, manufacturing opticians, electricians, and model makers. This firm makes a speciality of ship's models, and has supplied them to the chief shipbuilders at home and abroad. It also undertakes scientific apparatus of every description to order, and has, for instance, supplied the dynamo-metric apparatus for experiments with ship's models used by Messrs. William Denny & Brothers, the Italian and the Russian Governments. They also supply models to the designs of inventors, and thus are useful in assisting them in perfecting their inventions.

Messrs. Mackenzie & Co., 17 Douglas Street, Glasgow, opticians, model makers, electrical and philosophical instrument makers, and engravers, are well known among Clyde engineers and shipbuilders for their models and instruments.

Messrs. Schaffer & Budenberg. — This well-known firm has a branch establishment at 5 Wellington Street, Glasgow where they have a stock of their steam and hydraulic pressure gauges injectors, governors, reducing valves, steam traps, engine counters, steam-engine indicators, and other specialities.

The most important **Weighing Machine** makers are—

Messrs. Anderson Brothers, warehouse, 35 Stockwell Street; works, 29 South Shamrock Street, Glasgow—who supply every description of weighing apparatus used in shops, stores, warehouses, workshops, docks, and coal depots.

Messrs. W. & T. Avery, Ltd., who make every description of weighing apparatus, including weigh-bridges for railway waggons, lorry, and cart machines, hutch machines; also all the weighing requisites for ordinary commercial purposes. Showrooms, 8 and 10 Stockwell Street; works and office, Dumbarton Road, Partick.

Messrs. Henry Pooley & Son, Ltd., contractors to H.M. Government, British and foreign railways, patentees, and manufacturers of every description of weighing apparatus for railways, iron works, collieries, mills, warehouses, farms, etc., 22 Queen Street and 25 South [illegible]ing Place, Glasgow.

[illegible]rs. R. & J. Dick, Greenhead Works, Glasgow, supply patent

driving belts of gutta-percha, canvas, and balata, which possess great durability, enormous driving strength, perfect steadiness and smoothness in working, and entire absence of stretching or slipping.

Messrs. John Tullis & Son, St. Ann's Leather Works, Glasgow, supply all kinds of mechanical leathers for belting and other purposes. Their patent leather link chain belting is well known to engineers, and highly appreciated for its efficiency and durability.

MARINE ENGINEERING AND SHIPBUILDING.

The Clyde, which we have accustomed ourselves to call the premier shipbuilding river of the world, is perhaps the least endowed by nature of any to be the mother of great ships. It is not one of Nature's great waterways. For the better part it is narrow, comparatively shallow, and moderately tortuous, and it does not fill the eye as some others do. Yet its shipbuilders and engineers have accomplished much more than others, and Clyde men have been associated with practically every scientific advance in naval architecture of the last century. The first passenger steamer ever built in Britain was launched on its waters, and for a considerable number of years the development of the type was in the hands of local men. The earliest Cunarders were built on its banks, and through all the transitions—wood to iron, iron to steel, paddle to single screw, single screw to twin-screw—its shipyards have been represented by notable vessels. The practicability of compound and triple-expansion engines was first demonstrated in Clyde-built vessels, and lately the principle of quadruple-expansion has also been successfully applied. In fact, the history of the Clyde from the building of the "Comet" to the floating of the "Good Hope" is neither more nor less than the history of the steamship.

It would be impossible to bring within the compass of an account like this the whole history of Clyde shipbuilding. And it is not at all necessary. The shipbuilding of earlier times was pretty much what readers may know it to have been elsewhere. The story of the steamer from 1812 onward is one that has been told in detail even to tediousness.

What impresses the man who comes to the Clyde after an absence of many years is probably the tremendous industrial development that has taken place. Not altogether the scientific development; that is a necessary corollary of the quarter-century's enormous commercial expansion. Commercial necessities have been the mothers of inventions. And it is not intended to convey the impression that we think the Clyde alone, of all shipbuilding centres, has increased its productive powers in keeping with the times. The development of Belfast and of the North-East coast of England has been just as wonderful. But variety distinguishes the industry on the Clyde above all others, and its record is one of progress all along the line. The operations of its builders are not restricted to the production of one or two or three types. The building of everything that may be called a ship has been undertaken at any cost, and when you speak of Clyde shipbuilding you speak of the whole range of naval architecture.

On the Clyde is built every kind of sailing craft, from the tender rater of Fairlie to the square-rigged wind-jammer of Port-Glasgow, and every kind of steam yacht from the speedy Daimler motor to the sumptuously fitted "Lysistrata." Renfrew sends dredging plant to every part of the world, and year by year the fleet of barges and launches and sternwheelers for inland waters grows greater. Of the making of many "tramps" there is no end—at least, there seems to be no end. And greater speed and more sumptuous fittings mark the constantly increasing fleet of passenger steamers, from the fast cross-Channel express boat to the twin-screw Atlantic liner. And the tale is never told of the fighting ships—the flying destroyers, the cruisers, and the battleships.

Later on it is proposed to deal with the development of particular types; in these preliminary observations the desire is to show how the output has increased, and incidentally how the greater demand for shipping has been met. The task, however, looks much easier than it is, for there is no possible way of measuring the increase of productive power. The acreage covered by Clydebank and Fairfield indicates nothing, for in both establishments there have been considerable extensions within the original limits of the yards. Longer building berths have been provided, and bigger subsidiary shops erected without any perceptible inconvenience to anybody. At other places, notably Meadowside, additional ground certainly has been acquired, but in the majority of cases the demand for bigger ships has been met within the limits of existing accommodation.

Similarly it is impossible to convey any idea of the vast improvement that has been brought about by the modernising of shipyard and engine shop machinery, for the mere number of new tools introduced expresses practically nothing. We know that both in number and in power the steam and hydraulic tools have been enormously increased within the past decade, but we cannot measure the advance except by the work they do. Except in the case of Messrs. Russell & Co., the area covered by the works of the firms in the following table is practically the same in every year:—

COMPARISON OF ANNUAL RETURNS.

	1900 Tons gross	1890 Tons gross	1880 Tons gross
Russell & Co.,	54,413	70,370	10,205
Stephen & Sons,	34,555	16,841	19,005
Connell & Co.,	32,316	18,012	7,742
Denny & Bros.,	30,603	16,286	18,112
Scott & Co.,	29,970	15,822	11,850
Henderson & Co.,	29,045	21,196	12,341
*Brown & Co.,	26,250	14,800	7,900
Hamilton & Co.,	23,482	5,851	3,042
Caird & Co.,	22,714	16,318	7,227
†Napier & Miller,	21,518	5,616	2,625
Rodger & Co.,	19,615	—	—
Fairfield Co.,	17,765	33,705	33,262
Barclay, Curle & Co.,	17,650	19,496	6,959
Simons & Co.,	15,700	4,310	1,100

* Formerly Clydebank Shipbuilding and Engineering Company, Ltd., and James and George Thomson & Co., Ltd.
† Formerly Napier, Shanks & Bell.

M'Millan & Son, - -	15,010	5,280	13,815
Duncan & Co., - - -	12,000	10,742	5,025
Dunlop & Co., - - -	8,320	2,385	2,603
Lobnitz & Co., - - -	8,100	3,553	2,100
Inglis & Co., - - -	7,451	11,554	10,735
*Beardmore & Co., - -	6,250	5,650	5,866
Lon. & Glas. Co., - -	4,700	3,600	10,322

How greatly the resources of the shipyards have been increased may be inferred from these figures. The revolution in the engine and boiler shops has been, if anything, greater. Heavier engines and bigger boiler plates have called for the introduction of more powerful tools, and in the cases of many firms on the Admiralty list expensive plant has had to be provided for the making of Belleville boilers. The increase in the total i.h.p., which the following table shows, is, of course, partly due to the higher speeds, but the figures, nevertheless, are a fair index of the industry's development: —

I.H.P. OF ENGINES BUILT ON THE CLYDE.

	Total I.H.P.
1900, - - - - - - - - - - -	458,938
1899, - - - - - - - - - - -	478,503
1898, - - - - - - - - - - -	510,815
1897, - - - - - - - - - - -	373,195
1896, - - - - - - - - - - -	426,759
1895, - - - - - - - - - - -	363,490
1894, - - - - - - - - - - -	295,620
1893, - - - - - - - - - - -	256,545
1892, - - - - - - - - - - -	322,564
1891, - - - - - - - - - - -	308,886

But perhaps a better measure of the district's activity is to be found in the number of men employed. The figures which are used are based on official returns, and refer only to shipyards. Apprentices are included. The figures relating to engine and boiler shops are not included, for the reason that the association of engineering employers did not always embrace anything like a majority of the firms, and reliable statistics are not available: —

HANDS EMPLOYED IN CLYDE SHIPYARDS.

1900, - - - - - - - - - - -	25,500
1899, - - - - - - - - - - -	22,750
1898, - - - - - - - - - - -	23,780
1897, - - - - - - - - - - -	18,650
1896, - - - - - - - - - - -	23,280
1895, - - - - - - - - - - -	20,250
1894, - - - - - - - - - - -	16,500
1893, - - - - - - - - - - -	12,800
1892, - - - - - - - - - - -	14,000
1891, - - - - - - - - - - -	21,100

The production of the last decade is, of course, far and away greater

* Formerly Robert Napier & Sons.

than that of any preceding ten years. Comparisons would be idle. But the effect of bigger ships and greater powers of production may be judged from the following table. The totals are in every case for the ten years which ended in December last, and the figures are the builders' own:—

TEN YEARS' SHIPBUILDING ON THE CLYDE.

	Sail.		Steam.		
	Vessels.	Tons.	Vessels.	Tons.	Total Tons.
Russell & Co.,	121	214,508	95	253,402	467,910
Connell & Co.,	33	62,674	55	220,464	283,138
Denny Brothers,	53	21,248	133	243,035	264,283
Stephen & Sons,	3	5,807	57	231,761	237,568
Brown & Co.,	20	7,200	65	213,139	220,339
Fairfield Co.,	3	4,959	50	206,771	211,730
Henderson & Co.,	42	7,728	49	187,772	195,500
Scott & Co.,	16	21,165	67	156,723	177,888
Caird & Co.,	—	—	34	171,073	171,073
Barclay, Curle & Co.,	16	36,336	44	123,858	160,194
Hamilton & Co.,	19	36,345	51	111,274	147,619
M'Millan & Son,	34	45,453	43	83,993	129,446
Rodger & Co.,	23	41,072	36	78,455	119,527
London & Glasgow Co.,	—	—	34	111,605	111,605
Beardmore & Co.,	4	700	41	103,956	104,656
Simons & Co.,	—	1,250	95	77,956	79,206
Duncan & Co.,	18	37,425	24	36,171	73,596
Inglis & Co.,	4	475	44	66,793	67,268
Lobnitz & Co.,	57	6,856	99	59,124	65,980
Napier & Miller,	34	5,865	32	58,190	64,055
Mackie & Thomson,	7	13,507	222	45,967	59,474
Ailsa Co.,	8	9,968	65	41,534	51,502
Dunlop & Co.,	9	1,225	35	45,530	46,755
Fleming & Ferguson,	10	2,800	79	42,400	45,200
Campbeltown Co.,	—	—	28	41,146	41,146
Reid & Co.,	23	8,427	38	22,067	30,494
Murdoch & Murray,	—	—	73	30,258	30,258
Carmichael, M'Lean & Co.,	2	240	26	22,750	22,9[illegible]
Scott & Sons,	—	10	62	22,054	22,06[illegible]
Alley & MacLellan,	68	15,474	32	3,719	19,19[illegible]
Fullerton & Co.,	—	—	65	19,189	19,189
Blackwood & Gordon,	—	—	22	18,611	[illegible]
Ritchie, Graham & Milne,	82	7,522	61	7,393	14,915
M'Knight & Co.,	—	36	36	14,405	14,441
M'Arthur & Co.,	9	1,444	58	9,669	11,113
Shearer & Son,	—	22	20	8,494	8,516
Irvine Co.,	—	—	28	8,080	8,080
Seath & Co.,	7	1,012	26	4,614	5,626
Minor Firms,	—	10,667	—	15,673	26,340
Total Tons,		629,420		3,219,068	3,848,488

The bulk of the tonnage in the foregoing table was, of course, for British owners, but a considerable number of Clyde-built vessels have always been

for foreign firms or companies. The proportion of foreign to British tonnage 1891 follows:—

FOREIGN TONNAGE PROPORTIONS.

1891,	0·267
1892,	0·213
1893,	0·147
1894,	0·125
1895,	0·332
1896,	0·267
1897,	0·282
1898,	0·230
1899,	0·200
1900,	0·325

THE PASSENGER STEAMER.

The latter half of the Victorian era, with its amazingly brilliant record of scientific progress, will always be memorable as that in which the modern steamship was evolved. Other—possibly more notable—achievements are as prominently associated with the period, but none more strikingly illustrates what may be called general progress. Since the British Association last met in Glasgow, the four corners of the earth have been drawn much closer together. The United States have emerged as a great mercantile power; the far East has come into the councils of the civilised nations; and Britain's colonial possessions in Australasia, North America, India, and Africa have prospered abundantly. The trade of the world has expanded enormously, and the coming and going of people is immense. The development of the steamship has been concurrent with this change, and from the first it has been in the hands of British shipbuilders almost exclusively. At the moment Germany and the United States threaten our supremacy, and, by economic means which do not commend themselves to our statesmen, are nursing national industries into importance; but with all the fostering care of foreigners the shipbuilding output of the United Kingdom is still by far the greatest in the world.

The high place the Clyde occupies amongst shipbuilding centres is an honour on which the average Scotchman is not slow to congratulate himself. And even the Englishman from the North-East Coast admits that his pride is, in a measure, just. The development of the steamship, from the "Comet" to the "Campania," can be graphically shown in a series of Clyde models, such, for instance, as the series which may be seen in the Exhibition, and the records of leading Clyde firms is the whole story of what Chief Constructor Harry Williams—obviously not a Scotchman—calls "The Steam Navy of England." In much the same way every other development could be traced, so that, if variety alone be taken into account, the Clyde is indisputably the premier shipbuilding river of the world.

The early history of the steamship is a fascinating subject, but it need not be recounted in an article of this description. For our purpose, the period beginning in 1870 will be sufficient; and to facilitate the review it may be well to sub-divide passenger steamers into (1) ocean steamers, (2) channel steamers, (3) river steamers. In all these sub-divisions the tendency has been towards increase of size, speed, and luxury, and in every case it has been accelerated by the expansions noted on another page.

The high-speed, luxuriously fitted Atlantic liner is a just measure of America's growth; the slightly slower, but as palatial, P. & O., Cape, or Royal Mail boat reflects the accumulating prosperity of distant colonial possessions; and the fast, beautifully appointed channel or river steamer indicates the growth of wealth which has evolved the modern hotel and the corridor express train.

The problem of the engineer and the shipbuilder has been to make them economically possible, and naturally enough they have found its solution no ordinary task. Practically nothing is impossible to their skill, but obviously commercial success is essential to their existence.

To meet the different conditions of different services, there have necessarily been variations, and possibly the straightest line—certainly the highest development—is to be found on the Atlantic. One need not take the "Great Eastern" into account, for high pressure and surface condensation solved the problem which Brunel attempted to solve by bulk. When the period selected opened, the problem was concerned less with the hull than with machinery. Wood had given way to iron as material, and the majority of the vessels were still of the paddle type. Fourteen years previously John Elder had demonstrated the economy of the compound engine, first in the "Brandon," and subsequently in the Pacific Steam Navigation Company's "Valparaiso" and "Inca," but it was not until the advent of the screw Inman and White Star liners that the principle was applied to the propulsion of Atlantic steamers. Experience proved the benefit of the change, and the result was a fuller application of the principle. The completely jacketed cylinders of the engines of the "Admiral" and the "Callao," and the improved balance of driving forces, marked another notable advance, and with higher initial pressure and greater rates of expansion the economy became gradually more notable.

There were, however, many obstacles to progress, and some of them at the time seemed impassable. A great difficulty then, as now, was the boiler, which had to be of iron, and, to satisfy the Board of Trade and Lloyds, of exceptionally thick iron. Under the new conditions, too, the cylindrical furnace was liable to collapse, and altogether the engineer was at his wit's end to get the necessary power at a satisfactory weight. The table which appears further on shows the rise in pressures, and illustrates the general advance.

Singularly enough, the water-tube boiler suggested the next advance, for to meet the difficulties I have stated generators of that type were tried. To utilise steam of such high pressure as the water-tube boiler gave, Dr. Kirk—like John Elder, a Clyde man—"invented" the triple-expansion engine, and fitted a set on board the steamer "Propontis" in 1874. "The engines," says the author of "Our Ocean Railways," "gave perfect satisfaction; but," he adds, with almost brutal frankness, "the chambers over the fires of two of the boilers were burnt, and eventually burst."

The failure of the first examples of the water-tube boiler marked a halt in the development of the Kirk idea, but progress began again in 1877 or 1878, when mild steel, through improvements in its manufacture, became suitable for the construction of marine boilers. The strength and lightness of the steel as compared with the existing material were very marked, and with every possibility of further improvement the way of the engineer became easier. The safe limit of steam pressure was raised, and the cylindrical furnace in time gave way to the corrugated furnace associated with the name of Mr. Fox.

From this stage onward the development of the marine engine has been

constant, and it is not difficult to trace the various contributory causes of its greater economy. The gradual perfection of manufacturing processes has made possible a great reduction of weight, and experience has suggested many minor improvements of the working parts of the machinery. With higher pressure still, the economy of the quadruple-expansion engine has been proved, although the application of the principle has not been yet on any very general scale. The introduction of forced draught and the balancing of engines are notable contributions to the development which, in its later stages, however, is remarkable more for its general progress than for striking innovations.

As the tabulated statement shows, the Atlantic liner has greatly increased in speed since 1870, and as speed involves other considerations, I have deferred reference to it. The economical results of high speed may, as Dr. Inglis showed a year or two ago, be doubtful, but ocean greyhounds are nevertheless necessary. The rapidly increasing traffic between the United States and Europe called for bigger and faster ships, and bigger and faster ships meant more powerful engines. The increase of power and speed is seen at a glance. But there was naturally a limit to the power which could be used with single shafts and single screws, and twin-screws worked by separate engines were the result. The "Campania" is perhaps the last development in this direction to the credit of the Clyde, and the German built and owned "Deutschland" represents the type at its highest water-mark. The "Deutschland" holds the Atlantic record for power and speed, and she depends almost entirely on the passenger traffic. Bigger and more powerful ships are certainly possible, but if progress much exceeds the dimensions of the "Celtic," in the immediate future there will have to be a wholesale overhauling of the accommodation in harbours and docks. That, however, is another story.

The greater power of modern machinery has been obtained with remarkable economy, and the possibilities of further progress within existing limits are by no means exhausted. The boiler still is the stumbling-block to progress in marine engineering. With all the drawbacks, however, the engineer has done nobly, as the figures in the table on the following page tell.

The increase in the size of vessels is shown in the table on page 103. It is barely possible, however, to set forth as clearly the development of design, though the dimensions given in a measure show it. The supersession of iron by steel and the advance of engineering, which we have noted, have made, of course, a broad distinction between the steamship of "the seventies" and the steamship of to-day, but so intricate are the causes of the modern naval architect's progress that it is almost a hopeless task to trace them. So many, indeed, are the shipbuilders' restrictions, and so various the qualities he has to combine, that the high average of his complete successes is remarkable. His ship must be long and displace so much on a specified draught; his scantlings are prescribed in the interest of public safety and by a due appreciation of the difficulties of the engineer; and the arrangement of his vessel's accommodation must be economically perfect.

Only Atlantic liners are given in the tabulated statement, and the proportion of this work to the credit of the Clyde would be shown better perhaps in a list of all the ocean steamers of the highest class. The inclusion of all, however, is out of the question, and it will be admitted that the selection here made is fairly illustrative of the whole development.

It may be noted, however, that within the thirty years covered by this review the Clyde has contributed more famous vessels of the highest class than probably all the other shipbuilding centres put together. From

MACHINERY OF ATLANTIC LINERS SINCE 1870.

Vessel.	Builders.	Year.	Cylinders.		Boilers.			I.H.P.	Speed.
			Diameter.	Stroke.	Heating Surface.	Grate Area.	Working Pressure.		
				in.					
Britannic,	Harland & Wolff,	1874	Two 48 in., two 83 in.	60	..	..	70	5,500	16
Arizona,	Fairfield Company,	1879	One 62 in., two 90 in.	66	..	..	90	6,300	17
Servia,	Messrs. Thomson,	1881	One 72 in., two 100 in.	78	27,483	1014	90	10,300	16·9
Alaska,	Fairfield Company,	1881	One 68 in., two 100 in.	72	..	..	100	10,500	18
City of Rome,	Barrow Company,	1881	Three 46 in., three 86 in.	72	29,286	1398	90	11,890	18·23
Aurania,	Messrs. Thomson,	1882	One 68 in., two 91 in.	72	23,284	1001	90	8,500	17¾
Oregon,	Fairfield Company,	1883	One 70 in., two 104 in.	72	..	..	110	7,375	18·3
America,	Messrs. Thomson,	1884	One 63 in., two 91 in.	66	22,750	882	95	7,354	17·8
Umbria,	Fairfield Company,	1884	One 71 in., two 105 in.	72	38,817	1606	110	14,321	19
Lahn,	" "	1887	Two 32½ in., one 68 in., two 85 in.	72	..	..	150	9,500	18·64
City of Paris,	Messrs. Thomson,	1888	Two 45 in., two 71 in., two 113 in.	60	50,265	1293	150	20,605	21·8
Augusta-Victoria,	Vulcan Company,	1889	Two 41 5/16 in., two 66 15/16 in., two 106 5/16 in.	63	36,000	1120	150	14,110	18·31
Columbia,	Laird Bros.	1889	Two 41 in., two 66 in., two 101 in.	66	34,916	1226	150	13,680	19·15
Teutonic,	Harland & Wolff,	1890	Two 43 in., two 68 in., two 110 in.	60	40,072	1154	180	18,000	21
Normannia,	Fairfield Company,	1890	Two 40 in., two 67 in., two 106 in.	66	46,490	1452	160	16,352	19·34
Spree,	Vulcan Company,	1890	Two 38 in., one 75 in., two 100 in.	72	..	..	165	13,000	19·6
Fürst Bismarck,	" "	1891	Two 43⅜ in., two 67 in., two 106¼ in.	63	47,000	1450	157	16,412	20·7
Campania,	Fairfield Company,	1893	Four 37 in., two 79 in., four 98 in.	69	..	..	165	30,000	22
Kaiser Wilhelm der Grosse,	Vulcan Company,	1897	Two 52 in., two 89¾ in., four 96½ in.	69	..	..	..	27,000	22·4
Oceanic,	Harland & Wolff,	1899	Two 47½ in., two 79 in., four 93 in.	72	..	..	..	28,000	22
Deutschland,	Vulcan Company,	1900	Four 36⅝ in., two 73⅞ in., two 104 in., four 106½ in.	72	..	..	..	33,000	23·36

Fairfield have gone the "Arizona," "Alaska," "Umbria," "Etruria," "Normannia," "Campania," and "Lucania," and from Clydebank the "Servia," "Aurania," "America," "Paris," and "New York." Nearly the whole of the modern fleet of the Peninsular and Oriental Steam Navigation Company has been provided by Messrs. Caird & Co., Greenock, the best vessels of the Castle Line have been built at Fairfield, and between them Messrs. Denny, of Dumbarton, and Messrs. A. & J. Inglis, of Pointhouse, have produced the ships of the British India Steam Navigation Company. All the newer vessels of the Royal Mail Company have been built on the upper Clyde, and with the exceptions of the "Bavarian"—which came from Dumbarton—and the "City of Rome" and "Furnessia"—which came from Barrow—all the later vesels of the Allan and Anchor Line were built in the same quarter. By the addition of Elder-Dempster Liners, Orient Liners, Furness Liners, Pacific Liners, and Japanese Liners, the list could be swollen considerably, but probably enough has been written to show the commanding position of the river. In the table which follows, other than Clyde-built vesels are given to show the full development of the type:—

DIMENSIONS OF ATLANTIC LINERS SINCE 1870.

Vessel.	Builders.	Year.	Length B.P.	Breadth.	Depth.	Draught.	Gross Tonnage.
			ft. in.	ft. in.	ft. in.	ft. in.	
Britannic, - - -	Harland & Wolff,	1874	455 0	46 0	34 0	23 7	5,004
Arizona, - - -	Fairfield Company,	1879	450 2	45 2	37 6	18 9	5,147
Servia, - - -	J. & G. Thomson,	1881	515 0	52 0	40 9	23 3	7,392
Alaska, - - -	Fairfield Company,	1881	500 0	50 0	39 7	21 0	6,932
City of Rome, - -	Barrow Company,	1881	560 2	52 0	38 9	21 6	8,141
Aurania, - - -	J. & G. Thomson,	1882	470 0	57 0	39 0	..	7,269
Oregon, - - -	Fairfield Company,	1883	500 0	54 0	39 9	23 8	7,375
America, - - -	J. & G. Thomson,	1884	432 0	51 0	37 6	26 7	6,500
Umbria, - - -	Fairfield Company,	1884	501 6	57 2	38 2	..	7,718
Lahn, - - -	,, ,,	1887	465 0	49 0	36 6	22 0	5,661
Paris, - - -	J. & G. Thomson,	1888	527 6	63 2	43 0	24 6	10,499
Augusta-Victoria, -	Vulcan Company,	1889	480 0	56 0	38 0	22 9	7,661
Columbia, - -	Laird Brothers,	1889	480 0	56 0	38 0	22 9	7,578
Teutonic, - - -	Harland & Wolff,	1890	566 0	57 6	39 4	26 0	9,686
Normannia, - -	Fairfield Company,	1890	520 0	57 3	38 0	22 0	8,716
Spree, - - -	Vulcan Company,	1890	485 0	52 0	38 0	22 0	6,963
Fürst Bismarck, -	,, ,,	1891	502 6	57 6	38 0	22 6	8,000
Campania, - -	Fairfield Company,	1893	598 0	65 0	43 0	..	12,950
Kaiser Wilhelm der Grosse, - -	Vulcan Company,	1897	626 7	66 0	39 0	..	14,349
Oceanic, - - -	Harland & Wolff,	1899	685 7	68 3	44 5	..	17,274
Deutschland, - -	Vulcan Company,	1900	662 7	67 0	40 4	..	16,502

At each stage of this development there has naturally been a corresponding improvement in the accommodation for passengers. The line of progress fom the first record breaker leads straight to the express, purely passenger boat, and we have reached that extreme, if profit be considered, in the "Oceanic" and the "Deutschland." The cargo these vessels carry is of no account in the economic problem. The emergence of the intermediate boat as a result of this is referred to further on, and need be no more than mentioned now.

Compared with the ocean steamship of thirty years ago the modern liner is a palace. She is, at the best, nearly seven knots faster, and she plies between port and port with the regularity of a train. Her complement of pasengers and crew is about 3000, and the people fare as sumptuously as they could ashore. Sleeping quarters are roomy and well ventilated, and electrically-lit dining-rooms, drawing-rooms, libraries, and smoke rooms have the easy comfort one associates with home. Food is prepared and served with faultless care, and the odours of the galley no longer permeate the ship. The evil smells of the engine rooms and the stokehold are carefully excluded from the spaces devoted to passengers, and vibration is reduced to a minimum by the balancing of the engines; in fact, except for the very timid or the very delicate, voyaging has lost not only its terrors, but nearly all its irksomeness. And there is accommodation to suit every purse; luxuriously furnished suites of rooms for the voyageur with whom "money is no object," handsomely fitted cabins for travellers of every degree in the scale of wealth, comfortable quarters for the passenger whose means limit him to less of luxury, and steerage accommodation of a quality the emigrant of "the sixties" never dreamed of. The tendency may be towards overmuch luxury, but it is logical, and it pays. The length of the average voyage has been cut down enormously, and ocean trips are infinitely more tolerable than they were. Practical withdrawal from the busy world for even a week is admittedly a serious matter, but the liner newspaper is already an institution, and the time may come when, with Marconi's aid, it may run to several real live editions a day.

The development of the channel steamer has been quite as remarkable as that of the ocean steamer, and its tendencies have been practically in similar directions. It has been shaped, too, by much the same limitations, though the acceleration of locomotion ashore affected it to an extent it never did the other. The increase in size is not so marked if we except the Harwich, Fleetwood, and Holyhead boats, but the naturally limited accommodation of terminals sufficiently accounts for that.

Greater speed and more luxurious accommodation are the distinguishing qualities of what we call the modern cross-channel steamer, but as marked progress can hardly be claimed for the vessels which carry passengers and cargo between the ports of the United Kingdom, and between the East Coast and the Continent. There has, of course, been an advance. But the development of certain services is necessarily restricted by the opposition of railways, and increase of size in their case has been unaccompanied by greater speed or greater luxury. The improvement they have achieved has been largely in economy.

With the railway services it has been almost altogether different. They have been forced to keep pace with the accelerations ashore, and the result is the purely passenger steamer with a higher standard of comfort than that of the corridor train, and with as strict adherence to a time-table.

Most of the voyages accomplished in record time and under record conditions are certainly short, but the possibilities of the type may be fairly judged by the two boats Messrs. Caird, of Greenock, built recently for the Brindisi-Port-Said P. & O. service.

Nearly all the high speed cross-channel services are maintained by Clyde-built vessels. Messrs. Denny, of Dumbarton, built the paddle steamers for the Newhaven-Dieppe route, and several of the paddle steamers on the London and North-Western Holyhead-Dublin route, the twin-screw steamers for the Newhaven-Dieppe route, and several of the paddle steamers on the Dover-Ostend and Dover-Calais routes. Their record in this respect is, as the table shows, a notable one. Many of the Calais-Dover and Queenboro'-Flushing paddle boats were built at Fairfield, which has also produced splendid channel steamers in "La Marguerite" and the "Empress Queen." The two latter represent the highest development of the paddle steamer we have yet reached in this country. All the fastest and most finely fitted twin-screw steamers of the Southampton-Channel Island and Southampton-Havre fleet were built at Clydebank, which, as we shall see presently, is also noted for river paddle boats of a very high class.

The only important services which are not maintained by Clyde-built vessels are the Holyhead-Kingston, Weymouth-Channel Islands, Harwich-Hook of Holland, and Harwich-Antwerp. Messrs. Laird Brothers, of Birkenhead, build the Irish mail boats and the Great Western boats, and the Great Eastern steamers were built at Hull by Messrs. Earle. I have included typical ships from both these centres in order to make clear the full development of the type.

TYPICAL CROSS-CHANNEL PADDLE STEAMERS.

Vessel.	Built.	Year.	Tons.	I.H.P.	Speed, Knots.
Cambria,	Laird Bros.,	1848	—	1,200	14·5
Ulster,	Do.,	1860	—	4,200	18
William, Prins Van Oranje,	Fairfield Co.,	1883	1,700	4,500	18·25
Nederland,	Do.,	1887	1,700	4,000	19
Princess Henriette,	Denny Bros.,	1888	1,094	—	21·2
Princess May,	Do.,	1892	1,123	—	19·77
Leopold II.,	Do.,	1892	1,367	—	22
Empress Queen,	Fairfield Co.,	1897	2,500	10,000	22
Mabel Grace,	Laird Bros.,	1899	1,315	5,500	20·25

TYPICAL CROSS-CHANNEL TWIN-SCREW STEAMERS.

Vessel.	Builders.	Year.	Tons.	I.H.P.	Speed, Knots.
Frederica,	Thomson & Co.,	1890	1,059	5,500	19·5
Tynwald,	Fairfield Co.,	1891	937	5,100	19
Ibex,	Laird Bros.,	1891	1,150	4,200	20
Seaford,	Denny Bros.,	1893	—	—	20·16
Columbia,	Thomson & Co.,	1894	1,145	3,750	19·25
Rosstrevor,	Denny Bros.,	1895	1,065	—	19
Dresden,	Earle's Co.,	1897	1,805	—	—
Cambria,	Denny Bros.,	1897	1,842	—	22
Ulster,	Laird Bros.,	1897	2,632	9,000	23·75
Alberta,	Brown & Co.,	1900	1,700	5,350	19·85

On shorter runs, like those between Stranraer and Larne, Dover and Ostend, Calais, or Boulogne, and Queenboro' and Flushing, the paddle type fairly holds its own, but, except on the very shortest, there is a tendency to discard it in favour of the twin-screw. The economy of the finely-formed, lightly-built high-speed twin-screw vessel may not be remarkable at first sight, but maturer thought will bring the conviction that the penalty paid for pace is extremely light. Nothing is wasted on her. She embodies all the qualities that were specified, and the desired result is obtained in the most economical manner possible.

In addition to her speed and her luxurious accommodation, however, the cross-channel steamer, like the ocean greyhound, has another notable quality. She is, despite her speed, safer than her predecessor. The separation of her engine rooms by bulkheads, and the sub-division of her hull into watertight compartments, provide an element of safety that was never dreamed of in the earlier days of the steamship. She will float with any two compartments filled with water, and an Atlantic liner has maintained her buoyancy for three days with both engine rooms flooded. She is not only faster and more comfortable than her predecessor, but a great deal safer. And if she costs the owner more, she costs the traveller less.

The river steamer, as Scotland knows it, and as England and Ireland are beginning to know it, is peculiarly a Clyde product. The estuary out of which have sailed the world's most famous ships is noted for its natural beauty, and for years the summer homes of busy citizens have been built along its shores. The traffic of excursions to it has also been considerable, and one can hardly remember when its fleet of steamers was not a better one than was to be found elsewhere in the kingdom. Of course, it was not always what it is to-day, and for the comparative perfection which reigns, we have to thank the railway companies. But speed was always its strong point; it was always numerous, and its accommodation was seldom behind the times. A comparison of the river steamer of to-day and the river steamer of twenty-five years ago proves nothing, except that our standard of comfort is much higher than it was. The advance of speed in that period is not very remarkable, although the all-round average is much higher. The table which follows shows how high the level is that has been reached, and I leave it to tell the development alone:—

TYPICAL RIVER PADDLE STEAMERS.

Vessel.	Builders.	Year.	Tons.	I.H.P.	Speed, Knots.
Sultana,	Robertson,	1868	173	760	—
Columba,	Thomson & Co.,	1878	562	—	—
Chancellor,	Chambers, Jun.,	1880	272	950	—
Diana Vernon,	Barclay, Curle & Co.,	1885	193	678	14·87
Duchess of Hamilton,	Denny Bros.,	1890	553	—	18·1
Lord of the Isles,	Henderson & Co.,	1891	466	—	—
Glen Sannox,	Thomson & Co.,	1892	610	2,700	18·5
Waverley,	Inglis & Co.,	1899	449	2,220	19·75

Formerly there was no comparison between the pleasure steamers of English and Irish rivers and the pleasure steamers of the Clyde. All that has been changed, however, in the last decade, and the summer fleets of Belfast Lough, Bristol Channel, the Solent, and the Thames are in a transition stage. All the new boats in these services have been built on the Clyde, the Bristol and Southampton craft at several places on the river, the Belfast boats at Clydebank, and the floating palaces of the London River at Dumbarton and Fairfield. With a wider range and heavier weather the Thames steamers, and several of the South Coast boats as well, are necessarily more stoutly built, but they retain all the essential qualities of the Clyde type, and succeed by reason of them. The Palace steamers were built by the Fairfield Company, and the Belle steamers by Messrs. Denny Brothers. Messrs. John Brown & Co., Clydebank, have contributed the "Slieve Donard" and the "Slieve Bernagh" to the Belfast fleet, and similar boats to Blackpool and Brighton, but probably their claim in this respect rests more soundly on the Clyde steamers "Glen Sannox," "Juno," "Duchess of Rothesay," and "Jupiter."

How far the development of the type will go remains to be seen. It is interesting to note, however, that the opening of the century sees the application of a new principle to the propulsion of a Clyde passenger steamer in the steam turbine, which is being applied by Mr. Parsons to the "King Edward," built by Messrs. Denny.

I hope I have shown with sufficient clearness the main development of the passenger steamer. It has not been possible to pick up and hold every thread of the marvellous story, and I have simply attempted to convey to the reader the impression that the modern passenger steamer is a vessel of economy, size, speed, safety, and luxurious comfort.

THE CARGO STEAMER.

Before proceeding to trace the development of the cargo steamer a little consideration is due to the "wind-jammer," which threatens to become extinct under the British flag, and only exists in America and on the Continent under the fostering care of Governments. It pays to build sailing ships in France, and so long as foreign ships are excluded from the coasting trade it will pay to sail them in the United States. In Great Britain, however, the economies brought about by the shipbuilder and the engineer have made the sailing vessel nearly impossible, and even in the long trades it is being displaced by the cheap, cheaply-worked, and sure-if-slow tramp. Practically no sailing ships for general cargo have been built on the Clyde for three years, and much the same is true of other shipbuilding centres of the Kingdom. "In 1889," says Mr. Martell, "10 per cent. of the total output was composed of sailing tonnage. For the four following years (1890 to 1893) the proportion rose to 19 per cent. Since that period the construction of sailing vessels has rapidly declined, until in 1899 sailing tonnage formed less than 0·14 per cent. of the output."

The sailing tonnage produced on the Clyde in the last decade of the old century is, as I have shown in the opening, considerable, but smaller vessels are included in the total than are taken cognisance of by Lloyds. Analysed, however, the table brings out some facts which are interesting. Between 1890 and 1893 there was a big sailing ship boom on the Clyde, and the river alone is responsible probably for the increased proportion of that

class of tonnage. In 1892-93 Messrs. Russell & Co., Greenock, built sailing ships exclusively, and in 1891-92 Messrs. Connell & Co., Scotstoun, and Messrs. Duncan & Co., Port-Glasgow, were similarly employed. In the four years which ended in 1894, in fact, five firms between them contributed 185 sailing vessels of 342,528 tons, and only four of 6846 tons since 1896. Whether there will ever be another revival is difficult to say. Everything seems to point to the conclusion that there will not. The proportion has never been so low in the history of the industry on the river, but as the following table shows it has been very nearly as low:—

PROPORTION OF STEAM TO TOTAL CLYDE TONNAGE SINCE 1876.

1876,	0·579	1889,	0·755
1877,	0·552	1890,	0·736
1878,	0·730	1891,	0·680
1879,	0·908	1892,	0·523
1880,	0·936	1893,	0·648
1881,	0·892	1894,	0·736
1882,	0·822	1895,	0·896
1883,	0·847	1896,	0·890
1884,	0·769	1897,	0·831
1885,	0·463	1898,	0·815
1886,	0·625	1899,	0·986
1887,	0·796	1900,	0·976
1888,	0·816		

The exigencies of trade have largely controlled the development of the cargo steamer, and it is impossible, therefore, to point to one class as representative of the highest. Particular types suit particular trades. But in the main the tendency has been towards bigger ships and greater economy—greater economy not only in the matter of fuel, but in the handling of ship and cargo. The all-round economy effected has been remarkable, and cannot be expressed in figures. Every week sees it more marked too, for of the contriving of labour-saving appliances there appears to be no end, and economies in the engine room accumulate.

The engineering advance is largely the cause of all this cheapening, but a proportion of this credit is also due to the shipbuilder. The modern cargo boat is rarely a thing of beauty, and seldom a joy for any length of time. Its design, however, calls for just as much skill as the shaping of a greyhound, and the problem is oftener than not more difficult. The phase of the economic problem which concerns the naval architect is how much can be carried on how little, and to adapt the hackneyed phraseology of the launch and the trial trip, a cargo vessel can only be "a credit to her builders" when she is "a source of profit to her owners."

Since 1890 the well deck, the partial awning deck, and the raised fore deck, have been practically discarded, and there has been a reversion to flush-deck, beamier boats with short poop, bridge house, and forecastle. For certain trades large single-deck steamers, with a tier of middle deck or lower deck beams but no deck had found favour, and another recent development to suit the cattle trade is in the direction of what is known as the shelter-deck type. So far as the Clyde is concerned, these practi- [illegible] ent the recent changes; the turret and trunk types are peculiar [illegible] and the Tees.

The increase in the size of cargo vessels has been proportionately as great as in the case of passenger ships, but it is extremely difficult to show this in a succession of vessels. The growth has been practically all within the last decade, and a fair enough way of making it clear is perhaps to give the average dimensions of the ships built by a particular firm. For that purpose I have selected Messrs. Russell & Co., Port-Glasgow, and give their figures for the five years, 1896-1900. The sailing ship revival had spent itself by that time.

AVERAGE DIMENSIONS OF CARGO STEAMERS, 1896-1900.

Year.	Length. Ft.	In.	Breadth. Ft.	In.	Depth. Ft.	In.	Gross Tonnage.
1896,	226	0	34	9	16	0	1616
1897,	260	0	40	0	18	4	2679
1898,	303	5	43	4	22	6	3109
1899,	323	0	46	1	23	5	3270
1900,	324	6	45	4	22	7	3194

The averages of other Clyde builders of cargo vessels work out similarly, but for the full development of the type we have to seek the Laggan, where the average is very much higher. It is unnecessary to mention horse power or speed. Cargo vessels are not designed to steam quickly, and the quality most desired in their engines is economy. That the engineer has worked to the finest possible point within the limits that compass him.

The advance in one direction to the purely passenger boat, and in another to the purely cargo boat, has created in particular ocean trades the necessity of a third type economically combining the qualities of the two. The intermediate boat represents most strikingly the tendency towards bigness, and, significantly enough, the largest vessel in the world—for the time being, of course—is of this particular class.

The cause of the emergence of the leviathan intermediate boat is not far to seek. She is a necessity of trades like that to America, the Cape, and Australasia, because (1) old passenger boats cannot be made to combine her qualities economically; (2) the accommodation of "Campanias" and "Oceanics" is beyond the purses of all travellers; and (3) the trading conditions of the world are constantly undergoing change. It is admittedly the cargo vessels of most fleets that earn the dividends, and not having been built to carry merchandise profitably, satisfactory conversion of your time-worn "flyer" is impossible. The great volume of passenger traffic is still to, instead of from, America, the Cape, and Australia, and it is largely emigrant, which is indifferent as to speed. And the trade developments, of which I speak, both in progress and possible, call for a vessel of great capacity for cargo, extensive accommodation for passengers, and a broad margin of space which may, at short notice, be devoted to either passengers or cargo.

The strong point of the modern intermediate boat is her adaptability. Record-breaking speed is not necessary, and the standard of comfort desired is not so high, but the happy mean must be maintained in everything if the most is to be made of the new conditions. When the ordinary man talks of big ships it is the intermediate vessel that impresses him.

The type has reached its highest development on the North Atlantic, but notable ships of the class are to be seen elsewhere. The Castle-Union intermediate ships—built exclusively on the Clyde and at Belfast—are fine

specimens, and much the same praise is due to the White Star Australian fleet. Many of the newer German ships for foreign services are quite up to the North Atlantic standard, and the American shipbuilder, when he gets his wind—and his subsidies—may be expected to follow that lead.

And, of course, there are intermediate vessels on services where the distinction has no significance. The majority of the vessels which come into the first section of this article are passenger and cargo steamers with the accent, however, more and more on passenger and less and less on cargo. But the newer ships for services which offer inducements to provide for both passengers and cargo are essentially intermediate boats, and I must leave the reader to draw the line for himself between the passenger, the intermediate, and the cargo steamer. The cargo the high-speed liner carries is, as I have said, neither here nor there in her economy. The following particulars of well-known intermediate steamers may be interesting:—

LARGE INTERMEDIATE STEAMERS.

Vessel.	Builders.	Year.	Tons gross.
Cymric,	Harland & Wolff,	1898	12,647
Pennsylvania,	Do.,	1896	13,265
Minneapolis,	Do.,	1901	13,401
Minnehaha,	Do.,	1900	13,401
Ivernia,	Swan & Hunter,	1899	13,800
Saxonia,	Brown & Co.,	1900	13,963
Celtic,	Harland & Wolff,	1901	20,880

The "Campania" and the "Lucania" are the longest boats that have been built on the Clyde, but the "Saxonia" is really the biggest vessel ever built on the river. Belfast, as the table shows, is the place for big ships; the Queen's Island average was 11,300 tons last year, and 11,800 tons in 1899. A sister ship of the "Celtic" is on the stocks.

THE WARSHIP.

When we proceed to discuss the development of the warship we join issue with the multitude, for every man, from the horny-handed son of toil to the pugnacious Parliamentarian, is a naval expert in his own estimation. The British Navy has for long been going to the dogs. According to the keenly critical its ships are unstable, its engines full of flaws, its boilers dangerous, its armaments obsolete, its crews both insufficient and inefficient. The oldest inhabitant cannot recall when its "needs" were not clamant, and the political outlook is black, indeed, when there is not a naval question. There is nothing, of course, to justify this sweeping condemnation. That the administration of the Navy might be improved greatly is admitted, and that crews and engine-room complements could be recognised and increased with profit is true. But the British fleet is, beyond question, the finest in the world; its failures are notable because of its outstanding excellence, and it could never have been what it is without the knowledge of these failures.

In tracing the development of the warship it is unnecessary to do more than refer to foreign ships. Within the period under review only two foreign nations—Spain and Japan—have had war vessels built on the [illegible]de, and in both cases the ships were slight variations of British types. [illegible]estroyers for Spain, and the protected cruiser and battleship for

Japan—all built at Clydebank—were very little different from Sir William White's ships of the same class. And, except in the case of battleships, every stage of the development may be marked by a Clyde-built vessel.

It would be interesting to trace the growth of the steam warship from its early days of struggle to its later, but the story is so well told in other forms that it would be idle to do so. For the modern shipbuilder and engineer the real history of the warship dates from the Naval Defence Act of 1889.

It is sometimes urged, not unreasonably, that the Admiralty does not make the most of the immense shipbuilding resources of the country. Contractors could, it is said, accomplish more than they have accomplished in the past, and the country would be all the better of the knowledge. There is truth in that. Yet the decade's record of naval construction is a splendid one. Excluding gunboats, torpedo boats, and destroyers, and everything before the estimates of 1889, and after the estimates of 1899, the total additions to the British Fleet have been—

	No. of Vessels.	Displacement, Tons.	I.H.P.
Battleships, - - -	37	521,850	516,000
Armoured Cruisers, -	15	178,100	347,200
Protected Cruisers, - -	78	413,800	822,500
	130	1,113,750	1,685,700

The exceptions would, if included, swell these totals considerably, but it is better to leave the small fry out in order to emphasise the importance of naval work in the industry.

Clyde shipbuilders have built ships for nearly all these classes, the exceptions being third-class cruisers, and one or two classes of battleships. The only battleships constructed on the river have been of the "Royal Sovereign" and the "Majestic" classes, but machinery has been supplied to one of the "Canopus" class by a lower reach firm. Very few gunboats have been put together on the Clyde, but Clydebank and Fairfield between them have had some notable successes with destroyers of from 27 to over 30 knots speed.

It is extremely difficult to follow the development of the warship even in so short a space as ten years, for the reason that changes have been rapid, and progress not always very marked. But in the main the tendency has been towards greater offensive and defensive power, higher speed over a wider area, and easier manœuvring qualities. The question concerned with the best disposition of naval strength—whether more battleships should be built or more cruisers—is not one for the shipbuilder; but it should be noted in this connection that the newer cruisers are fitter for the line of battle than were the ironclads of twenty-five years ago. They combine the speed of the commerce protector with the offensive power of the battleship, and they represent probably as much a concession to public opinion as a natural development of the fighting ship in new conditions. The question, however, is one for the strategist purely.

The growth of the battleship during the decade has been very remarkable, and we have probably reached the extreme, in the meantime, of the type. Instead of a ship, she is a huge, complicated machine, with immense installations of steam, hydraulic, and electrical machinery,

which it is almost impossible to describe in detail. The engineer has given her of his best; the artillerist and armour-plate maker have mutually striven to make their tasks impossible. And the shipbuilder, with such an unstable thing as the uncertain sea to lay his foundations on, has had to accommodate them all. The improvements in guns, armour, and auxiliary machinery have been very great, but are beyond the scope of this article.

The increase in size and power may be shown best in tabular form, and to bring it out more clearly some older vessels may be included. The particulars given are taken from *The Naval Annual*, and the dates quoted are, of course, the dates on which the ships mentioned were completed. The tendency has not been directly towards size, but the causes of the variations are obvious.

PARTICULARS OF TYPICAL BATTLESHIPS.

Ship.	Year.	Class.	Displacement, Tons.	I.H.P.	Speed, Knots.
Dreadnought,	1875	2nd	10,820	6,500	13·7
Alexandra,	1877	2nd	9,490	7,000	14·3
Inflexible,	1881	2nd	11,880	6,500	12·8
Conqueror,	1882	3rd	6,200	6,000	15·3
Ajax,	1883	2nd	8,660	4,500	12·1
Collingwood,	1886	1st	9,500	9,500	16·5
Edinburgh,	1886	2nd	9,420	5,500	14·2
Hero,	1888	3rd	6,200	6,000	15·2
Anson,	1889	1st	10,600	11,500	16·9
Sans Pareil,	1889	1st	10,470	14,000	17·2
Ramillies,	1893	1st	14,150	13,000	17·5
Centurion,	1894	1st	10,500	13,163	18·5
Jupiter,	1897	1st	14,900	12,000	17·5
Renown,	1896	1st	12,350	12,000	18
Duncan,	1901	1st	14,000	18,000	19
Canopus,	1900	1st	12,950	13,500	18·25
Asahi,	1899	—	15,200	15,000	18

Of these only the "Ramillies," "Jupiter," and "Asahi"—the last-named for Japan—were built on the Clyde, but the engines for the "Inflexible," the "Centurion," and a sister ship, and the "Canopus," were constructed on the river. It is difficult to convey the full extent of the advance the table indicates, but all the types are represented in the list. The earlier vessels are iron, but all have twin-screws, and the advance in armament is most marked in the last decade. It should be noted, however, that British Admiralty practice differs from that of, say, the American Navy Department in one very important respect. The United States authorities have never gone back on a type in speed, in size, or in armament, whereas in speed and in size, at least, as the table shows, the British have. This, according to Sir John Hopkins, is not the fault of Sir William White, who, if he had his way, would exceed the 15,000 tons allowed him by 3000 or 4000 tons. But naval tacticians, like the gallant Admiral, incline the other way, for the reason evidently that—the words are Sir John Hopkins' own—"if all the vessels could turn round in the same circle it would facilitate the knowledge of the commander-in-chief as to what his fleet were doing." The man in the street, therefore, errs in thinking

that the commander-in-chief should know enough about his fleet to make the best possible disposition of its elements.

Another important difference in the development is that while the later British battleships are fitted with Belleville boilers, the American vessels are not. This is counted unto the Americans for wisdom, and yet it is merely cleverness. The Belleville boiler has perhaps failed, and may have to come out of the British ships, but if it had succeeded would the Americans have continued to exclude it from use? Service has disclosed weaknesses which nobody could have foreseen, or it would never have had the costly trial it has had.

The development of the cruiser will always be associated with the name of Sir William White, to whom the British people owes a debt it can hardly ever repay. Significantly enough, shipbuilders have never been adverse critics of the chief-constructor's work. Being themselves naval architects, they know the difficulties of his task, and they note how successfully he has fulfilled many apparently impossible conditions.

The fast cruisers of the past decade are notable ships, and the almost innumerable variations of the type may be taken as evidence of the interest in them. It is scarcely necessary to go beyond the programme of 1889 in this connection, for practically all the development worth speaking of has taken place since then. And in dealing with the cruiser I do not propose to take notice of anything below the second class.

High speed—bunker capacity is an important element here—the greatest possible offensive power, adequate protection of guns, magazines, and machinery, and good sea-going qualities appear to be the essentials of an ideal cruiser. The popular conception is of a ship that can both fight and run—sweep the seas of rival merchantmen and protect its own—scout, if need be, for the heavier metal represented by the battleships. Fast liners, which in time of peace could be profitably employed, might do these things, but for two drawbacks. Few merchantmen could show their heels to the newer armoured warships, and none has its vital parts protected. The whole interior of a legitimate cruiser is covered in by a steel deck of varying thickness. A scout class, like that proposed by Admiral Fitzgerald, is perfectly feasible, for, despite Sir William White's objection, they could have no more than a scout's chance of survival. But they would not be an improvement. Twenty-three knots continuous speed is not easily purchased, and at the best they would have no more value than the "Diadems."

If progress has not been continuous in battleship construction, it certainly has in the building of cruisers. This may be shown best, perhaps, in tabular form. Only protected cruisers are included in the list, and, —except in the case of the "Astræa" and the "Arrogant"—ships of the type built on the Clyde. As in the other table, the year stated is the year of completion.

TYPICAL PROTECTED CRUISERS BUILT ON CLYDE.

FIRST CLASS.

Vessel.	Year.	Displacement, Tons.	I.H.P.	Speed, Knots.	Bunkers, Tons.
Gibraltar,	1892	7,700	12,000	19·7	850
Terrible,	1895	14,200	25,000	22·4	1,500
Diadem,	1896	11,000	16,500	20·5	1,000
Ariadne,	1898	11,000	18,000	20·75	1,000

SECOND CLASS.

Vessel.	Year.	Displacement, Tons.	I.H.P.	Speed, Knots.	Bunkers, Tons.
Intrepid,	1891	3,600	9,000	19·75	400
Astræa,	1893	4,360	9,112	19·75	400
Venus,	1895	5,600	9,600	20·1*	550
Arrogant,	1896	5,800	10,000	19·1	500
Hermes,	1898	5,600	10,000	20	600

Between 1890 and 1900 no armoured cruisers were built in Great Britain, and the development was, as has been noted, towards "Ariadnes" and "Terribles." Foreign Governments, however, took latterly to the older type, and the result was the laying down of similar ships in this country. But the development was still in a direct line through the protected ships, and the result was practically improved "Dianas," "Diadems," and "Terribles" in the "County," "Cressy," and "Blake" classes. I include the "Australia" in the following list to permit of comparisons:—

TYPICAL ARMOURED CRUISERS BUILT ON CLYDE.

Vessel.	Year.	Displacement, Tons.	I.H.P.	Speed, Knots.	Bunkers, Tons.
Australia,	1888	5,600	8,500	18	900
Crissy,	1900	12,000	21,000	21	800
Monmouth,	1901	9,800	22,000	23	800
Leviathan,	1901	14,100	30,000	23	1,250

The increase in weight of armour, range of guns, and muzzle velocity has been, of course, very great, but to try to show it would overburden the account with detail. The increase of speed is the aspect of the advance which will have most interest for the engineer. There is very little in the propelling machinery or its arrangement to distinguish it from that of a fast merchantman, except the substitution of the water-tube for the cylindrical boiler. The majority of the newer ships in both the foregoing tables have Belleville boilers, but in several vessels of the "County" class other types—the Babcock & Wilcox and the Niclausse chiefly—are being given a trial. Every aid to high speed is made use of, and every knot added costs more in a rapidly rising scale than the one immediately preceding it.

The only other class of warship in which Clyde shipbuilders and engineers are interested is the lightly-built, high-powered destroyer. Clydebank and Fairfield have between them representatives at nearly all the speeds, and at present both are busy with specimens of the later types. Appended are some particulars of typical Clyde-built boats:—

CLYDE-BUILT TORPEDO BOAT DESTROYERS.

Vessel.	Year.	Displacement. Tons.	I.H.P.	Speed.	Bunkers, Tons.
Surly,	1894	280	4,400	28·05	50
Hunter,	1895	260	4,000	27·2	70
Brazen,	1896	300	6,000	30	80
Fairy,	1897	300	7,700	32	80

One or two gunboats, several dockyard tugs, and a couple of Indian

* Contract speed, 19·5 knots.

troopers exhaust the minor Admiralty work done on the river in recent years.

THE YACHT.

Yachting is not a pastime in which everybody may participate, and its devotees are necessarily people of means. Even the city man who spends his week-end cruising, the youth who has a—more or less—controlling interest in a rater, or the amateur with a head and a pair of hands, must have money to spend on his experience or the summer seafarer's joy will be of the slightest. Yet with all the drawbacks—and it is serious enough—the love of yachting is innate, and he is a poor sort of Briton, indeed, who does not make some shift to gratify it.

There may be room to doubt which is the centre of the yacht-racing world; the Clyde is absolutely the greatest yacht-building river of the kingdom. The fame of the Fifes at Fairlie needs no trumpeting, and there is no yachtsman who knows not the name of Watson. Clyde designers have produced five challengers for the America Cup—"Thistle," "Valkyrie II.," "Valkyrie III.," "Shamrock I.," and "Shamrock II.," and the Clyde shipbuilders have built six—"Genesta," "Galatea," "Thistle," "Valkyrie II.," "Valkyrie III.," and "Shamrock II.," so that on one showing alone the record of the river is unapproached. In every other respect it stands comparison with the best, as a glance at any register of yachts will disclose. Into the maze, however, suggested by the development of the racing yacht it is not proposed to go, and readers who desire to be filled with wonder at the progress are respectfully referred to Mr. Watson's able and exhaustive contribution to the Badminton series.

It is sufficient for the present purpose to point out the effect of succeeding rating rules on the sailing yacht. In older days racing craft had longer lives, and longer periods of usefulness in their antiquity. But initial cost and upkeep increased as years of usefulness decreased, and by and by only millionaires could keep succeeding big racer with big racer. The German Emperor, Lord Dunraven, Sir Thomas Lipton, and Mr. C. D. Rose are the only sportsmen who have attempted to do so. The others have either bewailed the tendencies of the times on very archaic specimens of naval architecture, or taken the logical leap into steam. Sir Thomas Lipton and Mr. Whittaker Wright possess, of course, both sailing and steam vessels of the highest class. Each is likelier to dispense with his racer than with his steamer.

The steamer is naturally repugnant to the breezy sailor of the ordinary type, who loves the sea in all its moods. For a long time steamer-ownership was no qualification for election to the Squadron. "If," wrote Sir Edward Sullivan in 1894, "I lived to the age of the Hyperboreans, and owned several gold mines, I should never keep a steamer for pleasure." That view is the avowed one of most yachtsmen; and yet the tendency to substitute steam for sail is stronger than ever. Mr. Coats' great schooner "Gleniffer" is almost the only set-off to the new development. Of course, the reason is obvious, if you have no prejudice. The increase of wealth has swollen the number of people who, to quote Bret Harte, "look to the ocean for rest." The standard of comfort has gone into pure luxury. Most of all, perhaps, the advance in shipbuilding and engineering has greatly reduced the cost and expense of steam yachting, and the fashion has become to provide

afloat as luxurious comfort as is to be found ashore. The very highest development of this is the "Hohenzollern" at her moorings with a cable laid ashore for the Emperor's use.

Given a start the development of the steam yacht was easy. Year by year yachts grew bigger, until the "Lysistrata" was reached. Power and speed increased, and the appointments became richer and richer. Instead of floating cottages they became floating hotels, and their steam launches and motor boats kept them in constant touch with the world. In the table below some idea of the progress is given. Most of the "palaces" in it are owned by Americans, which is strange when you consider the American Shipping Laws. Europe, however, is the playground of the average republican millionaire, and American legislation is not yet operative on this side of the broad Atlantic. The majority of the yachts in the list were designed by Mr. Watson and built on the Clyde, which renders it unnecessary to say in whose hands the recent development of the type has been. The "Lysistrata" is the largest yacht in the world.

TYPICAL CLYDE-BUILT STEAM YACHTS.

Yacht.	Year.	Thames Measurement.	Owner.
T.S.S. Lysistrata,	1901	2082	Gordon Bennett.
,, Mayflower,	1896	1844	Ogden Goelet.
,, Nahma,	1897	1806	Robert Goelet.
,, Margarita,	1900	1798	A. J. Drexel.
,, Giralda,	1894	1664	H. B. M'Calmont, M.P.
,, Varuna,	1896	1564	Eugene Higgins.
,, Atmah,	1898	1555	Baron Ed. Rothschild.
,, Erin,	1896	1242	Sir T. J. Lipton.
,, Ivy,	1895	1131	——
,, Veglia,	1895	1110	Baron Nath. Rothschild.
S.S. Zarnitza,	1891	1086	The Czarevich.
,, Sapphire,	1892	1023	A. O. Depree.

Mr. Watson is the best known designer of the day. He was the first to fit a yacht—the "Mohican"—with triple engines, and he was also the first to introduce water-tube boilers to the class. "La Belle Sauvage"—an auxiliary steamer built at Meadowside—was the first yacht to use the new generators, and the aforesaid "Mohican" was the second to have a complete electric installation for lighting. The sea-going qualities of the type have also been greatly improved by him, as the big underwater bodies, bilge keels, raised forecastles, and long, enclosed deck-houses and bridges of the "Mayflower," "Nahma," and others show.

MISCELLANEOUS.

Barges of every possible shape are built on the Clyde, chiefly for foreign rivers, and two or three firms have made a speciality of the shallow-draught stern-wheel steamer. A great variety of ferry steamers is also a feature of the annual record, with the abundant evidence of the limitless adaptability of the craft to almost any kind of harbour work. The elevating deck-steamer "Finnieston" is a case in point. But by [illegible]he most important of what may be described as the minor branches [illegible]building is the construction of dredging plant, a division of the

industry which has its seat in the ancient and royal burgh of Renfrew. The dredgers and hoppers of Renfrew are to be found everywhere, and orders have come for them from such distant spots as Brazil, Japan, China, and Central America, India, Australia, New Zealand, Canada, and South Africa, France, Russia, Denmark, and Holland. Practically all the important dock and harbour authorities in the kingdom are also amongst its customers, so that the development of the type lacked nothing which could accelerate it.

Two other firms—one in Paisley—are also engaged in work of the class, but Messrs. Simons, of Renfrew, are probably the best-known makers of the specialities in the world. They build dredging plant almost exclusively now. In 1861 they constructed the first steam-propelled hopper barge, in 1872 the first hopper dredger, and in 1900 the largest stern-wheel bucket dredger in the world. They are the inventors of the hopper dredger, and of the traversing bucket dredger, which enables a vessel to cut its own passage through banks and shoals. The stern-wheel dredger also originated with them. There is no need or space to describe these types in detail; they are familiar to most people. But the growth has been steady and notable. The hopper capacity of the first dredger constructed by Messrs. Simons was 200 tons; of their latest—"La Puissante" for Port Said Roads—it is 2200 tons. The earliest hopper barge was of 300 tons, while the latest have twin-screws, and are of 1500 tons. And the improvement in economy is as marked.

What the further development of the steamship will be is for no man to say rashly, but that the change, whichever way it is, will be gradual seems fairly well assured. It is a reproach to British industry that America out-develops it, and the extenuation truthfully stated is that the United States commenced later. There was no immense capital fixed in plant and machinery of an earlier development to hamper them, and with new minds, in a new continent, under new conditions, they have made the most of their position. Significantly enough, they have not improved the steamship.

TRANSPORT,

BY

DAVID T. SANDEMAN.

TRANSPORT.

During the twenty-five years that have elapsed since the British Association met last in Glasgow, an enormous advance has taken place throughout Scotland—more especially the West of Scotland—in that system of inter-communication which is claimed, and rightly so, as one of the leading triumphs of the nineteenth century. This is equally true of travel by sea and of travel by land. Many new lines of steamers have been established, while large additions have been made to the lines that previously existed, the result being that all the points on our coasts have been brought into closer touch with each other, and that the facilities for journeying to and from places far distant from our shores have been extended. Ample illustrations of this progress are to be found in Glasgow and its immediate neighbourhood. There are more ferry boats than ever on the river, crossing both by night and by day. An entirely new fleet of "Cluthas" has been placed on the upper reaches, and carries thousands of passengers every day between Stockwell and Whiteinch. The steamers belonging to the "Royal Route," the Inveraray, Belfast, Dublin, and Highland lines have increased in size, comfort, and the frequency of their sailings, and, though some of the old favourite boats no longer come so high up as the Broomielaw, they are still to be found on the lower reaches. Then the railway companies have taken a new departure in this branch of traffic. No longer content with the transference of their passengers at Greenock or elsewhere to steamers belonging to other people, they have built vessels of their own, and now convey travellers right away from the city to the various resorts on the Firth of Clyde. In their own proper domain of the iron road the Railway Companies have made gigantic strides, some of them dating from the very year in which the British Association last visited Glasgow. The great revolution inaugurated by the Midland Company of abolishing second-class carriages and of carrying third-class passengers by all trains is no doubt associated with the 1st of January, 1875. But it was a year later before the Scottish and other companies completely followed suit, and before the colossal effects of the new policy were really at all apparent. The beginning, therefore, of the marvellous growth in the railway system of Scotland must be reckoned from 1876. Apart, however, from the developments which have followed the recognition of the principle that the third-class passengers are the life and soul of railways, the Scottish companies, especially those having a connection with Glasgow, have done wonders in the way of catering for traffic of all kinds. Besides extending their network of lines above ground, and spanning rivers like the Forth and the Tay, they have dived under the surface and made ways for their engines and carriages below many of our

principal streets and thoroughfares. In this manner they have not only relieved the congestion at some of our great city stations, but by lessening the distances between the town and the country, have made it possible for many of our middle and working-class population to live some miles from their places of business, and to breathe, for a time at all events, a purer air. Nor are the efforts in this direction limited to the railway companies. The promoters of the Glasgow District Subway Company have aided in the good work by their underground cable line, which encircles the city and forms a most valuable connection between the north and south sides of the river. To the magnificent service of the Glasgow Corporation Tramways great credit must also be given for bringing the suburbs into nearer touch with each other, for affording frequent and rapid means of travelling between all quarters of the city, and for helping to build up that system of inter-communication to which reference has already been made.

I.—TRANSPORT BY LAND.

RAILWAYS.

In 1901, as in 1876, the railway service of Scotland is in the hands of five companies—the Caledonian, North British, Glasgow and South-Western, Highland, and Great North of Scotland. But though no rivals have sprung up to these companies, their mileage, carrying power, and revenues have during the last twenty-five years increased by leaps and bounds. The number of miles of iron road open in 1876 was only 2400; now it amounts to 3360. As regards capital, the sum has advanced from £93,870,500 to £139,100,000. The gross receipts were £5,830,550, as compared with £10,650,000. The number of passengers has increased to a still greater extent. During 1876 the whole number carried was 42,700,000, while during 1900 the aggregate comes to no less than 104,000,000. These passenger figures, moreover, are exclusive of season ticket holders, who number nowadays more than 110,000. If the repeated journeys made by them were taken into account, it would be found that the number of people carried on our railways during last year fell very little short of 120,000,000. With reference to season tickets a comparison has often been drawn between the railways of Scotland and England, which seems at first sight to be unfavourable to the former. The fact that in England thirteen times as many season tickets are used as in Scotland, though the population is only eight times larger, has been used to support the argument that the railway companies on the other side of the Border are more liberal in their terms than are the companies on this side. But there is little or no truth in this view. The Scottish companies are in some respects even more generous with their "seasons" than the English, but the fact of the matter is that in Scotland the ordinary fares—especially those to and from our seaside and golfing places—are cut down so low that it is often found cheaper to take ordinary tickets than to enter upon contracts. All the same, the use of season tickets has been advancing more rapidly in Scotland during late years, and this may to a large extent be traced to the circumstance that so many of the workers in great centres of population are now enabled by means of the new lines to live in the country. Another contrast drawn between

the railways of England and Scotland is deserving of some attention. The latter, it is contended, indulge in a great deal more fighting among themselves than do the former. At one time, no doubt, there was a good deal of truth in this statement; there is none now. Keen struggles for supremacy were being engaged in between the Caledonian and North British Companies when the British Association met in Glasgow in 1876, and these were carried on for some years afterwards. In 1891, however, the two companies arrived at what was styled "a peace agreement." This provided for the cessation of war by an agreement that neither company should for twenty-five years make, or assist in making, new lines in the district served by the other, or in districts connected to both; and for the dividing and sharing of all traffic between competitive stations in equitable proportions. The agreement has been loyally maintained. Another agreement making for peace, so far as cutting out speed is concerned, was arrived at a few years later in connection with what is known as the "railway race to Aberdeen." This also has been kept. Indeed, only a few months ago, when a proposal for the acceleration of a through Scottish express was advanced by an English Company, both the Caledonian and the North British opposed it, on the ground that it might open the way to a renewal of the old struggle. The acceleration was carried out all the same, in consequence of a decision by Lord Balfour of Burleigh, who acted as arbiter, but so far it has not led to any serious renewal of the "railway race."

CALEDONIAN SYSTEM.

The Caledonian Railway owns now a mileage open of close on 1000 miles, as compared with about 700 in 1876. It also works and maintains 130 miles of railway belonging to independent companies. Its authorised capital amounts to £52,304,474, as against £27,000,000 in 1876, while its gross receipts last year amounted to upwards of £4,000,000, an increase of nearly 50 per cent. over the previous period. Its passengers, twenty-five years ago, very little exceeded 10,000,000 per annum; now they are upwards of 40,000,000. By far the largest proportion of this advance is, of course, in third-class passengers. Along with the increased revenue from this source and also from goods traffic, there has also been a large increase in expenditure. The working expenses in 1876 were at the rate of about £48 per cent., while last year they were £59 per cent. Again, the cost of maintenance and renewal of the permanent way was at the rate of £369 in 1876, and of £417 in 1900. The Glasgow Central, the Dumbarton and Balloch, the Cathcart District, the Gourock, the Lanarkshire and Dumbartonshire, and the Paisley and Barrhead lines, along with the construction of the new dock and harbour at Grangemouth, have been among the most important additions to the Caledonian system since 1876. To take these in detail, it was during the year in which the British Association last visited Glasgow that the Act for the Grangemouth scheme was obtained. The measure authorised the making of a new wet dock, timber basins, and other works. These operations were pushed ahead with the utmost celerity, but it was 1882 before they were completed. Four years later, in 1886, the Cathcart District Railway was opened as far as Mount Florida, and before long to all parts of the route. In 1889

the line to Gourock and the pier were opened, thus enabling the Caledonian to take a still more prominent part in the immense traffic to the watering-places on the Firth of Clyde. The first portion of the great underground system known as the Glasgow Central was opened in 1895, and by 1897 the undertaking was completed. In 1897, also, the Lanarkshire and Dumbartonshire Railway, which is worked by the Caledonian Company, was opened for passenger traffic, and simultaneously with this event the company entered upon the joint ownership of the railway between Dumbarton and Balloch and the steamboats on Loch Lomond. Last year further progress was made with the Lanarkshire and Ayrshire lines, while contracts were entered into for widening part of the Wemyss Bay line and extending the pier at the seaside terminus. Great preparations have also been made for extensive additions to the Central Station at Glasgow. This station was originally opened in 1879, but already it has proved insufficient to accommodate the enormous traffic which flows from and to it. The operations now in progress promise to convert the station into one of the finest in the kingdom.

GLASGOW AND SOUTH-WESTERN SYSTEM.

The Glasgow and South-Western Railway Company are also engaged in carrying out great additions to their St. Enoch Station and its approaches. In mileage this company has advanced from 315 in 1876 to close on 400. During the same period its capital has increased from £8,800,000 to £16,300,000, its gross receipts from £900,000 to £1,682,000, its working expenditure from £579,000 to £987,000, and the unmber of its passengers from 6,000,000 to upwards of 18,000,000. The year 1876 was a memorable one in the history of the Glasgow and South-Western system, seeing that it witnessed the opening not only of the St. Enoch Station, but also of the Settle and Carlisle line, which provided for the company a direct through route to London and to England generally. Two years later came the extension of the system from Ardrossan to West Kilbride, while in 1880 the latter line was continued to Fairlie, thus opening up another access to the coast. Fairlie Pier was completed in 1882, and the Fairlie to Largs line in 1885. The same year marked the opening of the Canal route to Paisley. In 1892 the Ayrshire and Wigtownshire Railway line from Girvan to Challoch Junction was acquired by the company. Two years later witnessed the opening of the new station at Princes Pier, Greenock. The old station at this pier had long been unable to cope with the traffic for the coast resorts, and the new one, besides being picturesque in appearance, proved of great benefit to travellers. In 1896 took place the partition of the City of Glasgow Union Railway between the North British and the Glasgow and South-Western Companies. As already indicated, the Glasgow and South-Western are occupied in extending the St. Enoch Station—a work which involves the widening of the bridge across the Clyde—but other operations are also in hand. These include a new line and the widening of the present line from Johnstone to Dalry, a new line from Ayr to Girvan (Maidens and Dunure light railway), a new line from Dumfries to Moniaive (Cairn Valley light railway), and an extension from Darvel to the boundary of the county of Lanark.

NORTH BRITISH SYSTEM.

The North British Railway mileage has advanced from 782 miles in 1876 to 1145 in 1901. Its authorised capital is now £60,000,000, as compared with £27,000,000 twenty-five years ago. Its income last year was upwards of £4,000,000, as against £2,000,000, and its working expenditure rather more than £2,000,000, as against £1,200,000. Its passengers have increased in number from 14,000,000 to nearly 40,000,000 in 1900. When the British Association visited Glasgow in 1876 the North British Company were occupied in the construction of the Tay Bridge, which was opened two years later, only to come to an untimely end during the terrific gale of the 28th December, 1879. Nothing daunted, however, by the fate of the structure, the North British directors decided within a few days of the catastrophe to take steps for obtaining a new Act for the reconstruction of the bridge. This Act was passed by Parliament in 1881. With Mr. W. H. Barlow as designer, and Messrs. Wm. Arrol & Co., of Glasgow, as contractors, the new bridge was completed and opened in June, 1887. Its total length is practically the same as the old one—10,780 feet—but its cost was double, amounting to £700,000. As an almost necessary sequence the scheme of bridging the Forth was next taken in hand by the North British Company, in conjunction with the Midland and the East Coast Companies. Messrs. Arrol were again the contractors, and they carried out the cantilever design of Mr. Baker at a cost of rather more than £3,000,000. If the effect of the Tay Bridge was to double in a very short time the passenger traffic between the counties of Fife and Forfar, the Forth Bridge has had far-reaching results as regards the traffic between England and the North of Scotland. Both have proved public necessities. The North British Company have also constructed the City and District line right under the heart of Glasgow, and connected with the new route to the West Highlands.

HIGHLAND SYSTEM.

The Highland Railway had very little more than 450 miles open in 1876. It has now advanced to close on 500 miles. The capital has increased during the same period from £3,700,000 to £7,433,805, its gross receipts from £293,000 to £510,000, and its working expenditure from £157,000 to £336,000. The number of its passengers has been nearly doubled, the respective figures being 1,130,000 and 2,223,000. Several of the extensions made by the Highland directors in the course of last quarter of a century have opened out new routes for tourists, as well as for sheep and other traffic. From the beginning it was, to a large extent, a single line, but now arrangements are being made for doubling nearly the whole of the system.

GREAT NORTH OF SCOTLAND SYSTEM.

The Great North of Scotland Railway has grown from a mileage of 280 in 1876 to one of 331 in 1901, the capital having also increased from £157,000 to £336,000. Its passengers have nearly doubled in number, the respective figures being 1,130,000 and 2,223,000. Several of the extensions made by the Highland directors in the course of the last quarter of a century have opened out new routes for tourists, as well as

for sheep and other traffic. From the beginning it was, to a large extent, a single line, but now arrangements are being made for doubling cattle traffic of a flourishing kind.

GLASGOW DISTRICT SUBWAY.

The Glasgow District Subway, though not a railway in the sense that its carriages are not propelled by a locomotive, may yet be classed among the iron roads which tend to carry on the great system of inter-communication. It serves one important function in this respect by forming a link between the northern and southern sides of the city. It penetrates under the Clyde at two points, near the Broomielaw and near Partick, and traverses the various districts of Glasgow and suburbs. During the first year of its existence—1898—it carried 9,628,392 passengers, but the number increased in 1900 to close on 14,000,000.

GLASGOW CORPORATION TRAMWAYS.

Though tramways existed in Glasgow before 1876—the Glasgow Tramway and Omnibus Company having been established in 1871—their great development dates from July, 1894, when they were taken over by the Corporation. During the last year of the private company's management the number of passengers carried came to 53,729,472, but these figures, large as they may appear, were rapidly put in the shade. They expanded in 1895-96 to 86,462,594; in 1896-97 to 98,966,658; in 1897-98 to 106,344,437; in 1898-99 to 118,775,668; and in 1899-1900 to 127,628,484, so that even with horse traction the numbers continued to grow after a marvellous fashion. To what heights they will attain consequent on the application of electric traction and the influence of the International Exhibition remains to be seen, but estimates on the subject may be gained from the fact that in the month of May, when the Exhibition had just been opened, and when electric traction had been extended to only a portion of the system, the number of passengers showed an increase of 2,000,000 over the figures for the corresponding month of last year. The Corporation revenue from the tramways has grown side by side with the development of the traffic, and this notwithstanding the concessions in the form of reduced rates granted to the travelling public. Under the old order of things the lowest fare was a penny, but the Corporation appealed direct to the masses by the institution of a halfpenny ride. Before long smaller fares were introduced for the longer distances, until they stood at the following rates:—

For one halfpenny, - - - - -	·58 mile.
For one penny, - - - - -	1·75 miles.
For three halfpence, - - - - -	2·33 miles.
For twopence, - - - - - -	3·47 miles.
For twopence halfpenny, - - - -	4·18 miles.
For threepence, - - - - -	5·34 miles.

Along with—probably as a result of—this wise policy the receipts grew from £222,122 in 1894-95 to £328,827 in 1895-96, to £365,761 in 1896-97, to £389,216 in 1897-98, to £433,128 in 1898-99, and to £464,786 in

1899-1900. There seems every prospect that in the current year they will nearly reach, if they do not exceed, half a million sterling. Nor need that be looked upon as the ultimate limit. The average revenue per mile under the system of horse traction was, no doubt, as high in 1899-1900 as it could possibly be—11·30d. But much better results were being attained from the routes which had been opened for electric traction—Springburn and Mitchell Street in 1898, High Street and Castle Street in 1899, and Glasgow Cross and Govanhill in 1900. The electrically equipped cars on these routes produced 13·89d. per mile in 1898-99, and 13·87d. per mile in 1899-1900, and so, as the electric mileage is gradually enlarged, it may be expected that the revenue will also increase. The track mileage, it should be explained, has increased since 1894 from 63½ miles, measured as single track, to 75 miles in 1900. In addition, 8 miles of track were leased from the Govan Commissioners in 1896, and have since been operated on as a part of the Glasgow system. Other 8 miles of extensions are just being completed. When all the proposed extensions are completed the total length of track will be 145 miles.

II.—TRANSPORT BY SEA.

As regards the development of transport by sea, so far as Glasgow and the West of Scotland is concerned, some definite information may be gained from the statistics compiled by the Clyde Navigation Trust and those in the possession of private firms engaged in the shipping industry, coasting and foreign.

CLYDE TRUST PROGRESS.

The total tonnage of vessels entered and cleared at Glasgow Harbour in 1876 did not much exceed 3,000,000. Last year this had advanced to nearly 9,000,000, or threefold. It must be remembered also that a large proportion of the tonnage frequenting the port twenty-five years ago was made up of sailing ships. The vessels of to-day are nearly all steamers, and have thus made their repeated voyages much more expeditiously than did their predecessors. Hence it is that while the tonnage has increased by threefold, the extent of cargoes has gone up by fourfold. In 1876 the quantity imported and exported came to little over 2,000,000 tons: last year it was well nigh 8,000,000. To accommodate such a vast expansion of traffic more docks have been constructed and additions made to the quayage. A quarter of a century ago one dock, with a water area of five acres, and some 6700 lineal yards of quays were found sufficient for all purposes. Three docks are now required, with a water area of 74 acres and 15,000 lineal yards of quayage. These extensions, along with the operations necessary to provide a navigable channel deep enough to float steamers of the larger sizes now in use, have immensely swollen the expenditure of the Trust, from £171,162 in 1876 to £399,182 in 1900. But side by side with this there has been a gradual advance in revenue. In 1876 it was well under £200,000; in 1900 it was well above £400,000—the actual figures being £441,419. Some of this revenue is derived from the cross ferries, which have of late years been so greatly extended that they now carry 9,000,000 passengers to and fro in the course of a twelvemonth, and from the

"Cluthas," a class of swift steamers which pass up and down all the length of the harbour the whole day through. During the first complete year after their introduction—1885—these "Cluthas" carried more than a million of passengers; in 1900 they carried more than three millions. Nor has the work of the "Cluthas" by any means reached its limit. The Clyde Trustees are about to begin the construction of a new dock at Clydebank; and when it is completed, further calls will be made upon the fleet of steamers whose services have, so far, proved so useful.

COASTING TRAFFIC PROGRESS.

The Clyde Steam and Sailing Ship Associations have no records bearing on the transport situation in 1876, for the very simple reason that they did not come into existence until 1882. Since then, however, the tonnage on their books has much more than doubled. The number of shipping firms in Glasgow has also increased to an enormous extent, while at the same time the business of those firms which were established at the time of the formation of the Associations has been very largely extended. Some indications of the latter fact are afforded by a glance at the additions made to the fleets of some of the oldest firms engaged in the coasting trade. For example, Messrs. J. & G. Burns have since 1876 built twenty new steamers for their trade between Glasgow and Ireland, and two for their trade between Glasgow and Liverpool. These have an aggregate tonnage of close on 20,000, and an indicated horse-power of more than 35,000. In connection with this Irish traffic a fact not generally known is that at the time the British Association paid their last visit to Glasgow the Irish mails were being carried by Messrs. Burns free of charge. The reason for this was that, when the Admiralty mail packets proved such a failure about the middle of the century the firm offered to take over free of all charge the conveyance of Her Majesty's mails between Greenock and Belfast. With this handsome and advantageous proposal the Postmaster-General of the day—Lord Clanricarde—advised the Lords of the Treasury at once to close. The result was the signing of a one-sided contract, which continued from the end of 1849 till 1882. Thereafter the mails were paid for at a fixed rate per pound weight, and after that arrangement had gone on for some years, the present contract for a stated sum per annum was agreed upon. According to the records of another great coasting firm, the Clyde Shipping Company, the number of vessels on the lines between Glasgow and Plymouth, Southampton and London, with calls at the Irish ports of Belfast, Dublin, Waterford, and Cork, has increased from eight in 1876 to sixteen in 1901, the respective advance in tonnage being from 5915 to 17,863. The steam tugs in the possession of the company have also advanced from thirteen to twenty-one in number, and 1492 to 4270 in tonnage. Turning now to what is known as the Royal route to the Highlands, the steamers which fly Mr. David MacBrayne's flag have, during the last twenty-five years, risen in number from fifteen to thirty. Their tonnage has been considerably more than doubled—3377 then, as compared with 8757 now. What is still more significant, their horse-power has been nearly trebled, the exact figures being 8315 in 1876 and 23,340 in 1901. Before 1876, moreover, the ports in the West Highlands had, in winter at all

events, to depend for means of inter-communication with the outer world upon the weekly service of boats from Glasgow only. Now there are mail steamers daily during the whole year to almost every one of these ports. The summer tourist service has been in some cases more than trebled since 1876, and energetic efforts made to meet its requirements by the building of notable steamers like the "Columba," "Claymore," "Cavalier," "Grenadier," and "Fusilier."

OCEAN TRAFFIC PROGRESS.

Two illustrations may now be given of the progress of typical lines—the Allan Line and the Anchor Line—which keep up connection between Glasgow and distant parts of the world. In 1876 the Allan Line fleet consisted of 16 sailing vessels and 21 steamers. The largest of the former was the "Glendaruel," of 1760 tons, and of the latter the "Sardinian," of 4376 tons. On the whole, the fleet was made up of 37 vessels, representing a total tonnage of 74,722. At the present time the fleet is entirely one of steam tonnage. It numbers 36 steamers, including three that are building, and represents an aggregate tonnage of 162,134. The largest are the twin steamers "Bavarian" and "Tunisian," of 10,376 and 10,576 tons respectively. While the "Sardinian," the vessel of greatest dimensions in 1876, was 400 feet long, the "Bavarian" and "Tunisian" are 501. As regards breadth, the "Bavarian" and "Tunisian" are 59 feet, as compared with 42 feet in the case of the "Sardinian." Then as to speed, the old boat could not accomplish more than 12½ knots an hour; the new ones are 15-knot boats. During the South African war no less than eight steamers of the Allan Line fleet were engaged in the transport of troops and horses to and from South Africa. One of them, the "Bavarian," which has been described by the Government officials as "the finest troopship they ever had in the service," has alone dealt with 15,000 troops and Boer prisoners. Besides conducting a large passenger service—the total number conveyed to Canada and the States during the past twenty years being about three-quarters of a million—the Allan Line also carry on an extensive cattle and general live stock traffic. Their first shipment from Canada was made in 1875, and consisted of 34 head. Last year their consignments reached the large quantity of 40,000 head of cattle, 30,000 head of sheep, and 2000 head of horses—72,000 in all.

The Anchor Line, which was established as far back as 1852, had a fleet in 1876 of 29 steamers, with an aggregate tonnage of 63,668. Such, however, has been its development since then that the tonnage at its disposal now is 133,000, made up of 32 steamers of large dimensions. The largest vessel a quarter of a century ago was the "Anchoria," of 4162 tons, with a length of 400 feet, a breadth of 40 feet, and a speed of 12½ knots. Compare these with the figures applicable to the present leviathan of the fleet. The "City of Rome"—one of the best known vessels on the Atlantic—is 8453 tons burden, 526 feet long by 52 feet broad, and has a speed of 16 knots. Of the vessels building for the fleet, the "Columbia" is the most notable. She is a twin-screw of 8300 tons, being 500 feet long by 52 broad, and is designed to steam 15 knots at sea. The "Assyrian" and "Numidia," recently added to the Indian service of the line, are two of the largest carrying vessels trading regularly from the Clyde. As to the passenger

trade of the Anchor Line, records are not available for a longer period than twenty years, but during that time the number carried was 902,532. The largest carried in any one year was 58,149. Though the Anchor Line began to carry cattle from America as far back as 1873, they have recently given up the trade. During the South African war six of the steamers of the fleet, including the "City of Rome," have been under charter to the Government. The "City of Rome" was also employed by the American Government after the conclusion of the war with Spain in conveying Admiral Cervera and 1700 Spanish prisoners from Portsmouth, Mass., to Santander.

III.—POSTAL TRANSPORT.

For any complete history of the development of the great system of transport and inter-communication, reference must be made to the records of the Post Office. If the details connected with the growth of Railways, and Tramways, and Shipping are remarkable, no less so are those associated with the progress of postal work—with the amount of correspondence between the citizens of a large city and the outside world. In 1876 the number of letters dealt with every week at the Glasgow Post Office was on an average little more than 2,000,000. By 1890 this had increased to 3,500,000, and last year the number had advanced to no less than 5,500,000. No such comparison can be drawn with regard to parcels, as what is known as the Parcels Post did not come into existence until 1883. During the opening year of its establishment the number of parcels dealt with weekly at the Glasgow Post Office was 24,500; in 1901 the number is no less than 90,000. In the special matter of Christmas parcel traffic some extraordinary statistics may be quoted. During the twelve days of the Christmas and New Year season, 1883-84, the number of parcels ran to close on 100,000, showing that in these, comparatively speaking, early times the custom of the exchange of gifts was by no means uncommon. What were the corresponding figures for 1900-1901? They came to the gigantic total of 600,000. As regards telegrams, the statistics are of an equally interesting nature. The Post Office, as is well known, took over the telegraphic system of the country in 1870. By 1876 the annual number of telegrams dealt with at the Glasgow Post Office amounted to a little over 2,000,000. Last year this number had gone up by leaps and bounds to more than 9,000,000. As a matter of necessity the staff employed at the Post Office had in the interval been proportionately increased. In 1876 some six hundred employees were found quite sufficient for all the work that had to be done, but nowadays an army of nearly two thousand strong is required to carry out the immense operations that fall to be undertaken in the establishment in George Square.

IV.—MONEY SPENT IN TRANSPORT.

While it would be well nigh impossible to ascertain the whole amount of money spent in transport, even so far as the West of Scotland is concerned, some idea may be gained of the sums expended week by week and month by month by the citizens of Glasgow and the immediate suburbs in travelling about within their own districts. This expenditure is distributed amongst the underground and other

railways that circle through and around the city and suburbs, the Subway, the Corporation Tramways, the river "Cluthas" and cross ferry boats, the cabs and omnibuses. The receipts of the Tramways and Subway are well known, as they are published every week. It is more difficult to get at the proportion of the city and suburban revenue drawn by the railway companies, but this has to a large exent been overcome through the courtesy of the Caledonian, North British, and Glasgow and South-Western officials. The drawings of the "Cluthas" and ferry boats have also been kindly supplied by the Clyde Trust. As regards cabs and omnibuses, the details are to some extent a matter of surmise. Here, however, are the estimates of the outgoing per week of the public of Glasgow and suburbs, and of the visitors to the city, on personal transport:—

On Railways (including the Subway), - - - -	£14,000
On Corporation Tramways, - - - - - -	12,000
On Cabs and Omnibuses, - - - - - - -	6,700
On "Cluthas" and Ferry Boats, - - - - -	300
Total, - - - - - - - - - -	£33,000

This means an expenditure of over £130,000 every month, or more than £1,550,000 in the course of a year, on the methods of inter-communication provided within Glasgow and its suburban districts.

TEXTILE INDUSTRIES,

BY

ROBERT MACINTYRE.

TEXTILE INDUSTRIES.

INTRODUCTION.

Although the West of Scotland is one of the greatest industrial centres of the kingdom, it is not so by reason of its textile manufactures. Certainly the products of its looms are not unknown in the markets of the world, and fabrics of chaste design and rare colour still come from a district whose old-time weavers were peerless; but, compared with the rapid development of the iron industries, or with the tremendous manufacturing growths of Lancashire and Yorkshire, their expansion has been very slow and occasionally imperceptible.

The Treaty of Union was the beginning of the West Country's industrial development. Until the close of the seventeenth century practically all the home-grown, home-spun, and home-woven fabrics that were produced were absorbed locally, and with needs that were easily met, and with no desire for trade beyond the Borders, the people refrained from the hazard of exporting. There was a little foreign trade, however, before the Union, for in an account of the district about the middle of the seventeenth century we are told that, with certain exceptions, all the inhabitants were traders—"some to France with plaiding, coals, and herring." One may assume that in this plaiding the French had a foretaste of the quality which other foreign peoples enjoyed later; it is significant, at any rate, that the earliest patrons of our looms abroad were a race whose artistic tastes are noted for their refinement.

But the Glasgow Weavers were, long before that period, a separate trade incorporation—enjoying privileges which were defined with medieval exactness, and exercising powers which were absolute within the craft. In their charter of incorporation they were protected against the rural weaver as follows:—Whereas "the communitie of Websters walks, wards, stents, and beares all the common charges of the said towne . . . ilk out-of-the-towne Webster to landward that comes within the said towne and takes the stuff thereof, shall pay ilk time they are taken ane pund of walx to the light of the said altar, together with ane free dinner to the masters of the said craft." They were incorporated in 1528, and the extract from their charter sufficiently indicates their power. Indirectly it shows, too, that even in the sixteenth century the villages and towns in the neighbourhood of Glasgow must have been relatively as considerable centres of handloom weaving as we know them to have been later.

The middle of the seventeenth century seems to have been the time of the city's emergence as a place of manufacture. The year of the Union saw its place in the world of trade assured, but two facts show that a trade development was strong much earlier. In 1638 a company proposed to establish a weaving factory in the city, and the Town Council, with commendable enterprise, gave it the free use of a great lodging in the Drygate, which had belonged to one of the prebendaries of the Cathedral. The

City Fathers believed that "great good, utility, and profit to the town" would be the result. But they reckoned without the Corporation of Weavers, who protested against the concession, and remained obdurate until Mr. Robert Flemyng and his partners came under an obligation to employ only freemen of the Incorporation. The existence of the factory is proof that the manufacture of textiles was on a considerable scale more than half a century before the Union; and contemporary records testify much to the same effect. One—"Franck's Northern Memoirs"—speaks of "this eminent Glasgow, whose storehouses and warehouses are stuft with merchandise, as their shops swell big with foreign commodities," and enumerates amongst its staples linens, friezes, and tartans.

Obviously there were here exactly the conditions in which such an act as the Treaty of Union could best prosper. Wool was no longer allowed to be exported, and its manufacture increased. England, the English colonies and plantations, and hitherto inaccessible English markets were opened to Scottish enterprise, and the country was on the highway to commercial prosperity.

The commercial travellers of those days sold his wares in one minute and delivered them in the next. Instead of samples he carried bulk, and he was known far and near as a pedlar. Nowadays there is a wide social gulf fixed between the "ambassador of commerce" and the pedlar; but nevertheless more than one great house traces its descent from a man who had the instinct to see in "peddling" the beginning of great things. Pedlars from Glasgow and Paisley were the pioneers of Scottish trade in England, and the linens and other cloths they carried spoke eloquently of the country's resources. Attracted chiefly by the cheapness of labour, and compelled, in a sense, by the competition, English manufacturers came North, and, under more remunerative conditions, commenced textile industries which had hitherto been unknown in Scotland. The exchange of commodities naturally increased greatly. In the thirteenth year from the date of the Union, Scotland's linen exports represented no less than £200,000, and her imports of English woollen cloths nearly £400,000. In addition, a prodigious quantity of linen was sent from the Clyde to be exchanged for the produce of the West Indies and of the great American continent, whose people now vie with us in manufacturing skill in almost every industry. And to promote these developments came, created under the Treaty of Union in 1707, the Board of Trustees for Manufactures, with its subsidies, its schools, and its otherwise helpful influence.

The merging of the two Parliaments was not, strictly speaking, the cause of this commercial expansion, but it happened at the most favourable moment, and even detractors of the Union did not deny its effect. "The Union," says De Foe, writing in the year of the Board's establishment, "has indeed answered its end to them"—the citizens of Glasgow, that is—"more than to any other part of the Kingdom, their trade being new formed by it. For as the Union opened the door to the Scots into our American colonies, the Glasgow merchants presently embraced the opportunity; and though at its first concerting the rabble of this city made a formidable attempt to prevent it, yet afterwards they knew better when they found the great increase of their trade by it."

Amongst the local manufactures noted by the same writer are plaiding—"a stuff cross-striped with yellow, red, and other mixtures"; muslins—"generally striped," and "so good and fine that great quantities of them

are sent into England and to the British plantations, where they sell at a good price"; and linen—"common in all parts of Scotland, which improve in it daily." So that even then the textile manufactures of the West of Scotland were noted for their variety, though the preponderance of light textures like lawns, muslins, and gauzes was as marked as it is probably to-day. In our time, the dictates of fashion have multiplied the varieties, making one texture popular at the expense of another, and declining some to the verge of extinction. But these are the legitimate risks of all trades; they stimulate invention, and compel studious care not only of the needs of the moment but of the probable needs of the future.

At the dawn of the nineteenth century, therefore, the manufacture of textiles was firmly established in the West of Scotland, and the prospects of the industry were roseate in the extreme. Spinning and weaving provided plentiful employment in Glasgow and the villages around it for many miles, and in the counties of Lanark, Renfrew, and Ayr many cottars plied the craft in lonely places, far from the madding crowds of urban districts. The industry was common in almost every village, and to be a weaver was to be a person of importance in the land. The flax and wool, which until the introduction of cotton, about 1770, were the staple fibres, were cultivated in small quantities by the cottars themselves, or purchased from neighbouring farmers, and although natural causes created distinctions for some districts in the growing of flax or in the rearing of sheep, there was none of the concentration which came later with the power loom. It was essentially a village industry, and every cottage had its loom.

The student of Scottish life and manners in the eighteenth century will be struck with the frequent allusions to the spindle and spinning wheel in the literary records of the period. It is particularly enshrined in song, and more than one Scottish poet discloses intimate acquaintance with its technicalities. There is little reason to wonder at this when we consider that when the nineteenth century opened the rural population of the country kept aloof from the cities. The concentration which marked the beginning of our great industrial development had not set in, and the domestic circle was a community of itself.

The cultivation of small patches of lint, and the preparation of the fibre until it was ready for spinning were a recognised part of farm work. It was pulled, rippled, steeped, beetled, scutched and heckled by the farmer, who turned it over to be home-spun and bleached by his women folk. On the long winter nights the women round the ingle spun their tint of tow. The yarn so spun was turned over to the merchants of Glasgow and of Paisley, who distributed it to the weavers of the towns and villages and hamlets of the country around. The Scottish spinster, however, went down the vista of romance when Hargreaves, Arkwright, and Crompton came with their inventions.

Scotland was slow to adopt the mechanical improvements which had been made on English looms, and until nearly the close of the eighteenth century the loom used was of the most primitive description. Although it was introduced at Bury in 1733, the fly shuttle was unknown north of the Border for many years afterwards. But this conservatism could not stand in the face of mechanical progress, and the hand looms of the north gradually reached the standard which competition with rival centres demanded. The production of weaving yarns, rapidly and in large quantities, was greatly facilitated by the inventions of, amongst others, Arkwright,

and the producing powers of the hand loom were largely increased. Weavers came to be the best paid artisans in the West of Scotland, and there seemed to be no limit to their prosperity. They were for the greater part men of more than ordinary intelligence and of superior education.

In a review of this kind it is, of course, impossible to trace the cause of every little deviation from the straight line of progress. Our concern is the textile industry as a whole, and just here, on the threshold of a century of mechanical achievement, there is danger of confusion. The factory operative was to come when 1800 was passing, and the hand loom weaver was a power in the land. He continued to enjoy unparalleled prosperity until the Napoleonic wars were half through, and then the market for muslins at his price declined. The factory operative, with all his mechanical aids, had come, and wages fell with amazing rapidity. The following table from the report of the Commissioner appointed by the Government in 1838 shows the decline:—

RATE PER ELL AND WEEKLY EARNINGS OF A WEAVER ENGAGED ON A CERTAIN QUALITY OF PULLICATE IN DIFFERENT YEARS.

1806	15d. per ell,	32s. 6d. per week.
1810	12½d. ,,	26s. 9d. ,,
1815	12d. ,,	25s. 9d. ,,
1820	5d. ,,	10s. ,,
1825	5d. ,,	10s. ,,
1830	3d. ,,	5s. 6d. ,,
1835	3½d. ,,	6s. 7d. ,,
1838	3½d. ,,	6s. 7d. ,,

And in substance his finding was—"There appears no prospect whatever that the weaving trade will improve. The power-loom is applicable to many fabrics which the exceedingly low rate of wages alone enables the hand-loom to retain."

But the essential "exceedingly low rate of wages" barely supplied the weavers with the necessaries of life, and by and by even that cold comfort was denied them. Unable to adapt themselves—in the towns particularly—to the rapidly changing conditions, they were left literally to starve, and by and by their plight was so abject that the Commission, which has been referred to, became an absolute necessity. Their degradation was complete. Thefts of weft and other weaving material became alarmingly common, and the distress and its attendant evils became so marked that the community clamoured for Government intervention.

In the face of the report, only one remedy was possible—emigration on a wholesale scale. So the unfortunate weavers, many of them so scantily clad that clothing had to be provided in order that they might appear to be certified, were sent to ply other crafts in other lands. The lower cost of living enabled cottars to exist longer, and Paisley developed along a line which, for an all-too-brief space, became peculiarly its own.

The Paisley weavers suffered to a certain extent from the distress we have noted, but half-way in the period covered by the official investigation they turned their labour to account in another direction. Previously they had looked askance at shawls, chiefly because of the expensive looms necessary, but the decline of the muslin trade compelled other views, and they took up the manufacture. From 1824 to 1827 shawls largely made up of real Cashmere wool were woven in a factory under the supervision of a

Frenchman, whose introduction of the double ground increased the already great beauty of the fabric and cheapened the cost of production. Various other improvements which need not be enumerated here were made, and about 1830 Thibet shawls were the staple productions of the Paisley looms. The industry developed with amazing rapidity, and improvement followed improvement, until the city draper pushed Paisley goods as French, and even France, from which Paisley has learned much, imitated the work of its persevering rival. The introduction into Paisley of the Jaquard machine revolutionised the industry, and the rich white crape shawls, the silk gauze shawls, the lace shawls, the barege shawls, the harness-woven black satin shawls, the crape Indianas, the Cashmeres, and the mosaics of Paisley became famous all over the world.

But the tide of this prosperity ebbed in time, and Paisley shawls, from being articles of everyday wear, became practically heirlooms. And more than once the industry had experience of the fickleness of fashion. In 1841 and 1842 there was no demand for the shawls, and the unemployed weavers and their dependants suffered greatly. Our late beloved Queen saved this situation, as she did many others, by setting the fashion again; but the revival was short-lived, and the hand-loom weaver was face to face with his original difficulty.

The Paisley weaver of that day was a man of exquisite taste and untiring industry, and his work displayed rare skill. "As craftsmen," said Mr. John Ingram at the opening of the late Exhibition of Shawls in Glasgow, "the Paisley weaver and his assistant 'drawboy' of those early days have never been equalled in textile skill." But modern needs are more easily and more cheaply supplied, and the interesting figures had to follow their earlier exiled brethren into other walks and to other lands.

Fashion decreed the extinction as a manufacture of the high-class shawl, over which the weaver toiled for months, but the cheapening of fabrics of every kind by the development of the power loom was the real cause of the decay. Cheapened production widened the area of distribution, and to meet the increased demand concentration in gigantic factories became necessary. But in rural districts the hand-loom weaver lingered on, "a steadily declining remnant." "According to a kind of rough census," says Mr. Paton in 1878, "made in 1872 of the counties of Lanark, Renfrew, and Ayr, there were then about 10,000 hand-loom weavers either at work in their own houses or in shops belonging to manufacturers. . . . In 1875, working upon Paisley shawls, they could earn from 4s. to 5s. per day, but at shirtings and the common descriptions of work, which are, however, mostly left to women and boys, not more than 8s. per week could be earned, and that with the labour of twelve, fourteen, and sometimes even more hours. Working practically beyond the range of factory inspectors' supervision, the hand-loom weavers not only labour long and irregular hours, but children of tender years, taken in as apprentices, have to ply the shuttle for equally hurtful and unconscionable periods."

Obviously such a state of matters could not exist much longer. The hand-loom weaver of the rural districts gradually died out, and other industries provided more remunerative employment for his children. The concentration in great factories which was beginning to be marked then is almost complete now, and the music of the shuttle is rarely heard in the scattered villages of the West. Some fabrics, which it would be unprofitable to multiply, are still, of course, made on hand looms, but the number is necessarily small.

The displacement of labour which this revolution caused was serious, but naturally its abundance and low cost attracted other industries. Factories provided employment for large numbers, and what was not absorbed in that way was utilised by the new-comers. The lace curtain industry of the Loudoun Valley, the thread trade of Paisley, and one or two other branches of manufacture were established and developed, and by and by enforced idleness and its attendant evils were rare. Strange to say, however, the development of cotton spinning and weaving lasted only up to a point, and the trading world had the first evidence of a want of enterprise on the part of Scottish manufacturers. Twenty or thirty years ago there were a large number of factories in and around Glasgow manufacturing grey cloth, suitable for printing, but, unable to compete with the great and completely equipped establishments in Lancashire and Yorkshire, they have gradually disappeared. There are still one or two in existence, and it may be that but for the absorption of capital by other industries there might have been more; what has to be noted is that the only concern set up in the district with modern spinning machinery is a financial success. "The only hope," said a Glasgow merchant the other day, "of a return to the prosperity of former years seems to be the adoption of the most economical methods of production, so as to meet the powerful competition which has arisen."

Linen, which once was the staple, is now manufactured almost exclusively in the East of Scotland and in the North of Ireland, and the grey cottons of Lancashire are in vogue. But the plain muslins of the West of Scotland still represent a considerable industry, and the market for them is maintained steadily. Their manufacture absorbs a large quantity of the best descriptions of cotton yarn, and in that direction one looks reasonably for the development which is claimed elsewhere.

Dress fabrics, however, which not long ago represented a large interest in and around Glasgow, are declining in importance, chiefly through the competition of Bradford. For a very long time Glasgow manufacturers of coloured dress fabrics and other cloths were noted for their taste and care, but fashion first and then the Yorkshire factories, with their economical production and their enormous output, gradually displaced them. All attempts to meet this competition have failed, chiefly because the mill-workers of a city like Glasgow are not so utterly dependent on the factory as the operatives of Yorkshire and Lancashire are.

But the decline applies only to the heavier classes of dress fabrics. Zephyrs have been for many years manufactured largely; and the shirting trade has not only been maintained, but has grown in extent. Of some other branches much the same is true, though where so much depends on fashion the fluctuations are necessarily marked.

Other textile industries which have been developed in the West of Scotland are referred to further on, but may be noted briefly here. Chief place among these must be assigned to carpets, the manufacture of which has been developed with great care and rare artistic skill by the Messrs. Templeton, of Greenhead. Madras muslins are largely manufactured for window decoration to the ultimate exclusion, evidently, of the tapestry curtain. Satisfactory progress may also be reported of the silk trade—neckerchiefs, etc.—which has chiefly its markets at home and in Rangoon, and the details which follow sufficiently indicate the state of the many minor industries which come under the head of textiles.

The intimately related industries of bleaching, calico-printing, Turkey-

red dyeing and printing, and calendering and finishing may be briefly referred to, for their history is pretty much that of textiles. Their record is not one of continued progress from the first, though their ultimate development has been little short of marvellous. They have had their periods of deep depression, and have faced the ordeal of stern opposition from across the Border. But, unlike the kindred interests, they have made the best possible use of natural advantages; nothing in the way of equipment that was essential to success has been left unprovided, and they are now practically beyond the effect of local fluctuation. "They have," as Mr. Paton remarks, "undergone marvellous transformations." Calico printing was an industry in the neighbourhood of Glasgow as early as 1738 —nearly thirty years before it was known in Lancashire—and it has continued to be one ever since, though there were almost prohibitive duties—latterly the rate was 3¼d. per yard—until 1831. Bleaching with chlorine was first practised in 1787, at the suggestion of James Watt, who had had the process explained to him a year earlier by Berthollet.

The dyeing of Turkey-red, which is peculiarly a West of Scotland industry, and has been developed enormously, was first introduced at Dalmarnock under the direction of a dyer from Normandy. At the moment its outlook is not so favourable as it was a year or two ago, but the lull is not likely to be a prolonged one. There is keener competition to contend with from the Continent, and Bombay is a serious rival in India, China, and Japan, but there is nothing in the situation to give the slightest cause for uneasiness respecting the future.

The foregoing is simply an attempt to trace briefly the development of the textile industries of the West of Scotland, and to point out the causes of their variation and decline. All the information available has been embodied, as far as possible, in the foregoing brief historical narrative.

COTTON TEXTURES.

To the East Country belongs the credit of introducing cotton manufacture into Scotland, for, though "blunks"—handkerchiefs with linen warps and cotton wefts—were known earlier, it was at Penicuik in 1778 that the first cotton-mill was erected in Scotland. The second was built at Rothesay in the following year, and a little later similar erections appeared at Barrhead and Johnstone. The selection of Rothesay as the centre of a new industry, and the preference of Barrhead and Johnstone to Paisley or Glasgow may at first sight seem strange. But steam was not the motive power of those days, and the Clyde was not the navigable river it is now. The manufacturer depended for his power on water, and all these places were happily situated in that respect, besides enjoying as many transit facilities as greater centres. In the same way the choice of Lanark in 1785 for a more ambitious effort was natural. Here David Dale and Arkwright were associated, and their enterprise was for a time the most important in the country, in which there were altogether at the close of 1787 nineteen cotton-spinning mills. Of these, four were in Lanarkshire and four in Renfrewshire.

At New Lanark, it may be noted in passing, and at Orbiston, in the Parish of Bothwell, Robert Owen made the second of his three attempts to carry out his economic theory of socialism. Dale was his father-in-law. The attempt failed, and in the experiment Owen lost what has been

described as a princely fortune, the mills passing in 1827 into the hands of a commercial company.

The development of the spinning trade, which has been rapid and wonderful, was to a large extent the work of Englishmen. The mechanical inventions were all English, and to the Scotland of those early days belongs only the credit of making the most of them. Scotchmen altered them and adapted them to various purposes, and in a variety of ways improved their efficiency. Mr. William Kelly, who was manager at New Lanark in 1792 for Mr. Dale, initiated the working by power of Crompton's mule-jenny; and in 1795 Mr. Archibald Buchanan, of Catrine —one of Arkwright's earliest pupils—experimented with the self-acting mule which he only perfected in conjunction with his nephew, Mr. James Smith of Deanston, in 1826. The names of both these men stand high in the records of the industry. They were ingenious and they were patient, and their names are associated with several mechanical improvements in other fields. At Catrine many improved processes were introduced in opening, cleaning, lapping, and carding cotton fibre, and Mr. Smith was responsible alone for numerous improvements on carding engines. In the light of the vast mechanical changes that have taken place since those early days, these achievements may seem trivial, but they represented the high-pressure progress of the time, and they have a sentimental interest for most of us.

In the "New Statistical Account of Scotland" it is stated that in 1820 Mr. Smith "had contrived and constructed the mechanism of a self-acting mule; but his attention having been required for other more extensive and important operations, he laid it aside, it is believed, without trial. In 1833, Mr. Smith, seeing the desire that existed for a simple and efficient self-acting mule, and more especially such as could be applied to the mules of various constructions at present in general use in the trade, set about contriving one, and having made some progress he came to hear of a very simple contrivance for facilitating the process of backing off (one of the most difficult to accomplish in a self-actor) by Mr. John Robertson, an operative spinner and foreman to Mr. James Orr, of Crofthead mill in Renfrewshire. Mr. Robertson, through Mr. Orr, obtained a patent for his invention, which consisted of other movements rendering the mule completely self-acting. Mr. Smith, struck by the simplicity and efficacy of his backing-off movement, which consists in stripping the coils from the spindles, entered into an arrangement with Mr. Orr and Mr. Robertson, and having united the mechanism of his own patent with that of Robertson and Orr, a machine was brought out which is considered to be more simple and effective, and more generally applicable to all mules, than any other yet brought before the trade."

The Tape Loom was introduced in Glasgow in 1732, and its introducer was Mr. Alexander Harvie, who, at the risk of his life, brought away two Inkle looms and a weaver from Haarlem in Holland. Strategy of this description deserved lasting reward. But the Dutchman evidently did not like the treatment he received at the hands of the Glasgow people, and, proceeding to Manchester he unfolded his secret to our trade rivals there. Dr. Cartwright's power-loom was in use in Glasgow as early as 1793, but its introduction was a humble one, and its operations small. A citizen had seen it in the hulks in London, and, possessing himself of two, fitted them up in a cellar in Argyle Street. For power, he had a Newfoundland dog walking inside a revolving drum. A year later a factory with forty looms was

established at Milton, near Bowling, for weaving printing calicoes, and in the opening year of the nineteenth century a similar erection, to accommodate two hundred looms, appeared at Pollokshaws. Catrine Mills, which have already been noted as the scene of the achievements in spinning machinery of Buchanan and Smith, also adopted the improved apparatus, and the decline of the hand-loom was accelerated by every inevitable increase of its efficiency.

Considering the class of work which the West Country had excelled in, it was natural that its manufacturers should take to the more delicate fabrics into which cotton fibre could be woven. Linen, cambric, lawn, and silk gauzes—the latter only from 1760, and almost exclusively in Paisley—were the fabrics they had been used to, and when the change came, muslins—plain for the most part in Glasgow, and ornamented in Paisley—were the earliest substitutes.

About 1780 Mr. James Monteith, whose son founded the great printworks at Barrowfield and the spinning and weaving mills at Blantyre, warped the first muslin web attempted in Scotland, and subsequently set himself the task of imitating, with commercial success, the products of Dacca and the other famous muslin-producing centres of India. His great difficulty was yarn. What could be produced was not fine enough for his purpose, and he procured some bird-nest Indian yarn. He then "employed James Dalzell," says a historical account of Glasgow's progress, "to weave a 6-4th 12.00 book with a hand shuttle, for which he paid him 21d. per ell for weaving. It is worthy of note that the same kind of web is now (1840) wrought at 2½d. per ell. The second web was wove with a fly shuttle, which was the second used in Scotland. The Indian yarn was so difficult to wind that Christian Gray, wife of Robert Dougall, bellman, got 6s. 9d. for winding each pound of it. When the web was finished Mr. Monteith ordered a dress of it to be embroidered with gold, which he presented to Her Majesty Queen Charlotte."

The development of cotton manufacture was, as already indicated, rapid, and the reign of the "cotton lord" became almost supreme. Muslin was the chief of the textures into which the fibre was woven, but other remunerative uses were found for it also—in mulls and jaconets—and ginghams and pullicates found good markets both at home and in our West Indian Colonies. The making of checked and striped muslins also became common, and later were added spotted muslins and lappets—the latter in 1814. The hand loom weavers of the towns and villages found a deal of employment in the making of the ginghams and pullicates, and, broadly speaking, what has been called domestic weaving generally was at its high-water mark. Grey cloth for bleaching and printing was made on a fairly large scale, and occupied a place of importance for many years, but in an annually increasing proportion the great manufacturing districts of Lancashire provided the employment for the extensive bleaching and print works of the Clyde Valley. To-day the bulk of the grey cloth comes from the South.

Weaving was not the only branch of the industry associated with the hearth, for the plain muslins came to be ornamented, and women everywhere were employed hand-sewing the textures into things of beauty. There was a large and paying market for this class of work, and not only the women of the West of Scotland, but the women of the North of Ireland as well, were employed in it. The introduction of the Irish labour had its effect, Mr. Paton says, on prices, but it is hardly to be doubted that in any case the rate would have cheapened as the industry developed. For the

work, though it required taste and had to be done indoors, was comparatively easy. "Elaborate and artistic patterns were prepared for embroidering by specially trained designers; these patterns were printed from engraved cylinders of wood on the surface of suitable pieces of muslin, on which also was printed the number of the pattern, the length of time allowed for sewing it, and the price to be paid by the agent or manufacturer" for the work. The fixed prices were, we are told, poor; nevertheless the industry prospered. Manufacturers grew rich beyond the dream of avarice in it, and work people of every class shared in its general prosperity. But a change came—swift, sudden, and disastrous—in 1857. In the memorable financial crash of that year many firms of note in the commercial world went under; the next two decades saw between them the gradual withdrawal of many more, till now the trade is little more than a shadow of its former self. The embroidering machine entirely superseded hand labour.

In the face of all the displacements of labour that have taken place, the continuous growth of the West Country is wonderful. If its people had been altogether dependent on textiles the development, though suspended, might have been that way, for in every respect the district was as favourably situated as any of the English centres that have succeeded. But the making of the Clyde, the opening up of coal and iron fields, and one or two movements of minor degree absorbed much of the available capital and labour. Almost innumerable industries were initiated, and now the variety in and around Glasgow is possibly greater than it is anywhere else in the kingdom. The mechanic has a wide selection of employment, the attractions of counting-house, shop, and warehouse cannot be resisted by the young woman of the day, and unskilled labour has a price which was never dreamed of in earlier times.

Still, some part of the disengaged labour has been absorbed in alternative textile manufactures, and the success of these enterprises seems to prove that but for the tremendous counter development of iron we might have been rivals of Lancashire instead of Northumberland and Durham. The making of thread, for instance, saves so famous a textile centre as Paisley from complete capitulation to the engineer, and if Paisley could transplant Kilbowie to the Cart side of the Clyde we should have an example of a marvellous twin-development. The sewing machine has been the making of the thread industry. But there was thread even in pre-machine days, and necessarily very robust thread. Until the middle of the eighteenth century the chief sources of supply were in the counties of Aberdeen and Forfar, but as early as the close of the preceding hundred years the West of Scotland was associated with its manufacture. Christian Shaw, the daughter of John Shaw of Bargarran, was noted for her dexterity in spinning fine linen yarn, and Lady Blantyre took some of her "thread" to Bath, where it was sold to manufacturers of lace. That was Scotland's *debût* in the thread export trade which she now practically controls.

During a visit to Holland one of the Shaws accumulated much exclusive knowledge of thread manufacture. On his return home he naturally communicated all he knew to his relatives, and Miss Shaw—more than ordinarily fragile, but with the compensation of shrewd business instincts—reorganised her establishment on a more extensive scale. The ounce or nun's thread of Bargarran came to be widely used, and Paisley came to be identified with the industry through a Mr. Pollock, who set up its first thread factory.

Rather an unpleasant light is reflected on the period by an incident

in which the founder of the industry figured. Miss Shaw was, as I have said, rather a sickly young person, and her ailment, whatever it was, was beyond the skill of the medical practitioners of the day. Therefore, according to the superstitious notions of the time, she was regarded as bewitched. Three men and four women were found guilty at Paisley in 1797 of bewitching her, and were hanged on the Gallow Green on the 10th June. The bodies, it may be added, were afterwards cut down, and burned in a fire, the principal ingredient of which was a barrel of tar.

The manufacture of cotton and linen thread has developed with enormous strides, and one may not lightly put a limit to its growth. Glasgow and other considerable centres are interested in it, but Paisley is the seat of it. Fiscal policies are not without their effect on this as on other British industries, but when the scale of a manufacture is colossal, and its markets in every land, fear of disaster is slight. And fashion, which has decreed the supersession of many fabrics and the extinction of the Paisley shawl, stops far short of thread.

Other notable branches of cotton manufacture are lace making and Turkey-red dyeing. The last-named has long been practised, chiefly in the Vale of Leven, and its extent and influence are now very great. But, like the thread makers, the bleachers, and the calico printers, the Turkey-red dyers do not desire publicity. I have asked for information, and have received none.

As I have stated, the centre of the cotton manufacturing world has shifted since 1857. Forty years ago there was a large number of spinning mills in Glasgow and its vicinity, and the raw cotton was shipped direct to the Clyde. The rapid progress of Lancashire, however, made competition keener, and mechanical development was quicker over the Border than it was here. Transport became less and less a factor in cost with railways extending everywhere. The machinery in the Scotch mills became archaic alongside that of similar establishments in England, and few, if any, serious efforts were made to restore anything like equality in economy or speed of production. One by one the Scotch mills decreased, until now the total number may be counted on the fingers of one hand. The Glasgow Cotton Spinning Company (Limited) is the only concern which meets the Lancashire establishments on their own ground, and, significantly enough, its experience proves that commercial success is possible with capital, experience, and the right methods. The experience and expert knowledge of the right methods are easily obtainable, but there are obviously plenty of remunerative outlets elsewhere for the money.

The cotton manufactures of to-day are varied, and the production is nothing like what it was in former days. Grey cloth is still made, but not to any considerable extent; the great bulk of this comes, as I have said, from across the Border. The East End of Glasgow still produces muslins on a fairly large scale, and Madras curtains also represent a considerable interest. The weaving of zephyrs is likewise considerable, and the local fabrics of this kind have an excellent name for quality and finish.

Statistics of the cotton trade are not easy to get, and the few that are obtainable do not facilitate comparison with other industries. Value would be the just measure. But a calculation based on value is obviously impossible, and we have to fall back on official reports, prepared, of course, with different objects. I have said that in 1787 there were altogether 19 cotton mills in Scotland and that of these

4 were in Lanarkshire and 4 in Renfrewshire. In 1834 Mr. Leonard Horner, one of the Factory Commissioners, reports "that in Scotland there are 134 cotton mills. With the exception of some large establishments at Aberdeen, and one at Stanley, near Perth, the cotton manufacture is almost confined to Glasgow and the country immediately adjoining, to a distance of about 25 miles radius; and all these cotton mills, even including the great house at Stanley, are connected with Glasgow houses, or in the Glasgow trade. In Lanarkshire . . . there are 74 cotton factories, in Renfrewshire 41, in Dumbartonshire 4, in Buteshire 2, in Argyleshire 1, and in Perthshire 1." Of these, 100 belonged to Glasgow. "In Lanarkshire," proceeds Mr. Horner, "there are 74 cotton mills, 2 woollen, and 2 silk factories; 78 steam engines and 5 water wheels; total horse power, 2914; of which steam, 2394; water, 520. Total persons employed in factories, 17,969." Mr. Symons, whose report is referred to in the introduction, records that in 1838 the number of hand looms in the West of Scotland dependent on cotton weaving was over 37,000.

A parliamentary return made in 1850 states that there were at that time 149 cotton factories in the district—94 in Lanarkshire, 51 in Renfrewshire, and 4 in Ayrshire, and that between them they had 1,410,054 spindles, and 21,575 power looms, employing 31,710 persons. Ten years later the figures were 143 factories, 1,577,584 spindles, 28,085 power looms, and 36,903 hands. In 1875 there were in the counties of Lanark, Renfrew, and Ayr 64 factories, with 1,192,946 spinning spindles, 333,934 doubling spindles, 27,479 power looms, and 33,276 employees. There has been no official return since 1890. That return, which is given, shows an increase of factories, but the other details sufficiently discount the higher total. Many of the establishments included were not, strictly speaking, factories, although for the purposes of the Act they were registered as such. The decline, which was really marked then, has been slow but sure until now.

COTTON FACTORIES IN SCOTLAND IN 1890.

	Factories.	Spinning Spindles.	Doubling Spindles.	Power Looms.	Persons Employed.		
					Male.	Female.	Total.
SPINNING ONLY—							
Renfrew, Ayr, and Lanark, -	27	413,495	541,314	—	2,559	10,005	12,564
Total in Scotland, - - -	32	508,727	555,200	—	2,812	11,116	13,928
WEAVING ONLY—							
Renfrew, Ayr, and Lanark, -	56	—	—	21,727	2,460	12,701	15,161
Total in Scotland, - - -	58	—	—	22,047	2,472	12,864	15,336
SPINNING AND WEAVING—							
Renfrew, Ayr, and Lanark, -	8	109,032	9,260	5,615	589	3,610	4,199
Total in Scotland, - - -	9	130,836	9,350	6,046	730	3,897	4,627
UNENUMERATED—							
Renfrew, Ayr, and Lanark, -	23	—	—	—	233	692	925
Total in Scotland, - - -	25	—	—	—	242	740	982

FLAX MANUFACTURES.

The manufacture of linen is now practically an extinct industry in the West of Scotland. Time was, as I have stated, when its production was largely undertaken, and a considerable proportion of the population depended on it for employment. But cotton displaced it in the early part

of last century, and, so far as Scotland is concerned, the East is now the headquarters of the trade. Belfast and its vicinity is, of course, the great linen manufactory of the kingdom, and in variety and extent the output of its colossal mills is immense. But the fine damasks of Dunfermline, and the heavier fabrics of Dundee, have a fame that is world-wide. Thread is almost the only use to which the fibre is now put on a large scale in the West, and the traders of Glasgow, whose particular productions are sufficiently varied, have to seek elsewhere the linen they need.

That was not always so, for in 1780, when cotton weaving was in its infancy, there were in the Barony Parish of Glasgow alone about 3000 looms making lawns, cambrics, diapers, checks, handkerchiefs for printing, and "blunks"—fabrics of linen warp and cotton weft used for neckties, gowns, and bed curtains. And as an industry it had been of growing importance locally from the beginning of the century. The times in which it throve were times of transition for Scotland, which was slowly recovering commercially under the fostering care of the united Parliaments from the paralysing effects of the Darien failure. It was bolstered by bounties and protected by duties, and the Board of Trustees for Manufactures in Scotland—to give its full, unwieldy title—was generous in its grants for the cultivation of flax, the improvement of appliances, the perfection of manufacturing processes, and the extension of works. These methods of developing industry are not greatly in favour with us now, and it is easy to overstate the good effect of them on the trade. What cannot be overlooked is that during their nominally beneficent operation the manufacture of linen prospered and expanded in the face of a Stamp Act, which was in existence for practically a century—from 1727 till 1823. During that period no linen fabric could be exported, or in any way exposed for sale, which had not been examined, approved, and stamped by an official of the Government appointed for the purpose. Cotton decreed the banishment of the industry, and the gradual displacement is conveniently set forth in the following table:—

LINEN STAMPED DURING OPERATION OF STAMP ACT.

YEAR.	LANARKSHIRE.		RENFREWSHIRE.		AYRSHIRE.	
	YARDS.	VALUE.	YARDS.	VALUE.	YARDS.	VALUE.
1728	272,658⅜	£9,968	85,527⅜	£6,852	26,699⅛	£2086
1738	605,234	30,140	257,737	16,853	68,723⅜	3252
1748	1,191,982	54,127	398,279	25,291	95,190	5351
1758	1,951,693	86,530	788,491	51,660	139,161	7480
1768	1,994,906	172,764	674,178	66,387	123,543	6590
1778	1,748,674	142,446	1,467,935	96,201	50,286½	3000
1788	1,362,150¼	109,440	1,671,346	115,817	54,109⅜	3314
1822	22,869½	1,951	25,685	3,107	20,826	3196

The falling- of, it will be observed, is contemporaneous with the rise of cotton weaving, which had its beginning in the decade succeeding 1780. And it never recovered. In 1875 only 11 of the 159 linen factories in Scotland were in the three western counties, to which the figures refer. Of carding and combing engines they had only 28, out of a total of 670; of spindles, 39,000, out of nearly 300,000; and of power looms, only 1154, out of 18,529. And only a little over one-ninth of the 45,000

people employed in the industry in Scotland were engaged in the work. The latest official return, of which I give an abstract, is for 1890. The factories in the western district were engaged chiefly in the manufacture of linen thread.

FLAX FACTORIES IN 1890.

	Factories.	Spinning Spindles.	Doubling Spindles.	Power Looms.	Persons Employed.		
					Male.	Female.	Total.
SPINNING ONLY—							
Renfrew, Ayr, and Lanark, -	5	24,927	17,446	—	1,304	1,794	3,098
Total in Scotland, - - -	48	132,553	19,017	—	3,673	6,628	10,301
WEAVING ONLY—							
Renfrew, Ayr, and Lanark, -	—	—	—	—	—	—	—
Total in Scotland, - - -	76	—	—	15,232	3,422	11,923	15,345
SPINNING AND WEAVING—							
Renfrew, Ayr, and Lanark, -	1	1,304	196	57	68	208	276
Total in Scotland, - - -	10	55,202	1,582	3,455	2,426	6,108	8,534
UNENUMERATED—							
Renfrew, Ayr, and Lanark, -	—	—	—	—	—	—	—
Total in Scotland, - - -	2	—	—	—	32	10	42

JUTE MANUFACTURE.

The manufacture of jute is peculiar to Dundee, and has never thrived to any considerable extent elsewhere. When Tayside was at the height of its first prosperity in the spinning and weaving of the fibre, and its merchants were amassing wealth, there was naturally a desire to share in the trade, and many centres, including Glasgow, introduced the heavier plant necessary for the work. But Dundee has managed, in spite of the opposition, not only to keep its place, but to vastly improve it, and rivals one by one have found more remunerative employment in other directions. The city of Glasgow had only 3 of the 27 jute factories in Scotland in 1862, and they employed only 590 persons. In 1875 there were 84 factories north of the Border, with 185,419 spindles, 8325 power looms, and 30,893 employees, Glasgow's proportion being 4 factories, 14,662 spindles, 722 power looms, and 2242 employees. The return for 1890 is as follows:—

JUTE FACTORIES.

	Factories.	Spinning Spindles.	Doubling Spindles.	Power Looms.	Persons Employed.		
					Male.	Female.	Total.
SPINNING ONLY—							
Renfrew, Ayr, and Lanark, -	—	—	—	—	—	—	—
Total in Scotland, - - -	24	77,658	3,131	—	2,559	4,645	7,204
WEAVING ONLY—							
Renfrew, Ayr, and Lanark, -	—	—	—	—	—	—	—
Total in Scotland, - - -	34	—	—	5,219	1,646	4,525	6,181
SPINNING AND WEAVING—							
Renfrew, Ayr, and Lanark, -	2	2,738	46	146	66	471	537
Total in Scotland, - - -	44	164,547	7,737	7,678	8,786	17,634	26,420
UNENUMERATED—							
Renfrew, Ayr, and Lanark, -	—	—	—	—	—	—	—
[illegible]al in Scotland, - - -	1	—	—	—	16	64	80

WOOL MANUFACTURES.

Naturally, the manufacture of woollen fabrics bulked largely in a district so completely given over to domestic weaving as the West of Scotland once was, and until a comparatively recent date the people of remoter parts were in respect of clothing of that fibre independent of the spinner, or dyer, or weaver on a large scale. The description "home-spun" had its full significance then, and the vagaries of fashion were unknown. Fashion there certainly was, but its flights were few and slow. Fabrics had lasting qualities far beyond modern desires, if they lacked the charm of colour which came later. "The husbandmen in Scotland," says a writer of the seventeenth century, "the servants, and almost all the country, did wear coarse cloth, made at home, of grey or sky colour, and flat blue caps, very broad. . . . The inferior sort of citizens' wives and the women of the country did wear cloths made of a coarse stuff of two or three colours in checker work, vulgarly called pladon." A century and a half saw little change in that respect, though the weaving gradually became the work of the larger villages and the towns.

But even as early as the years immediately preceding the Union of the Crowns there was a considerable woollen industry in Scotland, and the manufactures of the West were known beyond the confines of the country. It suffered greatly, however, from the competition of England, and at times had enough to do, evidently, to hold its own at home. But in those days the benefits of free trade were unknown; the economic qualities of the system were not even discussed. Scottish trade was affected adversely by English woollen manufactures; therefore English woollen manufactures must be kept out of the country. So at the end of the sixteenth century their importation was forbidden by an Act of Parliament, which made no secret of its purpose by doubting the quality of the English cloth. According to the measure, "the same claith" had "only for the maist part an outward show, wanting the substance and strength whilk ofttimes it appears to have." Another Act, passed in 1701, was more drastic still, for it prohibited "the importation of all cloths and stuffs of any kind . . . excepting flannel allenarly."

The effect of this protective legislation was a steady development on well-defined lines, and the woollen manufactures of the West of Scotland became notable. The industry is still of very considerable interest, although it has declined of late in the face of the serious competition of Bradford. But the characteristic of its controllers is exactly that which distinguished the pioneers. Fashion is a factor in the success of both English and Scotch centres, and the efforts of Yorkshire to follow it have been more profitable. The trade here, however, is peculiar to the district, and instead of following Bradford, possibly with little profit, West of Scotland firms have made the most of their original ground.

Kilmarnock is probably the centre of the woollen and worsted trade of the West, although Ayr, Paisley, and, to a gradually greater extent, Glasgow and the Loudoun Valley, are interested in the manufacture. The modern range of woollen goods is wide, and one need not state it in detail. But woollen cloths of varying kinds, carpets and caps were, in the eighteenth century, made on a fairly large scale in Kilmarnock, and in their making many people were employed. Lord Provost Lindsay, in his "Interests of Scotland Considered," which was published in 1733, describes Kilmarnock as a town "where are made, of our own wool, low-priced serges

known by the name of that place where they are made. These are partly for home consumpt, and partly for the markets of Holland." There are no figures as to the extent of this trade, but we get some idea of it nearly half a century later in Mr. David Loch's "Essays on Scotland," which saw the light in 1778. According to Mr. Loch, there were at that time in Kilmarnock 66 looms working on carpets and 80 on other woollen fabrics. Ayr and Paisley did not emerge until much later, and in Glasgow there was only one factory engaged in the making of carpets.

Carpets were the distinguishing fabrics of earlier days, and to a great extent they are so still. The original fabric was of the Kidderminster description, and Kilmarnock shared its manufacture in early days with, amongst other places, Yorkshire, Durham, and Glasgow. The texture was thin and not at all durable, and naturally the range of colour was extremely limited. Only two colours could be interwoven, when a Kilmarnock engineer—Mr. Thomas Morton—became impressed with the possibilities of improvement. He was ingenious and patient, and his consideration of the problem was fruitful; for he invented the three-ply Scotch carpet, and superseded the draw-boy by an ingenious arrangement of a revolving cylinder studded with pins for moving the heddles. The new carpet represented a great advance on the old, for it was thicker and more durable, and necessarily richer in colour and more artistic in design. The other invention continued in use until the Jaquard came.

Then came the Brussels carpet—which was, according to Mr. Digby Wyatt, "one of the greatest triumphs of modern ingenuity"—and its conversion subsequently to what was known as the Jacquard woven cut-pile carpet. In the manufacture of both of these fabrics Kilmarnock became prominent, and the industry flourished greatly, with the approving help of the Board of Trustees for Manufactures in Scotland. Two premiums, of £150 and £30, were awarded a local firm—Messrs. Gregory, Thomson & Co. —for the first four Turkey carpets manufactured in Scotland, and between 1777 and 1825 the looms employed increased tenfold. In 1839 there were 1200 persons employed in the trade, and the annual value of the carpets produced by Kilmarnock alone was estimated at £150,000.

Glasgow was also engaged in the trade of making carpets, and the next marked advance in the manufacture is to the credit of one of her merchants. Patent Tapestry was the invention of Mr. Richard Whytock, of Edinburgh, but Patent Axminster—mechanically produced specimens of the art which the fugitive Huguenots brought to Devonshire—was the brilliant idea of the late Mr. James Templeton, of Glasgow. Mr. Templeton was a native of Campbeltown, who, after some travel in foreign parts, settled down in Paisley as a manufacturer of chenille shawls. It was while engaged in the making of these fabrics that the possibility of superseding the Axminster proper occurred to him, and his achievement consisted of the adaptation practically of the principle of chenille shawl manufacture to that of carpets. The chief difference was the production of the chenille in straight instead of twisted form, and the weaving of it on a stout warp. The old process of tufting or knotting on to a vertically placed warp the yarns which formed the surface and the pattern was a tedious one, and it occurred to Mr. Templeton and one of his weavers "that if cloth"—to quote the inventor himself—"could be so woven as when cut into shreds and not twisted to form chenille, but left free, so that the two cut edges of the shred might collapse and form a pile, or fur, as we term it, it would,

when rewoven on to another warp or surface, produce a velvet, a pile, or an Axminster surface. This was accomplished by a certain mode of gauze weaving, and a patent was taken out for it" in 1839. "The chenille or twisted strip or shred," said Mr. Templeton in a letter to Mr. Digby Wyatt, "becoming spiral, gave a pattern on both sides of the cloth, the cut edges standing out, when twisted, in every direction; while our backbone, with its vertebrae, formed a ready-made pile for throwing on one side of the cloth only."

Great difficulties were met with in developing the invention, and many prejudices had to be worn down, but Mr. Templeton was persevering, and one by one the obstacles to progress were removed. Many improvements which need not be described in detail were made, the best designers and the most capable workmen were employed, and step by step the manufacture attained eminence. But, wrote the inventor after success, both artistic and commercial, had come, "I do not believe that any consideration or remuneration would induce me to fight the first three or four years' battles over again."

Mr. Templeton, it may be noted, was also one of the pioneers, if not indeed the pioneer, of artistic manufacture. He saw the scope his invention gave to art, and he called to his aid some of the best designers of the day. At first they were inclined to look down on the work, and it was difficult to get the right people; but in 1851 Mr. E. T. Paris, a little later Mr. Digby Wyatt, and later still Mr. Owen Jones, were induced to prepare high-class patterns. A quarter of a century ago the example of Glasgow was being widely followed. The art education of the foreign manufacturer of figured goods was superior then, as it is now, but it is interesting to note that Glasgow, through another generation of Templetons, still provides an example in this respect. Taste and experienced judgment are still shown in the manufacture of the Templeton fabrics, which, more varied than they were, and the result of more intricate processes, are still the standard of excellence and design.

The firm, of course, has had no monopoly of carpet weaving. Ayrshire, with Kilmarnock as its centre, has always been noted for Scotch and for Brussels; in Paisley and around it, tapestry has been, and is, largely manufactured; and in Glasgow all three varieties have been, and are, made by various firms.

Another woollen industry—bonnet making—is peculiar to the West of Scotland. Kilmarnock or Stewarton was the original seat of the trade, but when hand-knitting was in the ascendant the participating area was much wider, and wires were busy all over Scotland and in Ireland as well. Richard Franck says that in 1698 the people of Kilmarnock were extensively engaged in bonnet making, and that they turned the manufacture to very good account. An earlier record indicates its importance with more point, for it tells of a deputation complaining to Lord Boyd and his bailies of certain abuses which existed in the trade. We are not told what measures of success attended the appeal, but the industry flourished, and "Kilmarnock caps" attained a wide fame. Soldiers wore them, travellers liked them, and ordinary people found use for them too. At first they were coarse, and made of home-grown wool; but latterly, with the introduction of the knitting machine, and the widening of the market, came colonial wools and finer qualities. It was estimated in 1869 that the gross yearly value of the manufacture was about £150,000, and of that

£48,000 was spent in wages. Twenty-five years ago about 30 firms were engaged in the trade.

Headgear is still largely manufactured in and around Kilmarnock, and the knitting machine has also been applied to the making of many kinds of underwear. Hosiery, as a matter of fact, is now extensively produced in the district, and the signs are of growth rather than of diminution. The dress trade of Glasgow and Paisley, however, has declined greatly in the face of the competition of Bradford and France. Freight charges are not now, as I have said, the factors they were, and the addition of carriage from even the towns of France makes little or no difference in the price of a fabric. Cheviots, after a long spell of neglect, seem to be coming in again, but the revival is not, as yet, very marked. But altogether manufacturers in this branch have less to grumble at than their neighbours. In 1875 there were 56 woollen factories in the counties of Lanark, Renfrew, and Ayr, with 14,197 spinning spindles, 870 doubling spindles, 6617 power looms, and 5975 employees. At the same date there were 35 worsted factories, with 40,402 spinning spindles, 11,894 doubling spindles, 5889 power looms, and 8903 employees. Abstracts of the 1890 returns follow:—

WOOLLEN FACTORIES IN 1890.

	Factories.	Spinning Spindles.	Doubling Spindles.	Power Looms.	Persons Employed.		
					Male.	Female.	Total.
SPINNING ONLY—							
Renfrew, Ayr, and Lanark,	14	7,460	1,282	—	125	182	307
Total in Scotland,	85	254,503	27,237	—	2406	1,701	4,107
WEAVING ONLY—							
Renfrew, Ayr, and Lanark,	19	—	—	2563	629	1,956	2,585
Total in Scotland,	48	—	—	4690	1876	5,008	6,884
SPINNING AND WEAVING—							
Renfrew, Ayr, and Lanark,	12	11,679	1,054	391	212	527	739
Total in Scotland,	118	310,643	46,741	5146	8293	10,998	19,291
UNENUMERATED—							
Renfrew, Ayr, and Lanark,	28	—	—	—	318	454	772
Total in Scotland,	31	—	—	—	340	455	795

WORSTED FACTORIES IN 1890.

	Factories.	Spinning Spindles.	Doubling Spindles.	Power Looms.	Persons Employed.		
					Male.	Female.	Total.
SPINNING ONLY—							
Renfrew, Ayr, and Lanark,	7	43,858	19,260	—	342	2,119	2,461
Total in Scotland,	11	58,212	25,455	—	612	2,907	3,519
WEAVING ONLY—							
Renfrew, Ayr, and Lanark,	5	—	—	523	735	1,000	1,735
Total in Scotland,	7	—	—	718	993	1,376	2,269
SPINNING AND WEAVING—							
Renfrew, Ayr, and Lanark,	1	912	390	43	88	60	148
Total in Scotland,	1	912	390	43	88	60	148
UNENUMERATED—							
Renfrew, Ayr, and Lanark,	1	—	—	—	27	50	77
Total in Scotland,	1	—	—	—	27	50	77

SILK FABRICS.

One of the earliest effects of the Spitalfields Act, fixing a minimum wage for silk weavers, was to drive the trade into the provinces, and Paisley was the first manufacturing centre in Scotland to benefit by the change. In 1760 Mr. Humphrey Fulton commenced in Paisley the manufacture of silk gauze, and ultimately he provided work for very close on 600 looms. During the succeeding quarter-century, the industry thrived and extended, and when cotton came a large number of weavers over a wide area in the West of Scotland were lucratively employed. Cotton, however, enabled manufacturers to produce cheaper muslins, and in a widening market the more expensive fabric was naturally displaced. The silk industry was not actually extinguished, but the first rush of competition was disastrous, and questions of economy narrowed its prospects. Ribbons were taken up in 1772, and several other developments of minor importance occurred later; but with all the efforts of manufacturers the trade never quite recovered the prosperity of its earlier years. And, as has been the case with cotton and with linen, the modern development of the silk trade is in other hands.

But at the end of the eighteenth century the West of Scotland's interest in the manufacture of silk was considerable. In 1784 no fewer than 5000 looms were at work, chiefly in the villages, to a greater or less extent, on gauzes and other silk fabrics, and the annual value of the output was put as high as £350,000. The silk trade originated in Scotland in the West, and, for reasons which are obvious, it never spread to any other district. As was to be expected where dependence on fashion was so complete, the fluctuations have been numerous, but in spite of them all—in spite, even, of the overwhelming competition of France—there has always been a silk industry in the West. Naturally, in a district prominently identified with the making of mixed fabrics, throwing and dyeing have been carried on more extensively than weaving. In 1875 there were 4 factories, with 226 power looms and 740 employees in the West of Scotland, and the principal productions were gauzes, gossamers, hat trimmings, shawls, handkerchiefs, and mourning crapes. Since then the change in the class of goods has been slight, and there has been a decided upward movement in at least one of the branches. Gauzes, gossamers, chiffons, neckerchiefs, handkerchiefs, and tie cloths are the chief manufactures of to-day, and despite the competition of weighted silks from France, Germany, and Switzerland, the local manufacture about holds its own. Value necessarily varies, but the annual output of cloth is at least as much as it was twenty or thirty years ago.

MIXED FABRICS.

The mixed fabrics of the West have been many and various, and to try to enumerate them within the compass of such an article as this would be to court failure. What they were depended largely on fashion, and what they are may be set down as the result of purely economic causes. In Paisley, shawls succeeded muslin, and Paisley shawls, like those which may be seen in the Exhibition, had a world-wide reputation for beauty and lasting qualities. Writing in 1878, Mr. James Paton says it is improbable "that the public will ever altogether forsake a fabric in which there may be so much beauty of texture, variety, and soft harmonious design combined." And speaking in January of this year at the Glasgow Weaving College of these same fabrics, Mr. John Ingram said—"They are only cherished heir-

looms once worn by loved ones, full of quaint interest to the younger race, and calling up a flood of memories of the times and faces of long ago to the older brigade." The decline of this mixed fabric is complete; and it is natural. For the cost of filled shawls necessarily narrowed the market for them, and mechanical progress made it possible to attract a far larger body of buyers with something cheaper, if less durable and artistic. Half the modern manufacturer's success is in meeting fashion half-way and leading it the rest.

The weavers of Paisley who reluctantly took to shawl making in the early years of last century were rather a notable set of men, and the high degree of excellence to which they brought the manufacture may be taken as evidence of their culture. They were great readers and keen politicians; some, like Robert Tannahill, were poets; and others, like Alexander Wilson, naturalists of no mean order. All were close students of nature, and the fierceness of modern industrial methods was to come. Centuries of civilisation separated them from the strangely-gifted needle artists who, under spreading trees in the valleys of Cashmere, first made the shawls; but in artistic aim and in technical skill the difference was much less. A writer in the *Evening Citizen* at the beginning of the present year gave an interesting account of the rise and decline of the industry, part of which may be quoted.

"Mr. James Paterson," he says, "was the first manufacturer who embarked in the business with ingenuity and perseverance, attended by success sufficient to establish the trade in the locality, and thereby prevent its being transferred to some other quarter. He was followed by others; but the operatives, from the expense of erecting a shawl loom and the length of time required to put it in a working condition, were many of them long deterred from entering upon this branch of business. The decay of the muslin trade and reduction of the price of labour impelled them at length to turn their attention to the shawl trade, and it was not long ere it proved the more important of the two. An early writer commends the Paisley operatives on their intelligence, perseverance, and industry. They conquered every difficulty; and serious as the outlay of money might be considered for them, few of them hesitated to engage in the business. In 1824, or about that year, the Messrs. Millar, of Paisley, attempted the introduction of shawls more closely resembling the Cashmere than anything as yet produced in the locality. They procured Cashmere wool of native growth, together with English materials nearly similar, employed a Frenchman to superintend the work, and built a factory where they could carry it on in secrecy. The operations, however, of this respectable and enterprising firm were closed in consequence of the commercial panic in 1826-27; but it was to their French superintendent the credit belonged for having introduced the double ground or two backs, as it was called, which, while it added beauty to the fabric, enabled more colouring to be thrown into the pattern, and effected a saving in the cost of production. Another improvement, afterwards introduced by the Messrs. Walker, and a positive advance in design, was the 'tweeling' of the spotting or colours which formed the pattern, a protracted demand for bordered goods ensuing in consequence of the increased beauty of the patterns. About 1830 Thibet shawls were the staple productions of the Paisley looms. These were shawls of plain ground, with figured border, woven separately and sewed on. During the next decade there were great diversities of style in the goods produced in Paisley. The manufacturers and pattern drawers saw the necessity of

paying much more attention to the varied styles of India and of France. From these sources, enriching their ideas and invigorating their fancies, they were led to adopt better methods of colouring and contrast. Among those particularly who infused a spirit of emulation into the ranks of the artists by exhibiting year after year the spirited effects capable of being accomplished by a series of patterns of increased style and dimensions, were the Messrs. Roxburgh, who eminently contributed to elevate the art of design in Paisley. The introduction of the French loom effected a revolution in the Paisley shawl trade. This loom was a simpler and more effective plan than the old looms either of Paisley or India. The Jacquard machine was almost universally adopted, notwithstanding its cost, and in the shawls manufactured there was an astonishing contrast to the work hitherto done by the Paisley loom, their superiority of design and beauty of execution being apparent to the most superficial observer. Of such superior character and extensive variety were the products of the Paisley loom then that many of the articles were disposed of by the draper as French goods, and some of them were even imitated by the French themselves. The Indian fabric, indeed, was more closely resembled than ever. Innumerable were the various kinds of fabrics produced in Paisley half a century ago—the rich white crape shawls, silk gauze shawls, lace shawls, barege shawls, massive harness-wove black satin shawls, crape Indianas, Cashmere, and mosaic shawls are a few of those excellent and celebrated fabrics that attracted the patronage of Royalty and secured the general sanction of fashion itself. But—alas for the fickleness of fashion!—the production of woven and figured shawls, in which Paisley attained such excellence, did not long remain the staple commodity of the trade of the town."

Mr. Paton says that the shawls made at first were of the kind known as filled middles, in which the whole article, border and middle, was harness-wove and in one piece. Later, plain middles—first made of spun silk—with borders sewed on, became fashionable, but finished shawls of the highest class were made either of real Cashmere goats'-wool yarn, of silk warp and silk, or very fine wool weft. Value, of course, depended on what was used, but the following is a fair calculation of the price of an average shawl in 1838:—

Warp,			£0	6	6
Orange silk,	32 Nos. at	3½d.,	0	9	4
Black wool,	26 ,,	2½d.,	0	5	5
Ruby wool,	26 ,,	2½d.,	0	5	5
Scarlet wool,	26 ,,	2½d.,	0	5	5
Green wool,	26 ,,	2½d.,	0	5	5
White cotton,	32 ,,	½d.,	0	1	4
Lavender cotton,	6 ,,	1d.,	0	0	6
Small-shot cotton,	16 ,,	1d.,	0	1	4
Flower of each valued at			0	8	0
Charges to cover loss, 15 per cent., nearly			0	10	0
Weaving 9 yards covering at 2s.,			0	18	0
Winding, about			0	2	6
			£3	19	2

On the final decline of the filled shawl, the harness looms of Paisley were put to the making of worsted goods of a superior description—coloured

checks, other than tartans and stripes and fancy borders. Tartans, plaids, mauds, scarves, bedcovers—coarse of texture and "large and loud" in pattern—damask window hangings, tablecloths, and furniture cloth were all pressed into the service, and for a time the change made comparatively little odds. But there never was another revival of the shawl trade, and Paisley gradually settled down to what we know it now. The rise and fall of the Paisley Weaving Industry would make an interesting story, and the wonder is that none of its literary weavers—for culture is still the characteristic of the Paisley weaver—has already told it.

Chenille shawls, in the making of which Mr. Templeton discovered the way to weave Patent Axminster carpets, were also largely manufactured in Paisley, and at one time shawls of Canton crape, with embroidered borders, were as beautiful and peculiar products. Chenille was introduced in 1822 by Mr. Alexander Buchanan, whose achievements in another textile industry we have already noted. It is hardly necessary to enumerate the mixed fabrics of the day; and it would be idle, for their variety is dependent on fashion. The following table shows the position of the textile industries as a whole:—

TEXTILE FACTORIES IN SCOTLAND.

	Factories.					Spindles.			Persons Employed.		
	Spinning.	Weaving.	Spinning & Weaving.	Other.	Total.	Spinning.	Doubling.	Power Looms.	Male.	Female.	Total.
1870	189	184	178	6	597	2,176,454	320,235	59,683	34,305	92,909	127,214
1874	229	195	211	45	680	2,436,947	446,429	74,195	44,269	110,650	154,919
1878	225	209	188	53	675	2,029,177	645,432	66,769	37,347	98,866	136,213
1885	251	221	190	114	776	1,725,173	643,931	72,279	45,440	106,839	152,279
1890	220	227	184	116	747	1,713,899	699,836	71,471	46,386	108,205	154,591
1895	—	—	—	—	—	—	—	—	43,115	103,704	146,819
1896	—	—	—	—	—	—	—	—	43,549	103,805	147,354

DYEING, BLEACHING, AND PRINTING.

In the first half of last century Paisley was a great centre of this industry, and not without reason is it claimed that, tedious as the processes were, the work of that period has never been surpassed. It is questionable if it has ever really been equalled in modern times with modern methods; in the matter of fastness, certainly, there is no comparison. The first check in the old-time dyers' prosperity came when the Germans commenced the export of yarns dyed in the fleece. That competition had its effect on prices, though the Paisley men managed to meet it for a time profitably. The real cause of the decline came with the aniline dyes, which were introduced into this country about thirty or forty years ago. Previously dyeing had been an art which men spent half a lifetime learning, and which depended on an intimate practical knowledge of chemistry. The [illegible]line preparations altered that. Little or no knowledge was required; [illegible] attention to the voluminous instructions which came with the

dyes from Germany. Brilliance was purchased at the expense of fastness, and the cost was incomparably less. For a time large profits were made under the new *régime*, but the prosperity was necessarily short-lived. The prospect of amassing wealth rapidly induced others to embark in the business, and the result was naturally a fall in prices that meant ruin to many of the concerns. Prices went far below their natural level, and the position was reflected in the poorer quality of the work. Happily, however, the industry ultimately steadied itself a little, and in combination with former rivals here and across the Border the general dyer is carrying on the work more remuneratively.

Bleaching and calico printing are still considerable industries in the West of Scotland, but their exact position as compared with former days is difficult to fix. Their origin is noted in the introduction, and their earlier development traced. The leading firms decline, however, to say anything of the position to-day, and it is impossible, therefore, to speak of the later and more important developments. Both are necessarily very large interests, representing enormous capital; but, as I have pointed out elsewhere, the bulk of the cloth they bleach and print comes from over the Border. Calico printing and Turkey-red dyeing and printing and bleaching are, however, really the only branches of the industry which have held their own in the West of Scotland.

GLASGOW WEAVING COLLEGE.

This article would be incomplete without a reference to the Glasgow Weaving College, which is the only institution of its kind in Scotland. The need of better technical education in Scotland was clamant very early, and amongst the first to feel it were the textile manufacturers. Mr. James Templeton early advocated the establishment of schools. In the letter to Mr. Digby Wyatt in 1868, from which I have already quoted, he speaks of "the superior art of education of foreign manufacturers and their workmen or designers," and fears that "we may be left in the background with regard to many of our textile fabrics," if steps are not taken to improve our position. Another supporter of the movement for better technical training was Mr. David Sandeman, and amongst others were Mr. John Ingram and Mr. Matthew Blair. Between them they succeeded in their project, and in 1877 the Glasgow Weaving College was opened. One hardly needs to mention the excellent work which the school has done, and is doing. The success of the institution is convincing. One wonders, however, what the development of the movement would have been without the enthusiastic labour of men like Mr. Ingram, Mr. Blair, and other members of the governing body.

CHEMICAL INDUSTRIES,

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CHEMICAL INDUSTRIES.

The object of the following notes is to draw attention to the principal changes which have occurred in the chemical industries of the West of Scotland since 1876, the date of the last visit of the British Association to Glasgow. Some of the industries which were flourishing at that time—for example, the manufacture of ferrocyanides, the extraction of iodine from kelp, and the refining of sugar—are much less prosperous to-day, and some others, such as the manufacture of soda ash by the Leblanc process and the preparation of alum from alum shale, have become practically extinct. On the other hand, there has been great progress in other branches of chemical manufacture, *e.g.*, the recovery of by-products from blast furnace gases, and some new and important industries, among which may be mentioned the manufacture of cyanides and of compressed gases, have been started. On the whole, it may be said that the chemical manufactures of the West of Scotland are characterised now, as they were twenty-five years ago, by their variety, for while as regards certain branches the extent of the manufacture is far greater in other localities, yet as regards the number of different products few other districts surpass Glasgow and its neighbourhood, and, moreover, certain of its industries are hardly represented elsewhere. Special sections of this volume are devoted to metallurgical processes, to the manufacture of pottery and glass, and to bleaching, dyeing, and printing; these chemical industries, therefore, are not referred to in the following pages.

ALKALI AND ACIDS.

Any account of the chemical industries of this country naturally commences with a description of the alkali works, which occupy a foremost place as regards both the quantity and the importance of the substances manufactured in them. The nominal products of an alkali work are soda ash (sodium carbonate), which for more than a century has been made from common salt by the Leblanc process, and caustic soda. As regards Scotland, in 1876 about 50,000 tons of common salt were converted into soda ash and caustic soda by the Leblanc process, while in 1889 the quantity of salt used in the alkali works had fallen to a little over 33,000 tons, and at the present day there is not a single alkali work in which soda ash is produced, and only one which manufactures caustic soda. It is not difficult to account for this state of affairs. In 1875 almost all of the soda ash made in Britain was obtained by the Leblanc process, but since that date the rival "ammonia soda" process has made such headway that by 1895 more than half of the total quantity of salt used in alkali works was converted into alkali

by the new method, which continues to gain steadily upon the old one. In the Leblanc process the first step is to prepare "salt cake" (sodium sulphate) by heating salt with sulphuric acid in furnaces, the hydrochloric acid which is liberated being collected and utilised. The next step is to convert the "salt cake" into "black ash," which is essentially a crude mixture of sodium carbonate and calcium sulphide, by heating a mixture of salt cake, small coal, and limestone in reverberatory or revolving furnaces. The third step is the systematic lixiviation of the black ash with warm water and the separation of the solution from the residue, which is known as "alkali waste." The solution, which contains sodium carbonate, some caustic soda, and small quantities of other salts, is treated in various ways; it is usually boiled down to small bulk, and the crystals of hydrated sodium carbonate, which separate as concentration proceeds, are collected, drained, and converted into common soda ash by exposure to heat in a reverberatory furnace. To obtain soda crystals, or washing soda, the soda ash is dissolved in boiling water, and the solution, after purification, is left to cool, when large glassy crystals separate. The liquor is drained off, and the mass of crystals is broken up and packed for transport. Caustic soda is made from the "red liquor," *i.e.*, the solution obtained by lixiviating the black ash, from which the greater part of the sodium carbonate has been removed by crystallisation. The liquor, after dilution, is boiled with lime, in order to causticise the carbonate of soda still present, and after the lime mud has settled, the clear caustic liquor is run off, boiled down in iron pans, and finally concentrated in iron pots, until the contents of the pots are raised to a dull red heat. The small quantities of sulphide and cyanide present are destroyed in various ways, and when the concentration is finished the molten caustic is ladled into iron drums, where it solidifies on cooling. In the ammonia soda process common salt is converted into bicarbonate of soda in one operation. A solution of salt, saturated with ammonia, is caused to flow down towers, which are separated into a number of superposed compartments by perforated partitions, and a current of carbon dioxide is forced up through the towers by means of pumps. The result of the chemical action which takes place is the formation of bicarbonate of soda, which separates as a crystalline powder, and ammonium chloride, which is dissolved by the water and is drawn off in solution. The bicarbonate of soda is pressed and converted into soda ash by calcination in a revolving furnace; the carbon dioxide, which is evolved in the process, is again utilised in the bicarbonate tower. From the liquor drawn from the bicarbonate tower, which contains the ammonium chloride, the ammonia is recovered by distillation with lime or magnesia. Soda crystals or caustic soda can, of course, be made from the soda ash. It will be seen that the ammonia soda process is, chemically, much simpler than the Leblanc process; however, it is only through the use of admirably designed plant, and by careful attention to the details of manufacture, that the former has proved so successful. Its chief advantages are that ammonia soda ash is purer than that made by the Leblanc process, and that the cost of manufacture is less, especially where salt is readily obtainable, as, for example, in Cheshire, where the brine is pumped direct from the salt beds to the alkali work. Moreover, there is no objectionable by-product such as the alkali waste of the Leblanc works, of which from one and a half to

two tons are produced for each ton of soda ash. The chief drawback to the ammonia soda process is that all of the chlorine of the common salt is lost, because hitherto no very successful process has been devised for recovering it on the large scale from the calcium or magnesium chloride formed in the ammonia stills, whereas in the Leblanc process the chlorine of the salt is converted into hydrochloric acid, from which chlorine can be obtained in several different ways.

No soda ash is made by the ammonia soda process in Scotland, chiefly because there are no such extensive deposits of salt as are found in different parts of England. But, while the progress of that process is mainly responsible for the cessation of alkali making in this country, other causes have contributed. Among these may be mentioned the recent development of electrolytic processes, whereby common salt is directly converted into caustic soda and chlorine, the latter being utilised for making bleaching powder. Moreover, about ten years ago most of the alkali makers in Britain combined to form the United Alkali Company, and as a result of the combination the several works were placed under a central management, and the manufacture of the various products was distributed among different works, according as the circumstances were most favourable. This involved the suspension of alkali making in the company's Scottish works.

In a Leblanc work the manufacture of alkali is almost invariably associated with that of other substances, chief among which is the sulphuric acid necessary for converting common salt into salt cake, while the object of other processes is to utilise the by-products, *e.g.*, the hydrochloric acid, obtained. Hence, although soda ash is no longer made in Scotland, the other products of the alkali works are still turned out in large quantity. Sulphuric acid, or "oil of vitriol," is made on a very large scale by the chamber process, in which sulphur dioxide, formed by roasting pyrites or by burning sulphur in a current of air, is led into large leaden chambers, and is there converted into sulphuric acid by the combined action of steam and air in presence of oxides of nitrogen, which act as carriers of oxygen. The weak "chamber acid" drawn from the leaden chambers is concentrated to a certain point, partly in Glover towers and partly by boiling down in leaden pans, and is finally rendered almost anhydrous by further concentration in stills of glass or of platinum. This chamber process has been in operation for a very long time, and the chief modifications of recent years are the very general substitution of pyrites for sulphur as a source of sulphur dioxide, and the equally general adoption of Gay-Lussac towers, in which the nitrous fumes escaping from the chamber are absorbed by sulphuric acid, and Glover towers, in which the nitrous fumes are liberated from the nitrous vitriol drawn from the Gay-Lussac towers, and the chamber acid concentrated by the action of the hot gases from the pyrites kilns. Also, the process devised by Kessler for concentrating sulphuric acid, at a temperature far below that attained by any other form of apparatus, has been widely adopted by vitriol makers in the West of Scotland. In Kessler's apparatus the acid is contained in a series of shallow evaporating pans made of siliceous materials covered with lead, and is exposed to the hot gases from a large open fire of slow draught. The weak acid is placed in the uppermost troughs and flows downwards, finally reaching the lowermost troughs; during its down-

ward passage it becomes gradually more and more concentrated by the action of the hot gases, which pass upwards over each succeeding trough of acid. Generally the hot gases are drawn upwards through the apparatus by an exhaust at the outlet. The temperature of the acid need not rise above 200°, and a product containing 96 per cent. of acid is easily obtained.

The hydrochloric acid gas which is evolved in the process of making salt cake is led into high towers packed with coke, and is there absorbed by water which flows down the tower. Recent improvements in the plant have had the effect of making the absorption of the acid vapours very complete, and only a minute quantity escapes into the air. By far the greater proportion of the hydrochloric acid is utilised for the production of chlorine, by means of which bleaching powder is made. The solution of the acid is heated in stills with manganese dioxide, and the chlorine which is thereby liberated is passed into large chambers containing trays on which slaked lime is exposed in thin layers. The lime absorbs a certain quantity of chlorine, and the compound known as bleaching powder* or chloride of lime is produced. The manganese is contained, as chloride of manganese, in the liquor from the chlorine stills, and various methods of recovering it are in use. In the St. Rollox Works, Glasgow, the process introduced in 1855 by C. T. Dunlop is still followed. In this process the liquors are first mixed with chalk in sufficient quantity to neutralise the free acid and precipitate the iron. After settling, the clear solution is run off into closed boilers, and is there decomposed with milk of chalk under a pressure of several atmospheres. The precipitate of carbonate of manganese which is formed is washed, drained, and spread upon trays, which are placed in an oven, where the precipitate is exposed to a current of hot air for forty-eight hours. The carbonate of manganese is thus converted into a finely divided black powder, known as "recovered manganese," which contains over 70 per cent. of manganese dioxide. In the more recent process of Weldon, which has been widely adopted, the liquor from the chlorine stills, after removal of free acid and iron by addition of calcium carbonate, is mixed with milk of lime in certain proportions, and the resulting mixture, which contains manganous hydroxide, calcium hydroxide, and calcium chloride, is heated by steam to a temperature of 55°, and exposed to the oxidising action of a current of air which is blown through it. The manganous hydroxide is converted into manganese dioxide, and the dioxide forms a compound with lime, which settles as a black deposit. After settling, the clear solution of calcium chloride is drawn off, and the "manganese mud" is returned to the chlorine stills.

The alkali waste of the Leblanc works contains, as calcium sulphide, practically all of the sulphur which is used, in the form of sulphuric acid, in the salt cake process. If allowed to accumulate it becomes a nuisance, because, by the action of the air upon the calcium sulphide, soluble sulphur compounds are formed which are apt to give rise to objectionable emanations of sulphuretted hydrogen. For this reason, and because of the value of sulphur, many processes have been tried for recovering the sulphur from the calcium sulphide in the waste. The most successful of these is that of Chance, which is based upon

* The process for making bleaching powder was patented by Charles Tennant of St. Rollox, the manufacture was started there in 1800.

two reactions—first, liberation of sulphuretted hydrogen by the action of carbon dioxide on a mixture of the alkali waste and water, and, second, combustion of the sulphuretted hydrogen with a limited quantity of air, so regulated that the products of the combustion are water and sulphur. At St. Rollox, where the alkali waste has accumulated in enormous quantity, the liquors draining from the old waste heaps, or "bog liquors," as they are technically termed, are utilised in the works for the purification of sulphuric acid. The bog liquors consist essentially of a solution of sulphide and polysulphides of calcium, and the sulphuretted hydrogen which is generated when they are decomposed by a weak acid is used for the purpose of removing arsenic from the sulphuric acid.

Among the principal alkali works in the West of Scotland which belong to the **United Alkali Company** are those of Charles Tennant & Co., St. Rollox, Glasgow, which were founded about the close of the eighteenth century, and the comparatively quite modern works of the Eglinton Chemical Co. and the Irvine Chemical Co., at Irvine, in Ayrshire. In these works, as already indicated, the manufacture of soda ash by the Leblanc process is no longer carried on, owing to the development of the ammonia soda process, but sulphuric acid,* salt cake, hydrochloric acid, bleaching powder, and recovered manganese (by the Dunlop process) are all produced, as well as soda crystals, which are made from ammonia soda ash from the company's extensive works at Fleetwood. The manufacture of dichromates, which was pursued for some time at the Eglinton Works, has been temporarily stopped, and owing to changes in trade the production of bleaching powder and caustic soda has been reduced. However, the demand for sulphuric acid has steadily increased, and the United Alkali Company possess a very large plant, producing acid of all strengths, and also have in operation a very extensive installation of platinum stills making pure oil of vitriol. Thus, while there has been a reduction in the manufacture of some articles during the last twenty-five years, there has been in the company's works a large increase in the production of sulphuric acid, which is now very largely used in the West of Scotland in the manufacture of explosives, manures, and sulphate of ammonia, and in oil refining and other industries.

Among the works where Leblanc soda ash was formerly manufactured are those of Messrs. R. & J. Garroway and Messrs. Alex. Hope, jun., & Co., both in Glasgow, and of Messrs. Wm. Henderson & Co., at Irvine, where Weldon's manganese recovery process was adopted.

At the present day the chief products of **Messrs. Alex. Hope, jun., & Co.'s** works at Port Dundas, which were started in 1843, are sulphuric, hydrochloric, and nitric acids, with a few articles used in the dyeing trade. In 1875 all of the sulphuric acid was made from brimstone, of which 525 tons were used, but the firm are now using pyrites as a source of sulphur; in 1899 2750 tons of pyrites were roasted. During the period under review the firm have adopted Gay-Lussac and Glover towers, renewed their plant, extended their chamber capacity, and fitted up pyrites kilns. All of the chamber acid is purified from arsenic, which is removed by precipitation as sulphide before concentration. Formerly concentration of the acid was effected

* Leaden chambers were erected at St. Rollox in 1803, and vitriol was first produced in the following year; the manufacture of soda ash by the Leblanc process was started in 1838.

by the old system of glass retorts, which not only was a costly process, but also caused annoyance owing to the escape of acid vapours when a breakage occurred, which was pretty frequent. Within the last few years Kessler's concentrating apparatus has been adopted, and has been found to work very satisfactorily. In the manufacture of hydrochloric acid the quantity of salt used now is much the same as formerly, viz., from 350 to 400 tons per annum, but much better yields have been obtained by improvement of the plant for condensation. The output of nitric acid has been greatly increased, for while in 1875 40 tons of nitre were used, in 1900 the consumpt was 200 tons; in this case also the introduction of improved plant has increased the yield.

Messrs. R. & J. Garroway also manufacture acids and many other substances at their Netherfield Works, which were started in 1819. Their products include hydrochloric, nitric, and sulphuric acids, oxalic acid and sulphurous acid; sulphites and bisulphites of sodium and calcium; salt cake, Glauber's salt, Epsom salt, and the sulphates of iron, zinc, copper, and aluminium; several salts of tin used in dyeing and printing, *e.g.*, tin crystals, double muriate of tin, and stannate of sodium; hyposulphite and sulphide of sodium; borax and boracic acid; roll sulphur and flowers of sulphur; arsenic. They distil wood and resin, and produce charcoal, acetic acid, and various acetates; and they also manufacture manures, such as dissolved bones and superphosphate of lime.

At the Forth and Clyde Chemical Works, Kirkintilloch, Messrs. Perry & Hope prepare phosphoric acid, pure and commercial, the phosphates of sodium, ammonium, and calcium, and superphosphate of lime. Their other products include sodium fluoride, bisulphates of potassium and sodium, and pure sulphates of iron, magnesium, and potassium.

Acids are also manufactured by Messrs. Wm. Henderson & Co., Irvine, by Messrs. R. Smith's Executors, West Street, Glasgow, and, incidentally, by a number of other firms.

AMMONIA.

No process is known by which ammonia or its compounds can be directly formed on the commercial scale, and it is still only obtained as a by-product of other manufactures. Until comparatively recently its chief sources were of animal origin, and twenty-five years ago a method of obtaining ammonia from urine was in operation in Glasgow. The raw material collected from the public urinals was left to stand until the nitrogenous compounds which it contained had undergone decomposition, and the ammonia produced in this way was then distilled off. This process has now been abandoned. When nitrogenous organic matter, *e.g.*, coal, is destructively distilled, part, at least, of the nitrogen is liberated as ammonia, and thus the "ammoniacal liquors" obtained in the gasworks, the paraffin oil works, the works for recovery of blast furnace gases, etc., are a rich source of that compound. The ammoniacal liquor contains carbonate, chloride, sulphide and other compounds of ammonium, and the ammonia is obtained from it by a very simple process. Steam is passed through the heated liquors, first without, and afterwards with, addition of lime, in order to decompose the ammonium salts; the free ammonia and other vapours evolved from the ammonia stills are then passed

through sulphuric acid, and the crystals of ammonium sulphate which are formed are removed at intervals. The process is a continuous one. Ammonium chloride can be obtained by using hydrochloric in place of sulphuric acid.

Of recent years there has been a great development in the manufacture of ammonium sulphate, which is partly due to the recognition of the value of that substance as a manure, and to the consequent great demand for it. The progress of the industry in Scotland can be gathered from the following figures, which show the quantities of ammonium salts (stated as sulphate) made in 1889 and in 1899:—

	1889.	1899.
From iron works, - -	5,645 tons	17,563 tons
From paraffin oil works, -	23,953 ,,	38,780 ,,
From gas works, - -	9,907 ,,	14,742 ,,
From coke, etc., works, -	—	1,578 ,,
Total, -	39,505 tons	72,663 tons

In 1889 fifty-one works in which ammonium salts are made were under inspection, while last year there were sixty-three. It will be noted that, while the quantities of ammonia recovered from gas and shale works are much greater now than even ten years ago, the greatest progress has been made in the case of the iron works. In the iron works in Scotland, in which coal is used for smelting the ore in the blast furnaces, the gases which escape from the furnaces contain ammonia derived from the nitrogen of the coal. Formerly the waste gases were allowed to burn at the mouth of the furnace, but now they are collected and used as fuel for heating steam boilers, and also for heating the air blown into the furnace. In Scotland much capital has been invested in the erection of plant for cooling and scrubbing the furnace gases before they are burned, in order to condense and collect the valuable tar and ammonia, and this has been found profitable to such an extent that in some cases more money has been spent in fitting up the necessary plant than is devoted to the production of the iron, and more profit is yielded by the waste gases of the blast furnace than by the iron itself. A full account of the different kinds of plant in use will be found in the section on metallurgy. As regards recovery of ammonia from coke ovens, etc., the use of these modern forms of coke oven which permit of utilisation of the gases has not so far extended widely in Scotland, but there is reason to believe that the quantity of ammonia recovered from this source will increase in the future.

DICHROMATES.

The manufacture of the dichromates of potassium and sodium, which are so largely used in the preparation of pigments such as chrome yellow, and in industrial organic chemistry, has for nearly a century been closely identified with Glasgow. Generally speaking, the manufacturing process remains, except in such details as the application of labour-saving appliances, much what it was twenty-five years ago. On the other hand, the number of firms manufacturing dichromates has increased so largely of late years—within the last seven or eight

years no fewer than fifteen new makers having started in different parts of the world—that the output of individual firms has necessarily been reduced.

The raw material from which practically all chromium compounds are obtained is chrome iron ore. In the manufacture of dichromates the ore is reduced to powder and mixed with lime and potassium carbonate; the mixture, in thin layers, is heated to bright redness in a reverberatory furnace; after cooling, the charge is lixiviated with hot water, which extracts potassium chromate, any calcium chromate present being decomposed by addition of potassium sulphate. The yellow solution of the chromate is mixed with the quantity of sulphuric acid necessary to convert the chromate into dichromate, run into tanks, and left to cool, when the greater part of the dichromate separates in large orange-red crystals.

Messrs. J. & J. White were the first, and for long the only, manufacturers in this district. Their works at Shawfield, Rutherglen, were begun in 1808, and though at first other chemicals were made there, for the last three-quarters of a century their only products have been dichromates and other chromium compounds. Their present products do not differ greatly from those of twenty-five years ago, except that crystallised dichromate of sodium is now made as well as the potassium salt. The firm also manufacture the sulphuric acid necessary for their processes, and hydrochloric acid.

The dichromates of sodium and potassium are also the chief products of Messrs. Stevenson, Carlile & Co., Ltd., at the Millburn Chemical Works, Glasgow. The firm occasionally produce other compounds such as ammonium dichromate, neutral chromates, chromic acid, and chromic oxide, but, of course, the principal demand is for the first named. Incidentally to their manufacture the firm also make sulphuric and hydrochloric acids, and the sulphates and carbonates of potassium and sodium.

The manufacture of dichromates was also begun in 1873 by the Eglinton Chemical Co., Irvine, but, as already stated, these works now belong to the United Alkali Company, and the production of these substances has been suspended.

BORAX AND BORACIC ACID.

Borax, boracic acid, and Epsom salt are the principal products of the old-established firm of Messrs. Joseph Townsend, Ltd., Port-Dundas. The raw materials used in the manufacture of the two former substances are "boracite" and "borate of lime." The boracite, which comes from Asia Minor, is a very pure borate of calcium, containing on the average 45 per cent. of boric oxide. It is white in colour, and massive, and, as it is shipped to this country in bulk, it requires to be broken up and ground for use in the manufacture. The borate of lime is imported from the Pacific slope of South America. This mineral is essentially a double borate of calcium and sodium, containing on the average 40 per cent. of boric oxide, but it varies much in quality, some lots containing as little as 34 per cent. and others up to 44 per cent. of boric oxide. It also contains about 5 per cent. of sodium chloride, as well as some calcium sulphate, both of which require to be reckoned with in the process of manufacture. It is a

soft, earthy material, varying in colour from greyish white to pink, fibrous in structure, and unctuous to the touch.

In manufacturing borax from these sources the crushed minerals are boiled with a solution of sodium carbonate, the sludge of calcium carbonate, etc., is removed, and the clear solution left to cool, when borax ($Na_2B_4O_7 \cdot 10H_2O$) separates in large colourless crystals. The sludge is generally taken out of the liquor by means of filter presses. In order to obtain boracic acid the minerals are decomposed by heating them with sulphuric acid, and the boracic acid which is thus liberated is crystallised from the solution after removal of the sludge of calcium sulphate, etc. The difficulties in the manufacture of both products vary in proportion to the impurity of the raw material, and various modifications of the process have to be introduced accordingly.

The raw material used in the manufacture of Epsom salt at Messrs. Townsend's works is kieserite, and the process is simply one of purification and crystallisation of the magnesium sulphate. The kieserite is imported from the Stassfurt district of Germany in the form of moulded blocks, of an average weight of 28 lbs., and containing about 60 per cent. of hydrated magnesium sulphate ($MgSO_4 \cdot H_2O$), the remainder of the mixture being chiefly sand and salts of calcium. The kieserite is dissolved in hot water, the sludge is left to settle, and, after clarification, the liquid is drawn off and run into coolers, where it is agitated so that the Epsom salt separates in small crystals.

Borax is also manufactured by Messrs. R. & J. Garroway, Glasgow.

BREWING AND DISTILLING.

There are several breweries in Glasgow and its neighbourhood, but the methods pursued in them do not, except in one instance, differ from those usually employed in this country. Barley is converted into malt by steeping in water, germinating, and suitable kiln drying; the malt is ground and mashed (or infused) with warm water; the wort is boiled with hops, after which it is cooled, yeast is added, and the fermentation is carried through. After being cleansed from the yeast the product is, after suitable storage, ready for use. The character of the different kinds of beers and stouts depends upon the quantity and kind of malt used, the amount of hops, and variations in the methods of manufacture. Success in brewing depends upon the quality of the malt and hops used, upon the composition of the brewing water, and upon many minor details which can only be properly adjusted by an experienced brewer.

One of the largest works in Glasgow is the Wellpark Brewery of Messrs. J. & R. Tennent. Founded in the year 1750 by H. & R. Tennent, it has attained large dimensions, and within its walls there are not only the modern maltings of large size, but also complete and separate breweries for the production of all kinds of pale ale, beer, and stout, and of the lager and Munich beers for which the firm is now so well known. As, in contradistinction to British beers which are fermented and stored at ordinary temperatures, the lager and Munich beers require low temperatures during the process of manufacture, the lager brewery is equipped with a magnificent refrigerating plant. A special kiln has also been built for the production of malt of the character necessary for the purpose of brewing the Munich beer.

The works, which are situated in Duke Street, cover about ten acres. All the raw materials and finished products are examined and the brewing operations controlled in the very complete laboratory of the brewery. Another Glasgow firm is Messrs. Gillespie, Gray & Co., of the Crown brewery, who make a speciality of stout and porter.

In the manufacture of spirits, as in that of beer, the first steps are the preparation of a saccharine liquid by mashing malt, or a mixture of ground barley or other grain with a small proportion of malt, with warm water, or by diluting molasses with water, and the subsequent conversion of the sugar into alcohol by fermentation with yeast. The next process is the separation of the alcohol from the solution by distilling either in ordinary pot-stills or more generally in modern Coffey stills. When pot-stills are used the weak, impure spirit which is distilled over in the first operation is again distilled, the first and last portions of the distillate being set aside, and the middle portion reserved for consumption. Malt whisky is made from malt alone, grain whisky, which has little or no flavour, from a mixture of barley or other grain and malt; the latter is principally used for blending with malt whisky. Rectified spirit, or spirit of wine, is made by filtering the raw spirit through charcoal and distilling over potash; methylated spirit is prepared by mixing spirit of wine with a certain proportion of wood naphtha. Methylated spirit is used for burning in lamps, for making varnishes, etc.

Among the Glasgow distilleries may be mentioned the Loch Katrine Distillery, Adelphi, of Messrs. C. & D. Gray, where both malt and grain whisky are made, and the Loch Katrine Distillery, Camlachie, belonging to Messrs. Bulloch, Lade & Co., for malt whisky. Methylated spirit is made by Messrs. Thom & Cameron and Messrs. S. & D. Macnair.

CYANIDES AND FERROCYANIDES.

Twelve years ago potassium cyanide was chiefly used in photography and electro-plating, and was produced in comparatively small quantities; probably the whole world did not consume more than fifty tons per annum. The commercial cyanide, which was made by fusing dried ferrocyanide of potassium with carbonate of potassium, contained only about 33 per cent. of potassium cyanide, along with a large proportion of cyanate and carbonate. Its price was about 1s. 6d. per lb., which was equivalent to 4s. 6d. per lb. for the actual cyanide it contained.

The advent of the cyanide process of gold extraction in 1888-89 produced a new demand for cyanide on a hitherto unthought of scale, and the Cassel Gold Extracting Company, as owners of the gold extracting patents, were obliged to make provision for an increased supply. They accordingly erected a factory in Glasgow, and succeeded in producing a commercial product which contained about 70 per cent. of potassium cyanide. Many hundreds of tons of this salt were made in the Glasgow factory and sent to the Transvaal and other gold-producing countries. Meanwhile the Deutsche Gold and Silber Scheide Anstalt of Frankfurt, who had for long been producers of cyanide for electro-plating purposes, enlarged their factory to meet the new demand, and, having obtained a monopoly of the metallic sodium produced by H. Y. Castner at Oldbury, they were able to make a much purer double cyanide of potassium and sodium than any previously in

the market. It contained cyanogen equal to 98 per cent. of potassium cyanide.

In 1890 G. Beilby devised a process for the production of potassium cyanide of great purity by the decomposition of ammonia gas in the presence of fused potassium carbonate and carbon. In 1891 he erected a small factory in Edinburgh for working out his process on a commercial scale, and in the following year this factory was turning out a ton per week of a product containing from 80 to 85 per cent. of potassium cyanide. In 1893 the Cassel Gold Extracting Company acquired the exclusive right to manufacture by Beilby's process, and a new factory was erected in Glasgow, from which an output of a ton per day was being obtained before the end of that year. The process has been improved year by year, so that as regards both quality and cost of manufacture the product has been able to hold its own against all competition. Hitherto ferrocyanide of potassium had been the only source of commercial cyanide, for which the new demand exercised a very stimulating effect on the production of ferrocyanide, both by the old process of fusing nitrogenous organic matter with potassium carbonate and scrap iron, and by the recovery of cyanogen from crude coal gas. After the Beilby process was fairly established the Cassel Company ceased to use ferrocyanide, and the effect of their withdrawal from the market was a steady reduction in the price of that substance from 10d. to under 6d. per lb. But the rapid spread of the cyanide process of gold extraction in all the gold-producing countries of the world prevented any serious over-production of cyanide, and for a number of years there was the curious spectacle of the simultaneous production of potassium cyanide by the newest and by the most ancient processes.

In the recovery of ferrocyanides from crude coal gas great progress has been made both in this country and in Germany. In Glasgow W. Foulis has invented a process for absorbing the cyanogen present in the crude gas by means of a mixture of ferrous hydrate and sodium carbonate, while in Germany Bueb has attained the same end by the use of a solution of ferrous sulphate. Both of these processes are capable of completely removing the cyanogen from coal gas. The Foulis process, in which the cyanogen is recovered in the form of sodium ferrocyanide, is in use in the gas works of the Glasgow Corporation.

It is stated that the cyanide works of the Cassel Gold Extracting Company have a manufacturing capacity more than double that of any other factory in the world. Statistics of actual output and costs are not available, but it may be mentioned that the selling price of 98 per cent. cyanide, which was 2s. per lb. in 1892, has fallen to 10d. per lb. to-day. In this company, of which Mr. Beilby is a director as well as the scientific expert, the staff includes a chief engineer and manager, four highly-trained chemists, and a large staff of testing chemists, of whom a number are young ladies.

It is interesting, and not a little curious, to note that this special branch of chemical manufacture has had a fascination for chemists and inventors out of all proportion to its magnitude as a trade. Not merely in this, but even in an earlier, generation large sums have been expended in the attempt to fix the nitrogen of the air either as ammonia or as cyanogen. It has been estimated that during the past ten years from £250,000 to £300,000 have been fruitlessly spent on new cyanide

processes, while quite an army of highly-skilled chemists, British and foreign, have been devoting their whole energies to devising these new processes. It is encouraging to find that, in spite of this keen and well-endowed competition, this important chemical industry has been retained in Glasgow by means of purely British skill and energy.

Ferrocyanide of potassium is now the principal product manufactured at the Campsie Alum Works, Lennoxtown, belonging to the **Hurlet and Campsie Alum Company**, of which firm the Messrs. King are the sole partners, and the same company have similar works at Falkirk and at Manchester. The Campsie Alum Works were established at Campsie nearly one hundred years ago for the manufacture of alum from a native alum shale, which occurs in the coal measures there and at Hurlet and other parts of Renfrewshire. The supply of shale having become exhausted fully twenty years ago the manufacture of alum was discontinued, but ferrocyanide of potassium has been made at Campsie for more than eighty years.

DESTRUCTIVE DISTILLATION.

The term destructive distillation is applied to any process in which organic substances are decomposed, with formation of new products, by exposure to a high temperature in absence of air. The industries based upon such processes are large and important, and, in addition, the development of methods for recovering valuable substances from some of the products of destructive distillation has led to the foundation of other even more important manufactures, *e.g.*, that of the coal tar colours, which, unfortunately, has been allowed to leave this country. In Scotland the list of substances which are destructively distilled includes coal, bituminous shale, wood, bones, and resin; the products obtained from these substances are very different, and therefore each process will be considered separately.

(1) *Coal Gas.*

When coal is destructively distilled a residue of coke is left in the retorts, and volatile products are given off; part of the latter condense to the liquid state on cooling, while part remain gaseous. The mixture of gaseous products is, after purification, used as a source of light and heat under the name of coal gas; the liquid products consist of (1) a watery liquid, the ammoniacal liquor of the gas works, which is one of the chief sources of ammonia; and (2) coal tar, a complicated mixture from which many valuable organic substances can be separated. The manufacture of coal gas in Glasgow is described in the article on Municipal Enterprises; here it is sufficient to note that, while there has been an enormous increase in the quantity of gas made, the introduction of numerous improvements in the process has greatly reduced the price and improved the quality of the gas. The following figures relating to the Glasgow Corporation Gas Works show the development of this branch of industry during the last twenty-five years:—

	Coal Used.	Gas Made.	Price Charged for Gas.	Coke Sold.
1875	175,884 tons	1,649,616,000 c. ft.	5s. 5d. per 1000 c. ft.	25,330 tons.
1900	666,768 ,,	5,969,111,000 ,,	2s. 6d.* ,,	259,679 ,,

* 2s. 2d. in 1899-1900.

The number of consumers has increased from 114,132 to 201,878, and of workmen employed in the gas works from 902 to 2466; the maximum quantity of gas sent out in twenty-four hours was, in 1875, 9,982,000 cubic feet, and in 1900 31,917,000 cubic feet.

(2) *Paraffin and Paraffin Oil.*

The manufacture of paraffin wax and paraffin oil by the destructive distillation of bituminous shale is one of great importance and interest to Scotland, where it was begun about half a century ago. The seams of shale, the raw material from which the paraffin is produced, occur below the coal measures of Central Scotland. The various seams yield different qualities of shale, which give on distillation from twenty to over thirty gallons of crude oil per ton, and, as a rule, the lower seams give a lower percentage of crude oil and more ammonia than those above them. It should be noted that the shales do not contain paraffin, but are impregnated with carbonaceous materials which yield paraffins, olefines, etc., when subjected to destructive distillation. The history of the paraffin industry in Scotland since the date of the last meeting of the Association in Glasgow has been that of a continuous struggle against the results of the overwhelming foreign competition which followed the discovery of the gigantic deposits of mineral oil in America and Asia Minor, and had it not been that the industry was fortunate in possessing a technical staff of the highest ability the great battle against heavy odds would probably have ended in defeat. As it is, no effort has been spared to improve the yield or reduce the cost of production, and it is not too much to say that the problem of how to distil a carbonaceous material most economically has been solved in the paraffin oil industry within the last thirty years. During that period the cost of handling a ton of shale from the time it leaves the pit until its ash has gone to the waste heap has been reduced from 5s. to less than 2s. In the manufacture of paraffin oil and paraffin wax the first process consists essentially in destructive distillation of the carbonaceous mineral at a comparatively low temperature. The products formed are a green, oily liquid (the crude oil), a weak ammoniacal liquor, and uncondensible gases.* When the crude oil is refined it yields naphtha or shale spirit, burning or paraffin oil, lubricating oil, and paraffin scale or wax, which is chiefly used for making candles. Fractional distillation is used to separate the liquids, and the solid paraffin, which distils over with that portion of the oil having a higher specific gravity than 0·840, is separated by cooling and crystallisation. Sulphuric acid and caustic soda are used to remove impurities of basic or acidic character respectively from the oils. The ammonia is recovered from the ammoniacal liquor and converted usually into sulphate, while the gases from the shale retorts are used as fuel. Many improvements have been introduced into the manufacture during the period under review, but only the most important of these can be noticed.

The method of distilling the bituminous shale was revolutionised in 1881-82 by the introduction of the Young and Beilby retort, which was designed for the purpose of subjecting the spent shale of the oil-making retort to a further treatment with steam at a higher temperature than that suitable for oil making; the primary object of this improve-

* Broxburn shale gives, on the average, 12 per cent. of crude oil, 8 per cent. of ammoniacal liquor, and 4 per cent. of permanent gases, by weight.

ment was to convert the nitrogen left in the spent shale into ammonia. In the Young and Beilby retort the upper half is made of iron, and the lower half of fire-brick; at the top of the retort is a hopper containing shale, which is heated by the hot gases passing up from the retort below. As the whole column of material in the retort is moved down by the removal of a part of the spent ash at the bottom, the shale passes in succession through the iron retort and the fire-brick oven. In the former it is exposed to a low red heat, and parts with its hydrocarbon oils and paraffin; in the latter, where it is heated to bright redness and exposed to the action of steam, the carbon is more or less completely burned away in steam, producing water gas and ammonia. The retorts are placed in chambers of fire-brick, and are heated by producer gas, which is burned along with the uncondensible gas in narrow flues around the retorts. In order to facilitate the removal of the spent ash, and thus to minimise the danger arising from fusion of the ash at the high temperature of the brick chamber, the retort is provided with an easily accessible curved mouthpiece and door at the bottom. This system of distilling the shale at two different temperatures has the effect of greatly increasing the yield of ammonia and of the valuable paraffin scale as well, as can be seen from the following figures:—

	1882 Retort.	1897 (Young & Beilby) Retort.
Burning oil from 1 ton of shale,	12·6 gals.	12·9 gals.
Lubricating oil ,,	5·4 ,,	5·4 ,,
Paraffin scale ,,	3·3 ,,	4·3 ,,
Ammonium sulphate ,,	12 lbs.	36 lbs.

These retorts were very generally adopted, and the system of distilling the shale at two different temperatures has been applied in all the more recent retorts which have been designed as improvements upon the original Young and Beilby type. The chief changes in the newest forms of shale retorts, apart from structural details, are an increase in the capacity, so that the shale remains a longer time in the retort, and the adoption of various mechanical devices for the removal of the spent shale ash; the main results of these improvements are a great reduction in the cost of retorting, and an increased yield of crude oil and ammonia.

In the chemistry of refining the crude oil there has been little or no change. Sulphuric acid is used to remove basic tars and resinous substances, and caustic soda solution for the removal of creosote tars and sulphur compounds; the different oils are separated by fractional distillation, and the paraffin by cooling, crystallisation, and filtration. The quality of the lubricating oil has been improved by distilling the heavy oils off caustic soda, by the plentiful use of superheated steam in the distillations, and by the adoption of improved freezing machines and filter processes. A great advance in the distillation process was made when N. M. Henderson designed his apparatus for continuous distillation. In this system the stills are arranged in series, and the oil flows from charging tanks through each still in succession, undergoing fractionation in its course. The most volatile fractions are distilled off from the first still, and the least volatile from the last. The use of this process has resulted in considerable economy in labour, fuel, maintenance, and chemicals, and the loss in refining has been materially reduced.

The methods of cooling the heavy oils and extracting the paraffin scale have also been improved; as a rule each work has its own process and apparatus for carrying out these operations. In refining paraffin wax the "sweating" process has almost completely superseded the old naphtha process, with good results as regards economy and safety. In this process the crude paraffin scale is melted and cast into cakes, which are then placed on drainers in ovens heated by steam pipes to such a temperature that the low melting portions of the scale are sweated out of the cake, taking with them the oil and colouring matter. One or two repetitions of the process are sufficient to render the wax as pure as is necessary for candle making, etc. N. M. Henderson has introduced modifications in the sweating process which reduce the handling of the wax to a minimum. The general effect of the improvements has been to reduce the cost of refining one gallon of crude oil from 2·2d. to 0·7d., the latter figure including the refining of the crude scale.*

Improvements have also been made in the manufacture of ammonium sulphate from the ammoniacal liquor, the chief being the adoption of column stills for distilling off the ammonia, and another the returning of waste steam from the "cracker boxes," in which the ammonia is converted into sulphate, into the retorts in place of a corresponding quantity of fresh steam.

The distillation of the Boghead and Torbanehill mineral was begun at Bathgate in 1850, and of shale in 1862, by the late James Young. At the present day the following companies are engaged in the industry:— **Young's Paraffin Light and Mineral Oil Co., Ltd.**, who possess works at Addiewell (where sulphuric acid also is manufactured), at Uphall, and near Winchburgh; the **Broxburn Oil Company, Ltd.**, Broxburn; the **Oakbank Oil Company, Ltd.**, Mid-Calder; the **Pumpherston Oil Company, Ltd.**; the **Linlithgow Oil Company, Ltd.**; the **Caledonian Oil Company**, Lanark; the **Dalmeny Oil Company**; **Messrs. James Ross & Co.**, Philipstoun; and the **Hermand Oil Company.**

(3) *Distillation of Wood.*

When wood is destructively distilled a residue of charcoal is left in the retort, and the following volatile products are obtained:— (1) Uncondensible gases; (2) an aqueous distillate containing acetic acid, methyl alcohol, acetone, and other substances; and (3) wood tar. The quantities and the character of the volatile products depend not only upon the kind of wood used, but also upon the conditions under which the distillation is conducted. From the aqueous distillate crude acetic acid or "pyroligneous acid" can be obtained in several ways; acetic acid of better quality is usually prepared by neutralising the crude acid with lime or sodium carbonate, evaporating the solution, and distilling the acetate of calcium or sodium thus produced with sulphuric acid. When the crude acetic acid is neutralised and the solution heated, crude wood naphtha, which contains wood spirit or methyl alcohol, acetone, etc., distils over. The wood naphtha is partially purified by distillation over lime, and from the crude wood spirit methyl alcohol can be obtained by adding calcium chloride, with which it combines, distilling off the acetone and other impurities, decomposing

* It is noteworthy that while all the other costs are reduced, that of mining and raising the shale to the surface has considerably increased.

the compound of methyl alcohol and calcium chloride by addition of water, and then distilling off and rectifying the methyl alcohol. Wood naphtha is used for making varnishes, etc., and for the preparation of methylated spirits. From acetic acid various acetates are made; the solutions of acetate of aluminium ("red liquor") and acetates of iron ("black liquor" and "iron liquor"), which are usually prepared on the large scale from pyroligneous acid, and the acetate of tin are used as mordants by dyers. Acetone is made by heating calcium acetate, or from acetic acid. Wood tar is used as such for creosoting wood, for application to roofing felts, and as an antiseptic. It is also distilled, yielding an oily liquid, which is usually separated into "light oil" and "heavy oil," and a residue of wood pitch, which is used by shoemakers. From the oily distillate "wood creosote" is separated by agitating it with caustic soda solution and adding acid to the alkaline liquid; the wood creosote is an oily liquid which differs considerably in composition from the creosote obtained from coal tar or blast furnace tar. It contains only very small quantities of carbolic acid, but, on the other hand, a number of derivations of that substance which render it powerfully antiseptic, though less caustic and less poisonous than carbolic acid itself.

Of late years, partly owing to the greater scarcity of home-grown hard woods, wood distillers have been utilising waste woods obtained from turners, cabinetmakers, sawyers, etc. For this class of raw material vertical retorts are required, while horizontal retorts are used for whole timber. Since 1876, owing to foreign competition, nearly all of the acetates have fallen in value from 40 to 60 per cent.; moreover, the introduction of new direct colours, which do not require mordants, has greatly affected the trade in mordant liquors.

Messrs. Turnbull & Co., Camlachie Chemical Works, Glasgow, are the oldest established firm of wood distillers in Scotland. Their first work was erected in the Vale of Leven towards the end of the eighteenth century, and they have since established other works in different parts of the country, the principal of which is the Camlachie factory, which was opened in 1806. They manufacture charcoal, acetic acid, wood spirit, acetone, and the acetates of sodium, calcium, aluminium, iron, lead, and copper. In their general processes there has not been any great change since 1876, though several economies have been introduced. The only new product since that date is acetone, which is largely used in the manufacture of smokeless powder, but of which, however, the chief supply comes from the Continent. The Cartvale Chemical Co., Paisley, are engaged in the same branch of manufacture. Their products are practically the same as those of twenty-five years ago, with the exception of 40 per cent. acetic acid, which at that time was only made on a small scale in Scotland. The output of their principal products, per month, is—charcoal, about 300 tons; calcium acetate, 80 tons; 40 per cent. acetic acid, 100 tons; methyl alcohol, 2000 gallons; mordant liquors (acetates of aluminium, etc.), about 20,000 gallons; tar, 80 tons. Messrs. R. & J. Garroway, Glasgow, also distil wood and work up the products, which are similar to those already mentioned.

(4) *Distillation of Bones.*

Bones are utilised in a number of different ways. When heated with water, after removal of the mineral matter by treatment with

acids, they yield bone fat and glue, and when destructively distilled they give a residue of animal charcoal and a large quantity of volatile substances, including uncondensible gases, an aqueous distillate containing ammonia, and bone tar.

Messrs. John Poynter, Son, & Macdonald have been engaged for more than fifty years in the manufacture of practically all the substances obtainable from bones. Their products include bone fat, glue, animal charcoal, ivory black (a very fine form of animal charcoal), sulphate of ammonia, bone pitch (obtained by distilling the bone tar), manures, and buttons. The gas produced in the distillation of the bones is used, after purification, for lighting the works, and as a source of heat. The manufacture of glue has only been started within recent years, and in this case the amount of moisture in the atmosphere of Greenock, where the work is situated, created a difficulty which has had to be overcome by the erection of very complete drying, cooling, and evaporating appliances. The bone tar is partially utilised for the manufacture of pitch, which is left as a residue when the tar is distilled, but the oil distilled from the tar, which is almost altogether composed of nitrogenous compounds, has not yet found any extended application, and is simply used as fuel.

(5) *Distillation of Resin.*

Common resin or colophony, when distilled, yields a "resin spirit," and, in far larger quantity, a "resin oil." The former is chiefly used in making varnishes, the latter in making lubricants, and as an ingredient in some printing inks. Resin oil unites with lime to form a greasy mass which serves as a lubricant. Resin is distilled at several works in Glasgow, but the process is usually associated with others.

(6) *Distillation of Tar.*

The great increase in the production of coal tar, obtained as a by-product of the manufacture of coal gas, and of blast furnace tar, recovered from the gases of the blast furnace, has led to a corresponding development in the number of tar-distilling works in Scotland; in 1893 there were 35 works of that class, while in 1899 the number had risen to 46. These works are situated, as a rule, in close proximity to the gas works and blast furnaces, *e.g.*, at Glengarnock, whence the raw material is obtained. One of the oldest works is that of Messrs. George Miller & Co., Dalmarnock.

Coal tar is a complicated mixture of many different substances. The composition of tar varies greatly, as it not only depends upon the character of the coal employed, but also is greatly affected by variations in the method of distilling the coal. When coal tar is distilled the principal volatile products are usually collected in several different fractions—naphtha, light oil, creosote oil, and heavy oil; a black residue, known as pitch, is left in the retort. The naphtha, after rectification, is used for burning in lamps. From the naphtha and light oil, after purification by agitation with sulphuric acid, benzene, xylene, and other hydrocarbons of the aromatic series, can be separated. Benzene is largely used in the manufacture of aniline, from which many dyestuffs can be prepared, and it is also employed as a solvent. The solid hydrocarbons naphthalene and anthracene are obtained on cooling the creosote oil and the heavy oil respectively; both are used for the

preparation of many other substances, among which may be noted the beautiful red dye-stuff alizarine, formerly obtained from madder, but now made from anthracene. The balance of the oily distillate is sold as tar oils of various grades. From the creosote oil carbolic acid (phenol), cresylic acids, and other compounds of the same class are extracted by agitation with caustic soda solution, in which they dissolve; from this solution they are separated by the addition of acids. The creosote oil is used very largely for preserving timber, for softening hard pitch, as a liquid fuel, in the manufacture of lamp black, and for making antiseptics, sheep dips, etc. The pitch is employed for building, roofing, and road making, and a considerable quantity is used in making briquettes.

Blast furnace tar is now produced in very large quantities in the West of Scotland. In composition it is quite unlike coal tar, because although both substances are formed from the same raw material, the conditions under which coal is decomposed in a blast furnace differ greatly from those which exist in a gas retort. On distillation blast furnace tar yields volatile products in the shape of a "light oil" and a "creosote oil," and a residue of pitch. The light oil is largely used for burning in furnaces and in lamps of the "Lucigen" type, in which it is burned in the form of a spray produced by means of compressed air, and for other purposes. The creosote oil contains a much larger proportion of substances soluble in caustic soda and belonging to the same class as carbolic acid, though less of carbolic acid itself, than creosote oil from coal tar. It has, however, great antiseptic power, and finds extended application.

EXPLOSIVES.

An important industry of the West of Scotland is the manufacture of explosives, which is carried on by **Nobel's Explosives Co., Ltd.**, whose principal factory is at Ardeer, near Stevenston, in Ayrshire. The basis of most of the explosives manufactured by the company is nitroglycerine, an oily liquid of highly explosive character, which is formed by the action of a mixture of concentrated nitric and sulphuric acids upon glycerine. Nitroglycerine was discovered by Sobrero in 1846, but for many years remained a laboratory curiosity, until in the early sixties Alfred Nobel began to prepare it on a commercial scale for use in mining. Its progress was slow at first, and many accidents, caused chiefly by ignorance of its properties and by a faulty method of detonation, attended its introduction. Being liquid in form it readily penetrated fissures in rocks, and thus caused accidents in quite unexpected places; it was very sensitive to shock and more than once exploded when being transported in tins; it sometimes caused deadly fumes when imperfectly detonated by a primer of black powder; it froze in winter and was troublesome to thaw; imperfect washing and other faults in its manufacture introduced a danger of spontaneous combustion. These defects and the accidents they caused led to absolute prohibition by Parliament of its manufacture in several countries, including Great Britain, where legislation was hastened by the introduction of guncotton as a mining explosive, which resulted from Abel's success in discovering how to make chemically stable guncotton on a large scale.

Nobel's energy and inventive genius were now brought to bear on the problem of how to overcome the defects of liquid nitroglycerine. Many absorbents were tried and at last one was found, namely, kieselguhr, a porous, friable, siliceous material composed of the remains of diatoms, which was capable of absorbing and retaining, under varying climatic conditions, three times its own weight of nitroglycerine. This mixture, to which the name "Dynamite" was given, soon became known over the whole world. It is a plastic substance of reddish brown colour, and though containing such a large proportion of nitroglycerine, it is safer than gunpowder as regards both transport and use. The difficulty of proper detonation was overcome by the introduction of detonators charged with fulminate of mercury, a most important improvement, and the results of these two inventions were startling. The world's consumption of dynamite, which in the year of its invention was only 11 tons, rose in 1868 to 78 tons, and in 1874 to no less than 3120 tons. In 1876 practically the only nitroglycerine explosive in use was No. 1 dynamite, and this substance, which is prepared by thoroughly incorporating three parts of nitroglycerine with one part of kieselguhr, was produced at Ardeer during that year to the extent of about 500 tons, while another mixture known as dynamite No. 2, which contained in addition potassium nitrate, charcoal, and paraffin wax, was manufactured to the extent of 16 tons only. At that time manufacturing operations were conducted under very great difficulty, and as the transport of explosives by rail was then impossible, vessels had to be loaded on the open beach.

At the present day No. 1 dynamite is still made at Ardeer, but its importance has been minimised by the introduction of the gelatinous explosives manufactured by the company. The absorption of nitroglycerine by kieselguhr, itself an inert substance, was an important step in the right direction, but an ideal explosive must resolve itself entirely into gases, and develop the maximum temperature, before it can evolve its utmost energy in explosion. To the solution of this problem Nobel now bent his mind, and, after eight years of investigation, in 1875 he took out his patent for blasting gelatine, a mixture, or rather a solution, of eight parts of a special nitro-cotton in ninety-two parts of nitroglycerine, which sets to a stiff jelly. This is a model explosive, the strongest and the safest yet produced, which twenty-five years of subsequent research have not been able to surpass or even to approach. Blasting gelatine is practically unaffected even by prolonged contact with water; it is even more insensitive to shock than dynamite, and its disruptive force is enormous. Gelatine dynamite, composed of about 80 per cent. of nitroglycerine mixed with sufficient nitro-cotton to make it thinly gelatinous, and with potassium nitrate and wood meal added in certain proportions, and gelignite, another modification of blasting gelatine, are also made at Ardeer. In addition there has arisen another class of safety explosives for use in coal mines, which are now manufactured under various forms of Nobel Carbonite and Nobel Ardeer Powder, while two forms of Nobel Gelignite have also been introduced for stone blasting in collieries.

Alfred Nobel, who was for so many years closely associated with Nobel's Explosives Company, Limited, as their technical director, did not permit his inventive powers to remain in idleness even after the production of the gelatinous explosives for blasting purposes, and in 1887 he invented a smokeless powder for propulsion, made by mixing nitroglycerine and nitrocellulose

in approximately equal proportions, and known under the name of ballistite, which, with slight modifications, became even better known as cordite. Ballistite is largely made, but so far as quantity produced is concerned, the Government smokeless powder, cordite, far surpasses it. Cordite has for months been manufactured at Ardeer at the rate of 50 tons per week.

In addition to cordite and ballistite, Nobel's Explosives Co., Ltd., now produce picric acid for lyddite, guncotton for cordite, compressed guncotton for torpedo charges, soluble nitro-cellulose for blasting gelatines, etc. None of these were manufactured in 1876.

Besides the Ardeer factory the company possesses eight others, three of which are situated in Scotland, viz., one at Redding Moor, another at Westquarter, both near Polmont Station, Stirlingshire, and the third at Regent Works, Linlithgow. The first of these is set apart for the manufacture of fulminate of mercury for use in detonators, caps, etc. This compound, which is obtained by the action of nitric acid and alcohol upon mercury, is a heavy grey powder, violently explosive, and very sensitive to friction or percussion when in the dry state. In the Westquarter factory there are two departments, one in which tubes for detonators, etc., are manufactured, and the other in which the tubes are charged with fulminate of mercury and other chemicals. It is to Alfred Nobel that we are indebted for the use of the detonator in its present form. The manufactures associated with detonators, namely, electric detonator fuses and fulminate of mercury, are all additions to the products of the company within the past twenty-five years.*

The period under review has been marked by great advances in the quantities of explosives made by the company. In 1876 their only manufactures were dynamite, nitric acid, and detonators, while at the present day they produce, besides these, all of the newer explosives mentioned above, and in addition sulphuric acid, nitrate of lead, etc. The operation of refining glycerine is carried out by appliances of the latest type, capable of producing 3600 tons per annum. Extensive additions have been made to other branches of the explosives trade in the production of shells; solid drawn metallic and other cartridge cases for military and sporting rifles, quick-firing guns, naval ordnance, etc.; ammunition for small arms; armour piercing and other projectiles; military, naval, and mining fuses; primers; percussion caps, etc. In the industrial department the chief products added since 1876 are cartridge metal, brass, copper, cupro-nickel, and aluminium in strips, cups, wire, etc; copper boiler and belt rivets; and various other metal products in connection with rolling mills. Marked progress has been made in the methods of producing nitroglycerine explosives, and very great improvements have been devised in the production of detonators, but as the methods adopted are due to the special discoveries of the chemical and research departments, details are naturally not available.

The following figures give a very good idea of the company's progress during the period under review:—

	Output in 1876.	Output in 1900.
Nitroglycerine explosives, - - -	468 tons	5,000 tons
Cordite, smokeless powder, fulminate of mercury, and other chemical products,	—	About 2,800 tons
Nobel detonators (1877), - - -	26,000	Nearly 70,000,000
Nobel electric detonator fuses, - -	—	Nearly 3,000,000

* The other works of the company are at Perranporth, Cornwall; Adderley Park and Streetly, near Birmingham; Clayton Bridge, Lancashire; and in Swansea.

In 1876 the scientific staff numbered 5, and the total number of workers was 102, while in 1900 the scientific staff numbered 53, of whom 12 were employed in the research department, and the total number of workers was over 4000.

Gunpowder and other explosives are also manufactured by the **Kames Gunpowder Co.**, whose works are situated at Kames, in the Kyles of Bute.

COMPRESSED AND LIQUEFIED GASES.

An industry which was not in existence in Glasgow at the time of the last meeting of the Association there is the manufacture of compressed and liquefied gases now carried on at the Rosehill Works, Polmadie, by the **Scotch and Irish Oxygen Co., Ltd.**, which began operations in 1888.

First in importance among the company's products is oxygen gas. This is extracted from the atmosphere by Brin's process, which consists essentially in the formation of barium dioxide by combination of barium monoxide with atmospheric oxygen, and the subsequent decomposition of the dioxide into the monoxide (which can be used repeatedly for the same purpose) and oxygen. Barium monoxide is prepared for use in this process by heating the nitrate in fire-clay crucibles to a temperature of about 880°; the oxide is obtained as a greyish, porous mass, which is again ignited in order to complete the decomposition of the nitrate, and the process is carefully regulated with the object of obtaining the oxide in as hard and porous a state as possible. The barium oxide is placed in vertical retorts, which are maintained at a temperature of about 700°, and air is pumped in under a pressure of about 25 lbs. per square inch; the air is previously freed from carbon dioxide and moisture by being drawn through two chambers containing quicklime and lumps of caustic soda respectively. The barium monoxide unites with the oxygen of the air, and after a period of seven and a half minutes the air supply is shut off and the pumps reversed for a second period of equal length so as to exhaust the retorts. The nitrogen which is first extracted from the retorts is blown off, and as the pressure falls the decomposition of the dioxide begins, and is practically complete when a pressure of about 3 inches of mercury has been reached; when all the nitrogen has been removed the oxygen is passed into a gas holder. An automatic arrangement controls the time of each operation, and reverses pumps and cocks, and the process is a continuous one. In each period of fifteen minutes about 0·015 cubic feet of gas, containing from 94 to 98 per cent. of oxygen is obtained per lb. of oxide. The main difficulty to be contended with is leakage of air into the retorts, but if this be avoided the retorts, each of which contains about 2 cwts. of oxide, can be run for twelve or eighteen months without interruption; at the end of that time about 20 per cent. of fresh oxide requires to be added to each retort. To compress the oxygen gas it is passed successively through three vertical pumps or cylinders, being subjected in the third to a pressure of 125 atmospheres; it is then stored in steel cylinders under a pressure of 120 atmospheres. Each new gas cylinder is annealed and tested by hydraulic pressure, and the annealing process is repeated every four years and the testing process every two years. In the Rosehill Works all of the new cylinders are tested to stand a

pressure of at least 3750 lbs. per square inch, and most at 4000 lbs per square inch; retests are carried to 3360 lbs. per square inch. Compressed oxygen is used for the lime-light, for brazing and lead burning, for the oxy-coal gas blowpipe,* in chemical laboratories, and as a remedial agent of great value, *e.g.*, for inhalation in cases of asphyxia and in affections of the lungs and heart. It is also applied, on the Continent at any rate, to remove aldehydes and other objectionable impurities from spirituous liquids, and it is claimed that spirits can be "matured" in a few seconds by bringing the compressed gas in contact with the liquid reduced to the form of a mist or fine spray.

Another substance manufactured in large quantity by the company is carbon dioxide, which is sent out in the liquid state. The gaseous carbon dioxide evolved by the action of dilute sulphuric acid upon sodium bicarbonate is passed into a scrubber charged with coke through which water trickles, then to a drying tower charged with fragments of calcium chloride, and then to a gas holder. The gas, which now contains 99·5 per cent. of carbon dioxide, is liquefied in the pumps at a pressure of about 90 atmospheres, the temperature being about 39°, and the liquid is passed into the cylinders, which, however, are never filled completely; in order to prevent any risk of over-pressure it is customary to fill the cylinders by weight. Compressed carbon dioxide is now largely used for refrigerating purposes, and its application in the preparation of aerated waters is extending on account of the purity of the gas.

The company also prepare compressed hydrogen (generated by the action of steel filings upon dilute sulphuric acid) and compressed coal gas, the latter in large quantities; the demand for the former is almost wholly for the lime-light, but coal gas is very generally substituted on account of the lower price. Nitrous oxide, ammonia, sulphur dioxide, chlorine, and nitrogen are also sent out in the compressed or liquefied state, the former chiefly for use in dentistry.

One department of the Rosehill Works is devoted to the manufacture of valves in bronze and steel for gas cylinders, reducing valves or regulators, keys, and all fittings for use with compressed gases, and it is claimed that the company turns out more work of this kind than any other firm in the United Kingdom.

IODINE.

The extraction of iodine from kelp is an industry which has been prosecuted in the West of Scotland for a long time. Iodine was first made in quantity in Glasgow in 1841; in 1846 there were twenty makers, and now there are only four. The chief reasons for the closing of so many works were the fall in the value of potash salts, as a result of the exploitation of the great mineral deposits at Stassfurt, the great fluctuations in the price of iodine, and, last, but not least, the importation of iodine obtained from *caliche*, the crude nitrate of soda found in Peru, which now forms the most important source of iodine. Iodine from caliche was first sent over to this country in quantity in 1874, and since then the import has steadily increased. The present output from this source must be five or six times the total production of Europe.

* This blowpipe is of great use to engineers for softening broken drills, taps, etc., in finished work preparatory to drilling them out.

In the West of Scotland iodine is extracted from kelp, a rough slag obtained by burning seaweed in long narrow pits, or charring it in retorts. Kelp comes from the Hebrides, from Ireland, and from Norway. The average annual imports into the Clyde were, for the ten years prior to 1876, 9187 tons; for 1876-1885, 6887 tons; and for 1891-1900, 6841 tons; the quantity imported has been practically stationary since 1876. Kelp was formerly used as a source of sodium carbonate, but now it is only used for the extraction of potassium salts—the sulphate and chloride, which are used principally for manurial purposes—and of iodine, which is either sold as such, in cakes or resublimed, or made into iodides of sodium and potassium, or into iodoform, the only additional new product of recent years. In making kelp for iodine only those kinds of seaweed which are always submerged are used; these are torn up by the storms of winter and cast ashore. If the seaweed is properly burned to a loose ash at a low temperature it ought to yield about 25 lbs. of iodine per ton of kelp, but, as it is difficult to avoid too high a temperature in the ordinary process of kelp burning, average kelp does not contain more than 12 lbs. of iodine per ton.

The process employed for the extraction of the iodine remains practically the same as it was. The kelp is broken up and lixiviated with hot water in vats heated by steam, and the clear solution is run off and boiled down in hemispherical iron pans. The salts which separate are fished out, the liquid is cooled, and another crop of crystals is removed; the process of boiling down, cooling, and removal of the crystallised salts is continued until the mother liquor has become sufficiently rich in iodine. The salts removed by crystallisation are chiefly potassium sulphate, potassium chloride, and "kelp salt," a mixture of the chloride and carbonate of sodium. The mother liquor is mixed with about one-seventh of its volume of sulphuric acid, when the sulphides, sulphites, and thiosulphates present are decomposed and a considerable quantity of sulphur is deposited. The mother liquor is strained off from the sulphur, and run into the iodine still, a deep iron pot covered with a strong leaden lid, to which are luted two earthenware arms, which are connected with two series of peculiarly shaped stoneware condensers, called udells. The still is heated, manganese dioxide is added at intervals, and the iodine, which is carried over with the steam, is condensed in the udells, which are not changed until they are full. The iodine is purified by resublimation in small covered pans of earthenware or porcelain.

At the present time the extraction of iodine from kelp is prosecuted by **Mr. H. C. Fairlie** at the Camelon Chemical Works, Falkirk; by the **British Chemical Co.**, at the Whitecrook Works, Clydebank; by the **Scottish Acid and Alkali Co.**, at the Longford Chemical Works, Kilwinning; and by the **Milnquarter Chemical Co.**, Bonnybridge.

OILS, PAINTS, AND VARNISHES.

The manufacture of paints and colours, which in many works is associated with the boiling and refining of oils, the distillation of resin, and the preparation of varnishes, has developed greatly in Glasgow, and the number of firms engaged in this industry is much larger than it was in 1876, while there have also been considerable changes in

processes. At that date lakes and colours made with the aid of coal tar dyes were hardly seen, while now they occupy a large and important place. Many beautiful oxides have been produced from waste iron liquors, and numberless interesting processes for the cheapening of colours which were formerly too costly for everyday use have been introduced.* The introduction of self-closing tins for paints and varnishes has been a marked feature of the trade, and the consumer can now obtain goods in a great variety of forms, which were comparative rarities some years ago. Such items as liquid paints, enamels, prepared distemper colours and stains must be credited to this period. The quality of paints has also been improved by the growing perfection of the grinding machinery used in their manufacture.

Messrs. Alexander, Fergusson & Co., Ltd., Glasgow Lead and Colour Works, besides carrying on the operations of sheet lead and pipe making, smelting and desilverising lead, and colour and paint manufacture, are the only Scottish manufacturers of white lead by the old Dutch process. In this process earthenware pots, partially filled with dilute acetic acid, are imbedded in spent tan, and gratings of pure lead are placed across the mouth of each pot. The pots are covered with planks, and on these another layer of tan and pots is placed; this is repeated until the brick chamber or "stack" in which the process takes place, and which may be 20 feet high, is completely filled. The fermentation of the tan produces heat which causes the vaporisation of the acetic acid in the pots; the acid vapours attack the lead, forming a basic acetate, and this compound is converted into basic carbonate of lead, or white lead, by the action of the carbon dioxide evolved from the fermenting tan. When all of the lead has been converted into white lead the gratings of white lead are removed, ground with water, and levigated in order to separate particles of unaltered lead; the water containing the white lead in suspension is run into settling tanks, and the white lead is collected and dried in stoves. Since 1876 the firm have added to their products red lead, orange lead, ground litharge, and flake litharge. They have introduced many improvements in the methods of making and handling red lead and white lead with the object of securing greater fineness and purity of the product, combined with safety for the workers.

Among the other paint manufacturers in Glasgow may be mentioned **Messrs. J. S. Craig & Co.,** Kingston; **Messrs. J. MacNeill & Co.,** Bridgeton, who make a speciality of sealing and bottling waxes of all kinds and colours; **Messrs. A. Eadie & Co.,** Tradeston; **Messrs. Craig & Rose,** Cadogan Street; **Messrs. Blacklock & Macarthur,** Dale Street; **Messrs. Matthews, Maclay & Manson,** Hydepark Street; and **Messrs. J. & J. G. Scott,** Dobbie's Loan. As already stated, several of these makers also carry on the boiling and refining of oils, the distillation of resin, and the manufacture of varnishes, in addition to the manufacture of paints and colours.

SOAP AND GLYCERINE.

When fats or fatty oils, of animal or vegetable origin, are boiled with solutions of caustic alkalis they undergo saponification, and a solution containing a soap and glycerine is obtained. From the solu-

* The natural result is that a large number of fugitive colours have almost completely disappeared from the market.

tion the soap is usually precipitated by the addition of common salt, and the soap is then dissolved in such a quantity of hot water that the solution solidifies on cooling. Ordinary hard soaps are mixtures of the sodium salts of certain fatty acids, while soft soaps are mixtures of the potassium salts, and the former are produced by using caustic soda for saponification, while caustic potash is employed for the production of soft soaps. Besides the ordinary hard and soft soaps, many special kinds are made for toilet purposes and for use in other industries, *e.g.*, soaps for calico printers, dyers, bleachers, etc., soaps for washing paint, liquid soaps, and soap powders. These consist usually of ordinary soaps containing an admixture of colouring matters, perfumes, glycerine, disinfectants, resin soaps, silicate of soda, or other substances.

There have been considerable changes in the industry since 1876. At that time tallow was almost the only fat used for making soaps, except in the case of special kinds for manufacturers' purposes—at least there were very few soaps made in which tallow in larger or smaller proportions was not one of the raw materials. However, soap-makers recognised that vegetable and nut oils were bound to play an important part in the future development of the industry, and by continued experiment brought the saponification of these oils into the region of practical soapmaking. The quick lathering, or so-called self-washing soaps, were the result, and as a class these are in many respects superior to the old tallow soaps. Perhaps the most important development of the soap trade during the last twenty-five years has been the general introduction of methods for recovering glycerine from spent lyes. Formerly soapmakers, though fully aware of the value of glycerine, were unable, with the knowledge at their command, to recover that by-product at a profit; indeed, it is doubtful if any soap work in Scotland possessed a plant for the recovery of glycerine. About twenty years ago, however, this was made possible by the adoption of a very simple process, the liquors being evaporated in open pots; in all modern soap works the evaporation is conducted in a vacuum. Glycerine is now manufactured in soap works in three forms—"crude glycerine," containing 10 per cent. of salts; "dynamite glycerine," practically free from impurities; and "chemically pure glycerine," largely used for medical and pharmaceutical purposes. In order to secure a perfectly saponified, and yet economically produced soap, the whole process of soapmaking is under chemical supervision, and the raw materials are tested before use.

During the period under review there has been a great increase in the West of Scotland in the number of firms manufacturing soaps of all kinds, as well as soap powders, regarding which it may be noted that soda in some form or other constitutes from two-thirds to four-fifths of the bulk of all the soap powders in common use. Considerations of space forbid the mention of more than a few of the soap manufacturers of the West of Scotland. In Messrs. Charles Tennant & Co.'s works at St. Rollox the manufacture of soap was started in 1803, and continued until recently, when the work was acquired by the United Alkali Co.; the soap plant was then transferred to an adjoining site, where the manufacture of hard, toilet, and soft soap is carried on by **Messrs. Ogston & Tennant.** In Glasgow soap is also made at the **Sydney Street Soap Works;** by **Mr. D. Dreghorn,** who has brought

the manufacture of soft soaps to a high pitch of perfection; by **Mr. James Young**, who makes both hard and soft soaps; by **Messrs. Sutherland & Abercrombie**, who produce a great variety of special soaps for manufacturers, as well as for household use; by **Messrs. R. & J. Garroway, L. & J. M'Lellan, T. Hinshelwood & Co., The Clydesdale Soap Co.**, who make soap powder and special soaps, and others. In Paisley the principal works are those of **Messrs. Isdale & M'Callum**, and of **Messrs. Robin & Houston**, who also have a candle-making work in Glasgow.

SUGAR.

The industry of sugar refining has for long been in existence on the Clyde. It was started in Greenock in the latter half of the eighteenth century, but it flourished in Glasgow at a much earlier period, and until 1866 it was also prosecuted in Port-Glasgow. In 1875 the only refineries working on the Clyde were those in Greenock, then thirteen in number, while in 1900 there were only five firms refining there. During the last quarter-century the industry, on the whole, has declined, not only on the Clyde, but throughout Britain. This was not caused by any want of enterprise on the part of the refiners, who have been very ready to adopt improvements, but is mainly due to the bounties given by foreign States to rival refiners who are thus enabled to undersell home-made sugar in the British market. But for this sugar refining in this country would almost certainly have developed along with the increase in the consumption of sugar, and many of the refineries closed during the last twenty-five years would be working profitably. The following figures speak for themselves:—

	1875.	1900.
Consumption of sugar in this country, - - -	860,000 tons	1,489,000 tons
Sugar refined in this country, - - - - -	760,000 ,,	610,000 ,,
Refined sugar imported, chiefly from the Continent,	100,000 ,,	950,000 ,,

In other words, in 1875 88·5 per cent., and in 1900 only 39 per cent., of the sugar consumed in this country was refined in Britain.

Sugar refining, as practised on the Clyde, is on the whole rather a physical and mechanical than a purely chemical process. Generally speaking, it consists in dissolution of the raw sugar in water, filtration of the liquor through cloth to remove insoluble impurities and then through charcoal to remove soluble colouring matters, and finally concentration of the liquor to obtain sugar crystals. The process, however, depends largely upon chemical analysis for determining the composition and value of the raw material and for checking the various operations in the refinery. A number of improvements have been introduced into the manufacture in the course of the last twenty-five years.

Raw sugar is essentially a mixture of sugar crystals and molasses, and an important advance has been made in the adoption of improved methods of washing it with steam, or with hot or cold water, in centrifugals. The raw sugar is mixed with syrup or water, and transferred to a centrifugal machine, where, after spinning out the syrup, the sugar is washed with water or steam until most of the molasses is removed. The product, which, of course, still contains all the insoluble impurity and some of the colouring matter, is thus raised in quality

though diminished in bulk. In this way the raw sugar is separated into the partially purified crystals, which are then submitted to the ordinary process of refining, and the washings containing the molasses, which go to make yellow sugars and syrups.

In the filtration of sugar liquors filter presses have been introduced for some classes of work, but in most refineries the old Taylor filters, consisting of bags of closely woven cotton, still hold their own. Sometimes sand, kieselguhr, or other inert matter is added to prevent choking of the pores of the cloth, or phosphate of calcium is precipitated in the solution in order to cause coagulation of gummy or gelatinous matter.

Animal charcoal is still the chief decolouriser used in sugar refining, though it is supplemented in many refineries by the addition of sulphurous acid to the filtered liquid. Large quantities of charcoal—at least one ton for each ton of sugar—are necessary, and hence any improvements in the char department, which is the most expensive in a refinery, are of value. Much progress has been made in the methods of drying and "revivifying" the char from the filters, mainly by the adoption of improved methods of handling. The wet charcoal is delivered mechanically to driers, which are placed on the top of the kilns in which the char is reburned, and are heated by waste gases from the kiln fires. The dried char is then delivered into fixed or revolving pipes placed in the kilns, and is there heated to low redness in order to destroy the organic matter absorbed from the sugar solutions. Below the kilns it enters into ample coolers, whence it is automatically discharged into receivers ready for use, and, as required, it is carried by endless bands from the receiver to the elevator. After a year or two the charcoal, through repeated revivifications, loses its power as a decolouriser, and the cost of renewing it is a serious item in the upkeep of a refinery. The deterioration is chiefly due to reduction of porosity, through shrinkage of the mineral matter in the charcoal during successive reheatings, and to the deposition of vegetable carbon, which has practically no decolourising power, by decomposition of the organic matter absorbed from the sugar. No remedy has been found for the former evil, but attempts have been made to remove the vegetable carbon without destroying the animal charcoal by burning the char in a limited supply of air. This process has not yet been sufficiently tested, but good results are hoped for.

The process of concentrating the purified solutions of sugar with the object of obtaining crystallised sugar—technically called "boiling"—is always carried out in vacuum pans heated by steam, because boiling under normal pressure injures the sugar solution, and causes discolouration. No notable improvement has been made recently in the apparatus itself, but there has been considerable progress in the methods of boiling on the lines of a "seeding" process introduced just prior to the period under review. The details are too technical for discussion here, but the chief results are that the refiner can more easily produce large and well-formed crystals, and that the time spent on this part of the process of refining has been materially reduced. It should be noted also that loaf sugar is no longer produced, and that the forms known as "granulated" and "cubes" have been introduced.

From the molasses, which is obtained in the refining process, the last available sugar that can be granulated can now be separated by the

method of "crystallisation in motion," which has been adopted recently. The syrups or molasses, concentrated to the granulation point, are cooled slowly in an apparatus surrounded by a hot water jacket, and provided with a stirring arrangement which is kept in very slow motion. The process lasts for fifty or sixty hours, while the molasses cool slowly to about 50°, and under this treatment the small crystals of sugar which are first formed grow in the viscous mother liquor until large enough to be separated in the centrifugals. Previous to the introduction of this process much of the small grained sugar boiled from low syrups passed through the meshes of the centrifugals and was lost in the molasses. The process has not been widely adopted, because most of the low syrups are refined and sold as "golden syrup," the manufacture of which has greatly increased during the last twenty-five years, while the quality has been greatly improved. The syrups used for making golden syrups must be partially "inverted" in order to prevent crystallisation of cane sugar in the finished product, and to effect this they are heated with a small quantity of sulphuric acid, which is afterwards neutralised by carbonate of calcium; the sulphate of calcium is then removed by filtration. Inversion is sometimes effected by the addition of yeast to the syrups. Good well inverted syrups require no addition, but poor syrups are mixed in large quantities with liquid "glucose" made from maize, with the object of improving the colour and preventing granulation. The molasses which is not made into golden syrup goes to distilleries, where the sugar which it contains is converted into alcohol.

TANNING.

The leather industry of the West of Scotland has undergone a very marked change during the last thirty-five or forty years. The small country yards in which tanning was carried on prior to that period, the occupation being handed on from father to son, have almost entirely disappeared, and tanneries of enormous dimensions, situated in the proximity of populous centres, have taken their place. With the introduction of these large works the processes for the conversion of hides into leather have also been greatly altered, especially as regards the time occupied by the process. Leather which used to remain months in process is now tanned in almost the same number of weeks, and with some specially rapid processes the tanning is effected in a few hours; whether the leather so tanned has the same strength and the same firmly knit fibre as it had when tanned in the old prolonged style has not yet been very clearly demonstrated. The essential element in the quick methods of leather production now in use is the improved preparation of the hide in the initial stages of the tanning process, whereby it is rendered much more rapidly receptive of the tanning materials. Concentrated extracts of tanning materials now play an important part—indeed, the great majority of tanning substances are used in this form—and the tanner's great desire is to get them with as large a percentage of tanning constituents as possible, because if weak they are a very expensive article to use, as the time and cost of handling the goods then increase out of all proportion. Several new tanning processes have been brought into use during the last few years, notably the "orange tan"—a combination of vegetable and mineral tannage—and the "chrome tan," a purely mineral tannage produced

by the use of various salts of chromium. Chrome tanned leather is chiefly in demand for boot and shoe manufacture, while orange tanned leather, owing to the toughness of its fibre and its great tensile strength, is in extensive use as a belt leather for the transmission of power.

The leading firms in Glasgow—who, indeed, are the largest tanners in the world of the special kinds of leather they produce—are **Messrs. John Tullis & Son, Limited,** who manufacture all kinds of leathers for mechanical purposes, and **Messrs. Martin & Millar,** who tan sole and saddlery leather.

MISCELLANEOUS CHEMICAL INDUSTRIES.

The Atlas Chemical Works, belonging to **Messrs. Fawsitt & Graham,** were started in 1884 for the rectification and purification of crude wood naphtha, in order to supply a methyl alcohol suitable for the manufacture of aniline colours, and at the same time an ordinary wood naphtha used in the preparation of methylated spirit. In 1885 the manufacture of disulphide of carbon and chloride of sulphur was added, for the first time in Scotland, in order to meet the requirements of indiarubber manufacturers. The consumption of these articles increased rapidly for some years, but for some time has decreased with equal rapidity owing to Government regulations and to the adoption of another process for vulcanising waterproof. The manufacture of hydrogen peroxide was started about 1890, but the demand in Scotland was too small, and the woollen bleachers were, in the majority of cases, unwilling to change from their ordinary process, although a much finer result could be obtained from hydrogen peroxide. About 1891 the firm began to manufacture barium salts, and also the borates of manganese and of lead, and, shortly afterwards, the linoleates and resinates used as driers for varnish, oil, and paint. This branch of manufacture developed, and resulted in the starting of a varnish work, which forms the largest part of the firm's business.

The development of the electric furnace has led to the preparation on the commercial scale of carbide of calcium, which is now in great demand as the source of acetylene gas, so largely used as an illuminant. The carbide is produced by heating a mixture of lime and carbon to the extremely high temperature attainable in the electric furnace, and the commercial product is obtained in brownish masses of somewhat metallic appearance. It is decomposed by water with formation of slaked lime and acetylene. Calcium carbide is now manufactured by the **Carbide Company** at Foyers, where there is abundant water power for the generation of electricity.

The manufacture of waterproof articles was started in Glasgow in 1823 by Charles Macintosh, and is now prosecuted by **Messrs. G. M'Lellan & Co., Messrs. Achnach & Co., The Clyde Rubber Co.,** and **Messrs. S. Wotherspoon & Sons.** For such purposes indiarubber is not used in the pure state, but in the form of "vulcanised" rubber. The old process of vulcanising indiarubber was to submit the rubber to the action of a weak solution of chloride of sulphur in carbon disulphide, when a certain quantity of sulphur was taken up and the properties of the rubber considerably altered, but this has been practically abandoned in Scotland in favour of a newer dry process. This dry process consists in mixing the rubber with a certain proportion of sulphur and

litharge, and exposing the articles to a temperature of about 105° to 110° in a stove (dry heat).

Chemicals for pharmaceutical purposes are manufactured by **Messrs. W. & R. Hatrick & Co.**, Renfield Buildings, Glasgow, as well as by the **Glasgow Apothecaries Co.** and other firms. The raw materials are partly the roots and leaves of medicinal plants grown in this country, which are extensively used, partly crude drugs imported in their various parts from abroad. Messrs. Hatrick's principal products are tinctures, chemical and vegetable syrups and liquors, concentrated infusions, decoctions, and liquid extracts, which are mainly prepared by the processes recommended in the British Pharmacopœia, of definite degrees of purity and strength. As regards the principal changes in the demand for medicines, it may be stated that while a dozen years ago drugs in their crude state were still largely taken, these have now been displaced by tablets, capsules, and cachets containing the active principles of the drugs compressed into small bulk; lard, which was formerly the basis of most ointments, is now, to a considerable extent, replaced by soft paraffin and wool fats; quinine, once standing alone as an antipyretic, has now its rivals in phenacetine, antipyrine, and other synthetic remedies; iodoform, boracic acid, salicylic acid and sodium salicylate, cocaine, and eucalyptus oil, principally of the globulus variety, are in great demand; codliver oil, of which the chief supply formerly came from Newfoundland, is now almost entirely obtained from Norway. Messrs. Hatrick's new factory, which was erected in 1899, is well equipped for their various manufactures with electric lighting, a sprinkler installation for prevention of fire, grinding mills driven by electric motors, and other appliances.

The manufacture of chemical manures is carried on to a considerable extent in the West of Scotland. The principal process involved is the treatment of bones or mineral phosphates with sulphuric acid in order to obtain a soluble phosphate of lime, which is dried and used either by itself or after admixture with other substances of manurial value. One of the principal firms engaged in the industry is **Messrs. Alexander Cross & Sons.** The firm was established in 1830, but their chemical work at Port-Dundas was not erected until 1872. The works are chiefly devoted to the production of chemical fertilisers—dissolved guano, superphosphate of lime, and mixed fertilisers of different kinds—but sulphuric acid is also manufactured to the extent of 20,000 tons per annum, much of which is used in the works. The firm possesses four sets of furnaces, nineteen sulphuric acid chambers, and an installation of platinum stills for concentrating the acid. The mineral phosphates used include Florida, Tennessee, Algerian, Peace River, and Belgian phosphates. Among the other products are ground bones, ground phosphate, ammonium sulphate, and feeding cake of different kinds, the cake mill being capable of turning out forty tons per week. This is the only work in Scotland where basic slag is ground, the whole output of the only steel company in Scotland which makes that article, which has considerable value as a manure, being consigned there; the quantity of basic slag ground is from 20,000 to 25,000 tons per annum. Chemical manures are also made by **Messrs. Robinson & Campbell**, Ruchill Bridge, Maryhill, who were established in Greenock about half a century ago, but removed to their present work in 1875, and by some other firms.

Starch of different kinds and qualities for use in manufacture, *e.g.*,

sizing paper and cotton goods, thickening colours, preparation of British gum, etc., or for laundry purposes, or for use as a food, is prepared in several works. The chief sources of starch now are rice and maize, and the process of separation is partly mechanical and partly chemical. The grain generally is soaked in water and finely ground between millstones, and the starch is separated from the husk, gluten, etc., partly by levigation, partly by the use of solutions of caustic soda to dissolve the gluten; the purity of the starch depends largely upon the thoroughness of the washing process. After settling the damp starch is cut into square blocks, and dried slowly in a stove. Dextrine or British gum, which is really a mixture of substances, is usually prepared by drying starch and heating it in rotating drums, or ovens provided with stirrers, to a temperature of 215° to 275°. The product is a powder, varying in colour from pale yellow to brown, and is used as a substitute for natural gums. Starches and British gum are manufactured by **Messrs. James Anderson & Co.**, Surrey Street, Glasgow; **Messrs. Brown & Polson**, Paisley, manufacture from maize great quantities of a very pure starch known as patent cornflour, as well as other qualities. The husk, gluten, oil, and other residual portions of the maize are collected, compressed, and dried, forming a highly nutritious food for cattle or poultry.

The British Dyewood and Chemical Co., at their Carntyne Dyewood Mill, Glasgow, have a very extensive plant for grinding dyewoods and for the preparation of liquid or solid extracts containing colouring materials or substances used in tanning. The dyewoods or tanning materials are ground in mills, and extracts are obtained by treatment of the ground woods with either cold or hot water, and suitable concentration. Among the company's products are extracts of Persian berry, logwood, quebracho, fustic, and quercitron bark, and also cutch, sapan, Indian yellow, hematine, and flavine for the use of dyers and printers, and extracts of sumac, myrabolams, and divi-divi for tanners.

Other manufactures of the West of Scotland which are at least partly chemical include the production of sheep dips and disinfectants of different kinds, *e.g.*, by **Messrs. J. G. Swan & Co.**, Glasgow; the preparation of aerated waters—an industry which has developed with great rapidity, and is now prosecuted by many firms; the manufacture of matches, and the manufacture of paper. Electro-plating with gold, silver, and nickel is carried on by a number of firms, and at the works of the **Glenfield Company**, Kilmarnock, and of **Messrs. Braby & Co.**, Glasgow, the interesting process known as "barffing," for the protection of iron or steel from rusting, is in operation. The process consists in heating the articles to redness in a reducing atmosphere, and then blowing in superheated steam, which causes the formation of a protective coating of the magnetic oxide of iron upon the surface of the metal.

GLASS, POTTERY, BRICK MAKING, ETC.,

BY

JAMES FLEMING.

GLASS, POTTERY, BRICK MAKING, ETC.

GLASS.

The industry of glassmaking is carried on in nearly all its varied forms in Glasgow. Common bottles, medicine bottles, plate glass, pressed glass, and flint glass or crystal, each requiring separate furnaces, and, in reality being different branches of one trade, are manufactured by various firms. While the bulk of the production of the cheaper class of goods is for local consumption, the products of the higher class of ware are distributed all over the kingdom, the chief firms having a large connection in London, and a well-established reputation for the high quality of their goods, and the artistic merit of their designs. The bottle glass trade has passed through many vicissitudes on account of wages on the Continent being so much less than in the United Kingdom, and, unless there is a decided advance in the scale of wages paid abroad, it cannot be expected that this branch of manufacture will extend. The improved market, however, for all kinds of bottles, was a feature last year, and Glasgow manufacturers were kept well employed and shared in the prosperity.

The firms presently engaged in the flint glass trade have been long established, one of them dating back over seventy years. It may be interesting to many to learn that, although the old term "flint glass" is still applied to crystal, it is a long time since flint formed any part of the "batch" used in the manufacture. The finest quality of silver sand, chiefly procured from the forests of Fontainbleau, near Rouen, has replaced the silica formerly obtained from flint.

In the early days of the industry, pressed, or moulded, glass was combined with hand-blown, but gradually it was found that the two kinds could not suitably be worked from the same furnaces. The demand for hand-blown articles made of the finest crystal necessitated special and superior "metal" for such, whilst price was the chief factor in the commoner articles. The requirements at that time were entirely confined to table-ware, and comparatively little competition was experienced. The conditions, more especially during the past five and twenty years, have completely changed. Growing competition from France, Germany, and Sweden, with cheaper wages and superior facilities for producing medium class table-wares, has wrested much of the British trade from local manufacturers. The continental workmen have been more ready to accept the aid of mechanical applicances to save labour, while the glass-blowers in this city as well as in other centres of glass-making in the United Kingdom, have resented changes of method, and, where these were introduced, failed to give the utmost return for them.

The flint glassmakers all belong to a National Trades' Union which is powerful and useful, particularly with regard to sick and aged members. There is, however, an impression largely prevailing amongst the masters that the restrictions brought to bear upon the trade by its means hamper production and limit the individual ability of the men. The fact that there are fewer glassmakers employed throughout the kingdom at the present time than thirty years ago, while the consumption of glass has enormously increased, favours this contention.

Manufacturers have turned their attention for many years to the growing requirements of the market for all kinds of globes and shades for gas lights—both ordinary and incandescent—for duplex lamps, and for electric light. It may be said that it is in this connection the local manufacturers have excelled, and have established a reputation for variety of patterns and beauty of designs not excelled elsewhere. Much attention has also been given to making high-class colours and fancy shapes for special electric fittings, and it is worthy of note that one of the Glasgow manufacturers has made a distinct artistic success by the introduction of an art glass, manufactured from the designs of Dr. Dresser, of London, and known as the "Clutha" glass.

The decoration by *cutting* still stands *par excellence* as the highest mode of embellishing flint glass. The slower method of melting the "metal," adopted by British manufacturers in their coal furnaces, as compared with the gas furnaces almost universally in use on the Continent, has the advantage of producing a more brilliant glass. This has enabled home manufacturers to give a sparkle and finish to their cut glass which is denied to their foreign rivals, and has been the chief means of retaining the bulk of the highest class of cutting in their hands. The manufacturers of this city have not been slow to turn their attention to this branch of the trade, more particularly in connection with electrical fittings, for which many handsome and chaste designs are produced.

The *etching* process is also largely in vogue, and, by means of hydrofluoric acid, many tasteful and moderately priced patterns are introduced. Many improvements in machines for tracing the designs with needles on bees'-wax—which is used to "resist" the action of the acid—have been brought into use. The constant watchfulness of the manufacturers to utilise the latest improvements and adaptations has enabled them to keep in the forefront in the markets with new patterns; as, if price were the only consideration, the trade would inevitably pass into the hands of the cheaper German and Swedish markets.

The familiar badges and crests for hotels and ships are etched on the glass by a "white acid" process. Decoration by the engraver's copper wheels with oil and emery is still carried on, but not to the same extent as formerly, etching having largely superseded it. Sand-blasting is also used for the cheaper forms of decoration. The branch of bevelling and silvering plate-glass is carried on successfully in the city, the great extension of bevelling for all kinds of mirrors for the furnishing trade, and of glass for photograph frames, having developed a large demand. What is termed the "Brilliant" cutting on plate-glass is also produced in considerable quantities.

WHITE EARTHENWARE.

This description of ware differs from all the commoner forms of clay manufactures, in respect that the latter are made from clays practically as they are dug out of the earth, which in only a few cases go through a very simple preparatory process, whereas white earthenware is composed of carefully balanced ingredients, all of which have to pass through preparatory processes requiring some attention and care. The materials used are clays got from Dorset and Devonshire, and are known to the trade as blue and black clays. These terms are supposed to indicate their natural appearance as they are dug out of the earth—not very accurately, however, as there is only a bare suggestion of blue or black in their colour. When burnt these clays are fairly white, and may be called of the colour of cream. There is further a clay got in Cornwall, and termed china clay. It is, both in its natural state and after it is burnt, much whiter than the Dorset and Devon clays. It goes through a process of washing in Cornwall which removes from it all grit, and makes it to the touch as firm as flour, and if the clay is good in quality it has a greasy feeling. The chief ingredients of all these clays are alumina and silica. The Dorset and Devon clays are to the potter stronger clays, because they have more alumina. There is also got in Cornwall a kind of granite, known to the potter as Cornish stone. It may be noted that the china clay, above referred to, has its origin in the decomposition of this stone. This stone, as well as the clays, are brought to Glasgow in cargoes by small sailing vessels. It is brought usually in lumps exactly as it is quarried from the hillside, and is ground at the potteries in pans with water by large revolving stones. Another method of grinding is in revolving drums by means of pebbles. Sometimes the grinding is done in Cornwall, but, as a rule, potters prefer to grind it themselves. Another, and the final ingredient in the making of earthenware is flint, in the form of small boulders. These, known as chalk flints, were got out of the chalk, chiefly at Gravesend, and were brought here by sea. Latterly, however, potters have preferred what are known as boulder flints. These also came originally from the chalk cliffs, but they have been rolled about in the English Channel until all the chalk has been removed and the boulders have got a rounded smooth surface. They are thrown up on the French shore for many miles on either side of Dieppe, and large numbers of women are constantly employed gathering them. Thousands of tons are shipped to this country every month. These flints are first burnt in a kiln, to render them more brittle, and therefore easier to grind—the heat also drives off the colouring matter, leaving the flints a pure white. They are afterwards ground in the same manner as the Cornwall stone. Flints were first used because of the purity of their colour, they being whiter than any of the other ingredients. From its hardness flint may be called the bones, while the clay forms the flesh, of white earthenware. After being ground it is run into a tub, and the properly ground material is run off by a process of washing, the rougher particles, which settle at the bottom of the tub, being put back into the pans for further grinding. All these ingredients go to the making of earthenware; they are mixed in the varying proportions which each manufacturer considers best suited to the description of ware he produces. In

the commoner qualities the blue and black clay predominate, the finer qualities having more of the china clays, stone, and flint. In order to ensure their being thoroughly mixed, they are put in their fixed proportions into a mixing tub, into which water is introduced, and after being agitated for several hours the mixture becomes in appearance like thick cream, and is called slip. At this stage a small and varying quantity of oxide of cobalt is added, the object being to counteract the yellowish brown tint of the clays. It has to be well mixed through the clay. Some makers use this very sparingly. This mixture on being run from the mixing tub is passed through fine sieves, called lawns, because the finer ones are made of silk; this is done to catch any sand or grit that may still be in the clay. The mixture is then forced by pumps into presses lined with cloth, which retains the clay and allows the water to escape. The clay comes out of these presses in sheets about one inch thick. Afterwards it is passed through a pug mill, which is an iron cylinder about five feet long, having in its centre a shaft with knives attached corkscrew fashion, which force the clay in one direction, and finally out through an aperture at the other end. The object of this is to have the clay thoroughly solid and of the same consistency, otherwise articles made from it would warp in the drying.

In this connection it may be interesting to refer to the introduction of machinery as applied to the making of pottery. About the time when machinery was first successfully applied to the manufacture of textiles, one of the great inventors of the times—Arkwright, it is believed—turned his attention to clay, and produced a most ingeniously constructed machine, which received the clay at one end, and aimed at turning out the finished plate, or other article at the other. The writer saw the machine, many years ago, and is of opinion that if the inventor had possessed a better knowledge of the material he had to deal with a certain amount of success might have been achieved. It was, however, pronounced a failure. This machine was seen in a garret at a Yorkshire pottery.

The plasticity of clay is the main difficulty, and potters long held firmly to the opinion that this and some other obstacles would for ever prevent the making of pots by machinery. Within the last fifty years, however, there has been quite a revolution in this respect, and it is only fair to Glasgow to say that one of its potters, of the last generation, to a considerable extent led the way in this direction. One of the earliest improvements was the introduction of the pug mill above referred to. Previously the potter took a lump of clay—which, by the way, at that time, had the moisture driven out of it by heat, in long shallow pans and flues underneath, a process which was superseded by the clay press, referred to already—and with a brass wire cut it in half; then lifting the upper half, he dashed it on the under portion, and repeated the process until he made the clay quite solid and of equal consistency throughout. The pug mill does this at once, and much more efficiently, and relieves the working potter of what was not only a slow, but also a most laborious, process. The potter's wheel, with which every one is familiar, was then driven by hand, as were also the round disks on which plates, bowls, and other round articles were made. These are now all driven by steam power. So much progress is being still made in the application of machinery

that the potter's wheel itself—which has so long stood before the world as almost part of the potter himself, which was pictured fifty centuries ago on the tombs of the Pharaohs, and which has been in use nearly as long by the potter of the East—is rapidly disappearing. Many of the largest factories have entirely dispensed with it, and are making all the articles, previously produced on the wheel, by machinery. Of the potter's wheel it has been said—"The bending figure of the careful workman over his wheel, the wheel turner's outstretched arm, and the attentive 'taker off' made a picture that the world has looked upon with interest, not unmixed with reverence. It is still with us here and there, but the desecrating hand of the engineer has been on it, and the whir of the wheels has replaced the comparative quietness of the old potter's thrower, as the worker at the wheel was called. We are somewhat brutal with our clay." Old Omar says—

> "For I remember stopping by the way
> To watch a potter thumping his wet clay,
> And with its all obliterated tongue,
> It murmured—'gently, brother, gently, pray.'"

There was a great deal of this feeling about the old craftsmen in clay—a sort of sympathy existing between the hand and the clay. The old potter spoke of the temper of the clay, talked of humouring it, and not forcing it against its will. And this feeling exists still with the potter who is interested in his work and is a real craftsman.

While machinery has superseded a great deal of hand work, there are still many articles that can only be made "by hand." Whatever is not round (and even then if the form is not comparatively simple), is still formed by the individual craftsman, in which, however, he is aided by moulds made of plaster of Paris, which absorb part of the moisture in the clay, and thus part easily with the clay-formed article. In this department considerable skill is required, and the intelligent workman leaves on his work the impress of his individuality. The ordinary workman by the aid of the moulds is able to produce his work in quantity without much carefulness in the finish; but even in the quantity produced, the interested workman, from his closer application, can usually excel those who in their work make their standard simply what will pass. These tradesmen are called hollow-ware pressers. In making, for example, a soup tureen the working potter beats out on a plaster block with a plaster mallet, called a batter, a piece of clay to the thickness required for one of the sides (this cake of clay is called a bat); he fits this into the mould; then the same process is gone through for the other side of the tureen, and also for the foot or bottom. These three moulds, with the clay in them, are then joined together. At the joinings the potter puts small rolls of clay, and with his hand works these in to join the pieces and make the body of the tureen. He uses a sponge to smooth the joining and to make it solid. The cover, handles, etc., he deals with in similar fashion. The moulds are then passed into a hot chamber, and as the moisture leaves the clay it contracts, loosening its hold on the mould, and is taken out ready for the process of burning. In the making of simple articles, such as plates, cups, bowls, etc., the mould is in one piece, and forms the face of the plate. A tool of clay or iron has the

form of the back of the plate, and as the mould revolves on a disk the tool, which is attached to a lever, is brought down on the clay placed in the mould, and the plate is made. The cake of clay to be put in the mould is formed on a revolving disk; the potter puts on it a piece of clay, and while he is making a plate a lever comes down automatically and presses this clay to the desired thickness.

The making of these moulds is a trade apart from that of the potter. Besides the mould-maker there is also the modeller, and in most potteries of any extent he is much more than an ordinary tradesman. He has had some artistic training, especially in the beauty of form, and he must possess some creative or designing power in bringing out new shapes. His models are always made in clay. When an article, such as a tureen, has handles, or knobs, or covers, these are all made separately. After the modeller has completed his work he passes it on to the mould maker. His first act is to take plaster casts from the model, not of the whole, but of the separate parts that the potter can make in one mould. A soup tureen requires a mould for each side, a mould for the foot or bottom, another for the cover, also separate moulds for the handles and the knobs. After he has done this he makes plaster blocks of these separated pieces, and from these the working moulds are cast. This is done by making a clay well round the block, leaving a space sufficient for the thickness of the mould. Into this space liquid plaster is poured which sets almost immediately.

After the potter has completed the forming of his wares, the important process of burning or firing takes place. Before this the moisture is thoroughly abstracted in apartments treated by steam—until quite recently this was done by flues and stoves with ordinary coal fires. The kilns or ovens in which the ware is burnt are not radically different from those in use during the greater part of last century, but various improvements in details have latterly been adopted. The kilns have gradually increased in dimensions, both in width and height; the fireplaces, of which there are about ten in each kiln, have been much altered and improved, with the result that much less fuel is now required, the heat being more thoroughly utilised before leaving the kiln. The ware is twice under fire—first, it goes into what are termed biscuit kilns, and after it passes through these kilns it is called biscuit ware. It undergoes the greatest heat here, and is thoroughly baked or hardened. It may be remarked that at no previous time was ware so thoroughly baked as it is by the principal potters of the present day. These biscuit kilns are continuously under fire for about fifty hours, and the fireman is a skilled man, as it is of the utmost importance that the ware should be solidly baked, not having only a hard skin, but being equally hard to the very centre, though not overdone. It is also essential that every part of the kiln should, as nearly as possible, be equally heated throughout.

It may be explained that the ware before being put into the kilns, both biscuit and glost (the latter, the second firing, will be referred to later), is placed in seggars. These are made of fire clay and are usually oval in form, about 20 inches long by 15 inches broad, and of height varying from about 6 to 16 inches. They are built up on each other inside the kiln until it is absolutely filled from floor to crown. The heat plays round them, but they pro-

tect the ware from the direct action of the heat. Indeed, in the glost kilns, each seggar has placed on its upper rim a thin roll of soft clay, so that the one placed above presses on this clay and hermetically seals up the ware from any direct action of the fires. The inside of the seggar used in the glost kiln is washed with glaze to prevent it drawing away any of the glaze from the articles placed in it. In the biscuit kilns sand is also used inside the seggars: the ware rests upon it, and, being a yielding body, it permits of the ware contracting regularly all over as the heat is operating on it. In the glost kiln each piece has to be kept separate, otherwise, as the glaze fused, the ware in a seggar would become a solid mass. Various ingenious methods are used to prevent this, and, at the same time, to have the seggars well filled. A number of sharp pointed articles enables this to be fairly well accomplished. The public, however, are becoming very fastidious about even the smallest marks, and amongst other expedients to reduce these marks is one whereby plates can be built up in the seggar and yet leave no mark whatever on the face.

In ordinary wares most of the decorations are put on the ware in the biscuit state. While it is hard it yet possesses a certain porosity which enables it to receive and to hold colours. Copper plates, having the patterns engraved on them, are the principal mediums of decoration. The pattern is printed from the copper plate to a special kind of tissue paper, this paper is placed on the ware, and by means of flannel rubbers the colour is rubbed into the ware, the paper being afterwards floated off in water. This ware has to pass through a small kiln called a muffle, in order to burn the oil used with the colour in printing, otherwise it would not receive the glaze. Simple patterns are also painted on with the brush. The term "Persian" is much used in connection with these painted patterns, but they are not at all after any designs seen on Persian ware, beyond that the principal colours used are red, blue, and green. Ware has simple bands or lines also placed on it at this stage. An easy and interesting process of decoration is also done on biscuit ware by means of patterns cut out on the roots of sponge. The sponge is dipped in colour and then brought in contact with the ware, leaving a stamp of the pattern, and this is repeated probably a dozen times with one supply of colour in the sponge. Hence it is by far the cheapest style, and yet it is often very effective in its colouring. This style is not confined to Scotland, although it probably had its origin here and certainly is more widely practised in this country than elsewhere.

The ware on being decorated is ready for glazing, that is, receiving the glossy surface, which is really a thin film of a special kind of glass adapted to the purpose, varying to some extent according to the composition of the clay. Borax is the principal ingredient. It is fused in a special furnace, called a fritt kiln, and when it comes out of this kiln the material is called fritt. The fritt is ground in large circular pans, similar to those used for grinding stone and flint, and it takes several days to reduce it to sufficient fineness for use. There are added to this fritt in the pan quantities of flint and china stone, and sometimes small quantities of china clay, etc. When it is run off the pan it passes through very fine silk lawns or sieves, and is then run into tubs. The biscuit ware is dipped into these tubs, and takes on and holds

a sufficient coating which, when fused in the glost kiln, gives it a fine glossy surface. After the moisture is driven out the ware is ready to be put into the glost kiln. The object to be gained there is the thorough fusion of the glaze. The process of burning in these kilns differs from that of the biscuit kiln; the latter gathers heat slowly to get the thorough baking, whereas in the glost kilns the heat, being required solely to fuse the glaze, may be as rapid as possible, provided always the fireman so regulates the heat that it pervades the kiln evenly throughout. The progress must be continuous, as serious results may follow on a kiln being allowed to fall in temperature. Damage results from either too great heat or the reverse. The fireman must therefore have a thorough knowledge of heat as it operates in his kilns. At various times efforts have been made to use continuous kilns, also to utilise the spent heat in various ways, but no real success has hitherto attended these efforts. Many years ago a Glasgow potter made experiments with gas as the heating medium, and obtained a certain measure of success, although not sufficient to encourage him to persevere.

The ware on being got out of the glost kiln is ready for the market. Most of the finer decorations, however, are placed above the glaze, including all the good hand painting and artistic decorations as well as all the gilding. The gold used on really good ware is pure gold, and costs about £4 per ounce. In some cases a certain amount of alloy is used, and in recent years a cheaper gold has been extensively used for the cheaper wares. It is called liquid or glanz gold, and is produced chiefly in Germany, but the use of it in this country is growing rapidly. The colours used are called enamels, and these as well as the gold are burnt on in a muffle.

This white earthenware has been made in Glasgow and neighbourhood for over a century. A tradition exists, believed to be true by those most likely to know, that more than one small pottery existed in Glasgow during the greater part of the eighteenth century, but nothing very definite is known about it. Towards the end of that century a pottery was erected in Lancefield Street. The business there created was transferred early in the nineteenth century to the **Verreville Pottery**, still existing in Finnieston Street. This factory, as the name indicates, was built originally as a glasswork. These works at some period of their history, not only produced the ordinary white and decorated wares for table use, which they still continue to do, but also manufactured considerable quantities of fine china and ornamental ware of a distinctive character. This had real artistic merit, and for a time commanded high prices. Later on in the century the **Glasgow Pottery** was established. It is still being carried on, and besides producing in quantity the ordinary household ware, it has made a speciality of what is known as sanitary ware. This trade, which began by making closet basins and plug basins, has in recent years spread out into multifarious articles, some of which are ornamented with quite expensive decorations. This pottery at one period of its history also made excellent china, which had a very good name in the market. It was found, however, in both instances that it is difficult to have china and earthenware in the same factory. About the middle of the century the **Britannia Pottery** was established at St. Rollox. To a considerable

extent the same class of wares is made here as in the potteries already mentioned. Besides this, it has from its commencement done a large business in North and South America, having always given special attention to the requirements of these markets. Until recent years the class of goods chiefly in demand there was a pure white ware called granite, made in imitation of the heavy white porcelain so long produced in France. But this has had its day, and it is now superseded by decorated ware. The patterns or designs called for by the Americans are of a slight nature, and may be said to be more dainty than what are regularly in demand in the home market. At these works attention is also given to other foreign markets besides those of America and our Colonies. There are one or two other potteries in Glasgow and neighbourhood, all of which including those above named, do a good business in the home market. Some of them have an excellent connection in Ireland, and also in those parts of England which have direct water communication with Glasgow.

Earthenware has always been a feature in the shipments to foreign countries from the Clyde. It is a bulky article, and as the staple products of Glasgow are heavy, the lighter pottery ware forms a very useful part of a ship's cargo. The Glasgow potter puts his wares alongside the ship free of charge, which is a great advantage to the merchant. He finds when he buys in England that he has almost invariably inland carriage to pay. As ships go to every part of the world from Glasgow, its earthenware finds its way into almost every market, and is known all over the globe. So varied an experience has naturally led the Glasgow potter to introduce a great variety both in the form and method of the decoration of wares.

It may be of interest to know that the potter does his part in connection with the great industry of shipbuilding by supplying many of the ships built here with crockery which is so necessary a part of the equipment of every passenger steamer. Large quantities of goods are made for steamship companies (having special badges and patterns indicating the companies for which this ware is produced), and also for hotels.

Amongst the numerous changes which have come about during the last twenty years, not the least notable is the increased variety in shapes, in designs, and styles of decoration which the potter is compelled to produce. In former times he was content to work away year after year at the same things, and with the old patterns and shapes. The dealer resented any attempt at novelty, because it was so much easier for him to manage his business by simply keeping up stocks of his old things; favourite styles have in this way been known to run continuously for over half a century. Indeed he was to some extent forced to do this by his customers always matching their sets. Now all this is changed. The public demand novelty; above all, they demand more artistic articles. The old custom of getting expensive dinner or tea sets, which were to last a lifetime or longer, has practically passed away. These expensive sets were then only used on special occasions, but now people use their best, and often their only, sets for daily family use. Consequently, they buy less expensive sets, and instead of matching these as formerly, a new set is by and by called for, which, if not an improvement, must be at least

something different from what they had previously. This has created a new department—that of pattern designing—in all potteries of any extent, and potters at least believe that the styles of the present day are an immense improvement on the old, and that in this trade there is a steady progress in the production of more artistic wares. Especially is this the case with moderately priced goods, which in the old days were much more commonplace in style. Of course, it goes without saying that much of the old costly ware is artistically really excellent, but it was very dear in comparison with present prices.

STONEWARE.

The stoneware branch of the pottery trade is in a flourishing condition. There are five manufactories in Glasgow and neighbourhood, and two in Portobello. They employ about eighty throwers, besides machines for making jam jars, etc. The clay used all comes from Devonshire, and the annual import of it to Glasgow is nearly 20,000 tons. Home consumpt of bottles, etc., alone is large, but there is also an extensive export business, which continues to increase yearly. The stoneware branch of pottery in Scotland is an old-established one, one at least of the manufactories having been established early last century. The firms are all amalgamated under the Potters' Federation, Ltd., to regulate prices, wages, and other important points which turn up from time to time, but at the same time every firm conducts its own business as previously.

FIRE BRICK AND FIRE CLAY.

Extensive deposits of fire clay exist in Lanarkshire. These were worked to a small extent in making very moderate quantities of fire brick until well on in the early part of last century, when the extensive fields in the neighbourhood of Garnkirk and Glenboig were discovered. The fire clay is got here at no great depth, and the seams are specially thick. It is in these districts that the trade has had its greatest development. From very small beginnings the making of fire bricks grew alongside the iron and steel trades, and latterly has become the great industry which makes it so prominent a feature in the West of Scotland.

The fire clays in the neighbourhood of Glasgow are situated geologically in the upper coal series and limestone series. They are found at all depths, from the surface open-cast workings to pits 40 or 50 fathoms. The workable seams vary in thickness from about 3 feet to 30 or 40 feet. The process of fire brick making is pretty much the same all over the West of Scotland. For precision, we will briefly follow the process as applied at the Glenboig works. The clay is there found 113 feet deep, and varies in thickness from 6 to 9 feet. In descending the shaft, we pass through from 12 to 20 feet of floating whinstone, which covers a considerable part of the Glenboig district; under this are numerous beds of fire clay and siliceous rocks, some of them almost pure silica. The system of mining is what is called stoop-and-room. The workings are 12 feet wide, and the stoops left in are 30 feet square, excepting at the pit bottom, where they are much larger. The stoops may be cut through, and when the proper time comes removed altogether. The clay in its natural state is very hard, and requires to be blown down with gunpowder. The average daily output

of each man is from 4 to 5 tons, according to the thickness or the hardness of the clay. The clay is sent out in pieces about the size of ordinary coal. It is raised to a high pithead platform, whence it is run either to the crushing mill direct or to the bing, where it is exposed to the action of the weather.

In bricks for general furnace purposes a close texture is not required. The brick must have sufficient flour in it to give it toughness and strength so that it may bear the rough shunting of our railways, and the careless treatment which fire bricks too often receive in shipping and trans-shipping. But when that is accomplished, they are made as rough and open in the grain as possible, that they may be the better able to resist high and variable temperatures.

The crushing and milling are effected by means of revolving pans, in which heavy iron-edge rollers run. The clay is first broken with hammers and shovelled into the crushing mill, the bottom of which has perforations through which the clay is crushed. Scrapers attached to the pan beneath throw it into an iron box, whence it is lifted by means of an endless chain fitted with elevator buckets, and delivered into a cylindrical riddle 8 feet long and 2½ feet in diameter. This is so placed that the riddled clay drops to a second set of elevators, while the pieces too large to pass through drop back into the crushing mill. The second set of elevators has two duties to perform—it either sends the fine-ground fire clay, which is used as mortar in furnace building, to an endless belt, which carries it to the waggons on the railway outside, or the rougher brick clay to the tempering pans by means of a box 60 feet long placed overhead. In this box there is a travelling chain fitted with clots, by means of which the clay is dragged along. In the bottom of the box are holes to which conductors are attached, one to each mill. These, from their position, are always kept full, and when the millman requires clay he has only to draw a sluice at the lower end of the conductor and the clay drops into the pan. He then turns on the water, and the mill is charged in a second or two. For mortar clay, a fine riddle is used, and for brick clay one of larger mesh. In preparing clay for glass house blocks, gas retorts, Bessemer tuyeres, and all large articles, a proportion of previously burnt bricks or clay is added, to prevent cracking in the drying and burning. Dry mills are generally employed for tempering when the clay is of a soft aluminous nature, but they are not suitable for hard, gritty, siliceous clays. When ready for moulding, the clay is discharged into small tipping bogeys, which are raised by means of a steam hoist to the upper floor of the drying store. It is there run along a little railway, whence it is dropped down through suitable openings to the moulders' benches. By this method one man delivers the clay to nine or ten moulders. It has also the advantage of taking the traffic off the drying floor. Once in the moulders' hands, the clay is rapidly turned into bricks. A good workman, with his carrier, will make 2500 bricks a day. Solid brass moulds are used for regular sizes, but for the larger sizes wooden moulds are employed. Iron, zinc, and glass have been tried, but hard brass has many advantages. The moulds are made one-twelfth larger than the size of the burnt brick, to allow for shrinkage. The face board on which the brick is made is covered with thick "plaiding," and the trade mark is fixed upon it, so that making and stamping are performed in one operation. No machine has yet been made capable of taking well-milled fire clay as it leaves the pans, turning it rapidly into bricks, and delivering them, square and sharp-edged, on the

pallet-boards. When the brick is moulded by hand, the moulder discharges it on to a pallet board; the carrier then places another board on the top of it, and between the two the soft brick is carried with safety and deposited on edge on the stove floor, where it remains till it is hard and ready for the kiln. The defects most common in fire brick (with the exception of soft burning) are produced in the stove, and it is here alone that soundness and finish can be given to them. If the stove floor is uneven, the shape of the brick is spoiled, and if too much heat is applied the bricks are warped and cracked. Some clays are very liable to crack when too quickly dried, and where stoves are badly constructed this occasions loss and injures the quality of the brick to a serious extent. Bricks of this description give also increased breakage in the kiln and, indeed, in every stage of their existence. To meet all this, a patented construction of stove is employed at Glenboig. The stoves are 120 feet in length by 36 feet wide, and are fired from one end. The drying floors are entirely formed with cast-iron plates, each 4 feet by 2 feet by ¼ of an inch. These are smooth and easily heated. Underneath the iron floor there is another, formed of fire-clay slabs, about 3 inches thick, which run from the furnace end to the middle of the stove, a distance of 60 feet. The fires and hot flues are underneath the fire-clay slabs, and between the fire-clay slabs and the iron plates forming the upper floor there is an air space 8 inches deep. This communicates with the outer air at the gable over the fires. Each flue has its own air space. By this means the stove may be fired up so as to heat effectually the back end, while too much heat in the furnace end is prevented by the current of cold air passing between the two floors. The air so admitted joins the lower flue at the middle of the stove, carrying with it the superfluous heat at the furnace end, and utilising it where it is required. Each stove of the dimensions named turns out 24,000 bricks a day. Every brick is ready for the kiln the day after it is moulded. By this system of drying the cost is lessened, while the production for a given space is nearly doubled and the quality much improved. Various methods have been tried, such as exhaust steam in pipes or flues, and hot air in a variety of ways. The method just described gives steady night and day drying, as it is not dependent on the boiler being off or on, and is in every respect to be preferred, particularly where large production and perfect regularity are required. When dry, the bricks are wheeled to the kilns. The firing is done very gently at first. This is continued for two days, till the damp is completely steamed out of them. The kiln is then put on full fire, which is kept up for about two days, during which a bright white heat is steadily arrived at, this being maintained till the sink in the bricks has taken place, when the firing ceases and the kiln gradually cools down.

The making of a fire brick is like the making of a pin—the article looks a simple one, yet the process is complex and somewhat elaborate. In no process is close and continued attention more essential if the best results are to be obtained. As in scientific investigation, the smallest gleam of truth has its value and its place, so in the workshop every ascertained fact has its value also, and if it gets its place it will bring its reward in the general result.

A brick rich in silica, yet containing a fair proportion of alumina, and comparatively free from alkalis and other impurities, is the one which combines in the highest degree infusibility and freedom from splitting, and is consequently found to be best suited for the greatest number of the most

important furnace purposes, such as puddling, rolling mill and forge furnaces, gas retorts, etc., where the great desideratum is the combination of these qualities. The following is the analysis of a Glenboig brick by Sir Frederick Abel, F.R.S., taken from the stock as used at the Royal Arsenal, Woolwich:—

Silica,	62·50
Aluminium,	34·00
Iron per oxide,	2·70
Alkalis loss, etc.,	0·80

Two clays might be found giving a similar analysis which would yet produce very different fire bricks. In this very analysis we have a case in point. The silica and alumina are largely combined as a silicate of alumina, and this is much to be preferred to a clay possessing the same proportions of these substances but not chemically combined.

It is not surprising, therefore, that these bricks are extensively used at home, and that their use has spread to England, gradually over Europe, and latterly, it may be said, to almost every part of the globe. Wherever they have gone they have made for themselves a reputation and a market which grows from year to year.

Many other articles are made from this fire clay, notably gas retorts made in one piece, and also blocks for built gas retorts. Sewage pipes are also made in great quantities and of all dimensions, and as sewage works are now being constructed in many lands these pipes are being regularly shipped to many foreign countries. Attention is also given to the requirements for special furnaces, such as glass-works, where large blocks of varying size and shape are required. The manufacture of bricks with a white glazed surface is another branch of the trade which is rapidly developing here. These are being increasingly used for facing walls in back courts, underground railway stations, etc. Several makers are giving special attention to the development of this branch.

It is interesting to know that in this connection several of the fire clay makers in the West of Scotland are working at sanitary ware, not only at articles of a coarse description, such as sinks, troughs, urinals for railway stations, etc., but also at what may be considered as the better articles, such as water-closet pans, wash-hand basins, etc. This branch is already of considerable dimensions, and, like the other branches, it is expanding with rapid strides. Chimney cans in greatly varying shapes and sizes, roof ridges, copings of walls, bottoms for sewers, vases, and other ornamental articles for use in gardens, the forms of some of which are admittedly fine, and claim to have artistic merit, are likewise made. There are other things which all show how this manufacture—starting with fire bricks, which still are its backbone—is spreading out to most varied productions.

One or two of the makers show vases and other ornamental articles for garden use, and the forms of some of them are undoubtedly good and artistic.

This brief reference—which is far from being exhaustive—to the varied nature of the fire-clay trade gives some idea of its great development. The manufacture stands out as one of the most growing industries of the district, and is carried on with great enterprise.

Skill is displayed in the methods and processes of manufacture, and the business is pushed with energy in every part of the world.

Before concluding, reference must be made to a patent kiln invented by Mr. Dunnachie, the well-known managing director of the largest fire-clay works in the district. It is known as the regenerative gas kiln or oven. Whilst its main feature is the use of gas as the heating agent, it is also to some extent of the nature of a continuous kiln or oven—the heat from the kiln directly fired being carried into the next, while the air for combustion is passed through the one that had previously been fired, thus coming into contact with the gas at a high temperature. It has been in use for a good many years, and its success has long been established in this country and elsewhere, notably in America. It not only does the work well by producing thoroughly burnt bricks, but is far more economical than the ordinary method of burning fire bricks.

At least one firm gives special attention to what are known as adamantine bricks, etc. These are exceptionally hard. They are used for the paving of railway stations, stables, etc., and are of special value for the foundation of tall chimneys and other erections, as they are able to bear almost any pressure from the superincumbent material. The trade employs quite an army of workmen, and its production is enormous, the quantities sent out from Glasgow being a feature in the shipping trade of the city. Moreover, it is a trade which seems to have no bounds to its rapid growth, which has now continued for so many years.

TOBACCO CLAY PIPES.

While the manufacture of tobacco clay pipes is carried on in various parts of the three kingdoms, the city of Glasgow, although not so long engaged at the manufacture as Derbyshire or Shropshire, has, since the beginning of last century, been the chief seat of the industry. Pipe clay, from which tobacco clay pipes are made, is got from open mines in South Devonshire, around Kingsteighton. It is aluminous, as opposed to siliceous, clay. The latter is used in the manufacture of stoneware. The pipe clay, being aluminous, is very plastic. It is brought round to Glasgow by sea. Something approaching 2000 tons is used annually, and about 600 people are employed. The most interesting place in connection with this peculiar industry is the factory of Messrs. M'Dougall & Co., in Charles Street, by far the largest in the city. In this one place are made more than four hundred different patterns of pipes. The pipe chiefly made in Glasgow is the short or "cutty" pipe, averaging about 7 inches long. Only a small portion of these pipes is taken up in the home market. Glasgow pipes are known to, and used by, white people, as well as our dusky brothers, all over the world, our colonies and the United States being the largest and steadiest markets. The firm above named have a very ingenious little kiln which they use for glazing the mouthpieces of pipes.

All clay tobacco pipes are made by hand. Machinery has been tried over and over again, and thousands of pounds have been spent to make it a commercial success, but all to no purpose. It is the old question of the clay in the hands of the potter, and nothing has yet been invented to supersede this method in the making of tobacco pipes. Pipe making is one of the most interesting of the side trades of Glasgow, and

contributes its quota towards maintaining the name Glasgow has acquired for the variety and number of its industries.

COMMON BUILDING BRICKS.

Around Glasgow there exist extensive beds of good clay for brick making. In many instances these are not exhausted by the brick maker before the builder comes on the scene and drives him off. But the brick maker only moves further afield, and on fresh ground resumes his operations, so that now, in almost every direction around the city, the familiar brickfield is to be seen. Owing to the abundance of stone in the West of Scotland, bricks have been little used in the erection of dwellings, except in the building of partitions and, to a greater extent, of gables and back walls. They are, however, extensively used in the erection of workshops and factories of every kind. The clay, being well adapted for the purpose, makes excellent bricks, and factories are constructed in which practically no stone whatever is used, the bricks, when well burned, being exceptionally strong and solid. There are somewhere approaching forty millions of these bricks made in the neighbourhood of Glasgow annually, and the great bulk of these is used in the city and neighbourhood. There are fully one thousand men employed. These bricks are largely used in the erection of factory chimneys; indeed all such chimneys are built with this material in this quarter, and carefully burnt bricks are excellently adapted for the purpose, being well able to carry any weight that may be placed upon them. Formerly these common bricks were all made by hand, and as they were dried outside, brick making only continued during the summer months, the clay being prepared during the winter. But years ago some makers turned their attention to the possibility of making bricks by the aid of machinery, and ultimately with entire success. The machinery then adopted is still in use in this district, and is said to have been the forerunner of all such machines. These machines, combined with the adoption of drying sheds heated by steam and the use of the pug mill for preparing the clay, enables brick making to go steadily on throughout the whole year. As the city extends, there is also a natural increase in the number of bricks used.

Some ten years ago the interesting discovery was made that the great heaps of "blaise" which accumulate around ironstone pit banks, and which so frequently formed part of the landscape around Glasgow, could be turned into building bricks at very moderate expense, as a certain portion of this material was partly combustible, and aided in the burning of the bricks. This material not being plastic, the process of making differs from that used for bricks made of clay. It is crushed into a powder, then it is placed in moulds, and the brick is formed under very considerable pressure. These bricks are burned in kilns constructed after the Hoffman plan. In exposed situations bricks of clay are preferable, as it is thought they better resist the action of the weather; but these "blaise" bricks are used chiefly for inside partitions, gable walls, etc., and other places where there is no excessive pressure or exposure, and as they are cheap they are used somewhat extensively. Both of these branches of brick making have fully participated in the prosperity which has been enjoyed for several years in the building trade of the district.

MUNICIPAL ENTERPRISES,

BY

The Hon. SAMUEL CHISHOLM, LL.D.,

Lord Provost of the City of Glasgow, and Lord-Lieutenant of the County of the City of Glasgow.

MUNICIPAL ENTERPRISES.

INTRODUCTION.

The years that have elapsed since the last visit of the British Association to Glasgow have not been more distinguished for their commercial prosperity and for the advances they have witnessed in scientific discoveries than they have been for the striking growth in municipal government and the extension of municipal enterprises. The cities of the land have grown, actually and relatively. They are larger in themselves, and they bear an immensely larger proportion to the entire population of the country. Police burghs have sprung up in multitudes of "populous places," while even remote villages and hamlets have been brought under the control of the popularly elected County Council. There has been developed over all the land an increased spirit of municipal interest and activity.

In all these respects Glasgow fully shares the characteristics of the time. When the British Association visited Glasgow in 1876 the population of the city was 510,000. To-day it stands at 760,000. If we include the population which clusters around its municipal boundaries, and which is but the surge of its advancing tide, the number is 910,000.

But mere growth in size is a petty boast, and if that were all Glasgow had to show for herself during the last twenty-five years, it would be pitiful indeed. But the extension of her area; the growth of her population; the deepening and the broadening of the Clyde (her great highway to the sea); the marvellous extension of inter-city railway communication; all these things have been accompanied by a growth in civic spirit and an enlarged activity in what may be called municipal welldoing, which have produced great and beneficent results.

Twenty-five years ago the acreage of the public parks in the city was 370. To-day it is no less than 1055, while open spaces and children's playgrounds, provided by the Health Department, number 19, and are scattered over every part of the city.

Twenty-five years ago there clustered around the Cross a multitude of narrow streets, dismal lanes, and filthy closes, where disease and death held high carnival, and vice and crime lifted their heads unabashed. In the exercise of powers obtained by special Acts of Parliament the larger portion of this entire district has been reconstructed, while the remainder is in the course of being dealt with, so that now, instead of narrow and stifling lanes, we have the light and air of heaven playing freely along broad and cheerful streets. The result of these varied operations has been not only a great improvement in the external appearance of the

city, and an equally great improvement in the general comfort and well-being of the community, but the death-rate over the city, which in 1876 was 27·4, is now 21·1, and in this central district the rate has been reduced from 40 to 30 per thousand.

The multiplication of the channels of municipal enterprise during the period referred to has been not a little noteworthy. At its commencement water and gas had already been brought under municipal control, but these added to the management of the Common Good and of the few parks which Glasgow then possessed, and the ordinary police administration of the city, might be said to sum up its municipal duties. Since then, however, such additions as the following have been made. The provision of houses for the poor has been definitely added to the work of the Improvement Trust, and is now, indeed, perhaps its most important function. The tramways have been municipalised, as has also the supply of electric light, together with water for hydraulic power. The Telephone Committee addresses itself to the task of supplying the citizens with cheap and efficient telephonic communication. In 1876 there was no municipal library, Mr. Stephen Mitchell's generous bequest of a library having been too recent to enable the citizens to take advantage of it till 1877, but to-day the committee has not only under its charge the Mitchell Library, with its thousands of readers, but is engaged in drawing up a scheme for district libraries to embrace all parts of the city, Mr. Carnegie's munificent gift of £100,000 enabling it to provide buildings, leaving a rating power up to a penny per £ to secure equipment and maintenance.

The Bazaar Committee provides concerts on Saturday afternoons for six months of the year in various parts of the city, and the citizens in their thousands crowd their own halls to spend an hour or two in rational and healthful enjoyment. The Parks and Galleries Committee has now a gallery which uniform testimony asserts to be second to none in the United Kingdom, and which has cost a quarter of a million sterling, and now forms perhaps the most attractive feature in the great International Exhibition. It will be the duty and privilege of this committee, when the Exhibition is over, so to occupy the gallery with permanent and loan collections as shall enable it to minister to the enjoyment and improvement of the entire body of the people.

Such is a rapid summary of the leading enterprises of the city of Glasgow, further details of which are appended hereto. I hope the members and friends of the British Association and all visitors to our city during its session will find some feature of interest in one or other of our civic schemes, and if in any way I can guide or assist any student of municipal institutions who wishes to inquire more fully into the details of our work it will be to me a pleasure to be able to do so.

SAMUEL CHISHOLM, *Lord Provost.*

WATER DEPARTMENT.

In 1855, the Lord Provost, Magistrates, and Council of Glasgow obtained power, as Water Commissioners, to acquire the works of the Glasgow Water Company and the Gorbals Gravitation Water Company, and to construct new works for bringing a plentiful supply of pure water to the city and surrounding districts, from Loch Katrine, in the Perthshire Highlands, a distance of 34½ miles.

Loch Katrine Works.—There are now two lines of aqueduct for conveying the water from Loch Katrine to Glasgow. One was constructed under the Act of 1855, and was designed and carried out by the late Mr. J. F. La Trobe Bateman, M.Inst.C.E.; the other was constructed under an Act of 1885, and was designed and carried out by Mr. James M. Gale, M.Inst.C.E., the engineer to the Corporation Water Department.

By the Act of 1855, power was taken (1) to raise Loch Katrine 4 feet above its previous summer level, and to draw it down 3 feet below its previous summer level, making 7 feet in depth to which the loch could be drawn upon; (2) to take 50,000,000 gallons of water per day for the supply of the city and suburbs; (3) to construct a line of aqueduct and a service reservoir; and (4) to utilise the waters of Lochs Vennachar and Drunkie as compensation water to the river Teith.

By the Act of 1885, power was taken (1) to raise Loch Katrine other 5 feet, making 12 feet in all that may be drawn upon for the supply to the city; (2) to take a further 60,000,000 gallons of water per day for the supply of the city and suburbs; (3) to construct a duplicate line of aqueduct and service reservoir, with lines of pipes to the city; and (4) to raise Loch Arklet 25 feet above its present level, and lead the water from this loch into Loch Katrine by a tunnel.

The Aqueducts.—The first aqueduct from Loch Katrine to the service reservoir at Milngavie is 25¾ miles in length. It is 8 feet wide by 8 feet high, with arched roof, and is capable of discharging 40,000,000 gallons per day. The second aqueduct, which runs almost parallel to the first all the way from the loch to the service reservoirs, is 23½ miles in length. It is 12 feet wide by 9 feet high, with arched roof, where not lined with concrete, and 10 feet wide by 9 feet high, with arched roof, where lined with concrete, and is capable of discharging 70,000,000 gallons per day. The two aqueducts, taken together, are capable of discharging 110,000,000 gallons per day into the two service reservoirs, which are distant about 7 miles from the city. This quantity of water would fill a canal 30 feet wide and 6 feet deep for 19 miles.

The Service Reservoirs.—The Mugdock Reservoir has a water surface of 62 acres and a capacity of 500,000,000 gallons. The Craigmaddie Reservoir has a water surface of 88 acres and a capacity of 700,000,000 gallons. Combined, these two reservoirs contain 24 days' supply at the rate of 50,000,000 gallons per day. Six lines of 36-inch main pipes convey the water from the reservoirs to Glasgow, viz., four from Mugdock Reservoir and two from Craigmaddie Reservoir.

The water from Loch Katrine undergoes no filtration, being merely strained through fine wire gauze netting to prevent sticks, leaves, etc., from passing into the pipes. In order that the water might be kept free from pollution, the feuing rights over the whole drainage area of Loch Katrine and Loch Arklet, extending to 26,295 acres, were, in 1892, pur-

chased by the Corporation at a cost of £17,000, and the owners of the lands within that area are prohibited from erecting any houses or buildings on any part of those lands.

Gorbals Works.—The Gorbals Works are situated about eight miles to the south-west of Glasgow. They were constructed in 1847 and 1848, and were acquired by the Water Commissioners, as formerly stated, under the Act of 1855.

The supply is drawn from a stream called the Brockburn, a tributary of the White Cart. The water is collected into four artificial reservoirs, covering 226 acres, and the amount of water drawn (excluding compensation water) is about 4½ million gallons per day.

The water in the Gorbals Reservoirs is not so pure as Loch Katrine water, and is therefore filtered by passing through 4½ feet of filtering material, consisting mainly of Arran sand and gravel.

The water is supplied to some of the outskirts of Glasgow on the south side of the river, and is conveyed from the works by a 24-inch main pipe.

Hydraulic Power Supply.—The Hydraulic Power Works are situated at the top of High Street. They were erected a few years ago for the purpose of supplying high-pressure water for power purposes. This branch of the work is in its infancy, but it supplies a felt want, and has already been taken advantage of to a considerable extent in working hoists, hydraulic presses, and other machinery. The plant consists of four large Lancashire boilers with economisers, three sets of pumping engines of 200 horse power each, and two accumulators. Each of the pumping engines will pump 250 gallons of water per minute against an accumulator pressure of 1120 lbs., and this with a steam pressure of 150 lbs. The engines work independently, and deliver the water into either of the four 7-inch main pipes. About 17 miles of special pipes for this high-pressure water have been laid in the streets of the city, and the cost of the works has been upwards of £113,000. The quantity of water supplied during the year 1900-1901 was 125,788 gallons per day, and the revenue received was £8255.

River Supply Works.—The River Supply Works were erected in 1876 and 1877 on the lands of Westthorn, situated about two and a half miles above Glasgow Bridge, to supply the millowners and others along the banks of the river Clyde with water pumped from the river, and were rendered necessary in consequence of the removal of the weir. The machinery consists of two pairs of compound tandem horizontal engines of about 100 horse power each, with double acting pumps, and four Lancashire boilers with economiser and feed pumps. Each engine is capable of pumping 200,000 gallons of water per hour into reservoirs, which are about 60 feet above the level of the river. The average quantity of water pumped during the year 1900-1901 was 2,543,871 gallons per day. The cost of the works has been £102,281, and the revenue drawn is £3500 per annum.

Finance.—In 1857 the capital account of the Water Department (including £525,380, being the share capital of the old companies) was £752,693, and in 1901 it amounted to £3,907,577.

Revenue, exclusive of Hydraulic Power Works and River Supply Works—

In 1859-60, when the Loch Katrine water was introduced, the revenue was - -	£71,449 per annum.
In 1869-70, with reduced rates - - -	111,486 ,,

In 1879-80, with rates further reduced -	-	£138,993 per annum.
In 1889-90 ,, ,,	-	171,256 ,,
In 1900-01 ,, ,,	-	204,716 ,,

Within the municipality of Glasgow, on the north side of the river Clyde, where the power of rating is unlimited, the domestic rate

In 1856-57 was - - - - -	1s. 2d. per £ on rental.
In 1862-63 and 1863-64 - - - -	1s. 4d. ,,
In 1864-65 - - - - - -	1s. 2d. ,,
In 1865-66 to 1869-70 - - - -	1s. ,,
In 1870-71 - - - - - -	9d. ,,
In 1871-72 to 1886-87 - - - -	8d. ,,
In 1887-88 to 1889-90 - - - -	7d. ,,
In 1890-91 to 1898-99 - - - -	6d. ,,
In 1899-1900 to 1901-02 - - -	5d. ,,

Within the municipality on the south side of the river Clyde, where the domestic rate is restricted to 1s. per £, the rates levied have been—In 1856-57 to 1869-70, 1s. per £ on rental; in 1870-71, 9d. per £ on rental; and since 1871 the same rate as on the north side of the river. In addition, a public water rate of 1d. per £, payable by the owner, is levied on all property within the municipality.

Beyond the municipality the domestic rates have been reduced from 1s. 2d. and 1s. to 10d. per £ on rental.

Water rates have been reduced from a sliding scale, beginning at 1s. per 1000 gallons in 1861-62, to a present uniform charge of 4d. per 1000 gallons, minimum charge £2 per annum; charges for shops, warehouses, etc., private taps, from 5s. to 10s., according to rental; tap common to more than one tenant, from 3s. to 5s., according to rental; closets, 3s. to 5s.

All charitable institutions are supplied free of charge. The Water Department also supply water free of charge to twelve public baths and wash-houses in the city belonging to the Corporation. The Water Department do not charge the Corporation for water used for cleansing purposes, watering streets, flushing sewers, etc.; and, in exchange, the Corporation, as the Police Department, do not levy any assessment on the value of water pipes, etc., for Police and Statute Labour purposes. The Water Department has, since 1870, when the sinking fund came into operation, set aside from revenue in connection with their works £1,075,628 as a sinking fund, and that fund has been, and is being, used in paying off borrowed money, and in the purchase of the annuities granted to the shareholders of the old companies.

Population Supplied, etc.—The population at present being supplied is about 1,032,000, and the quantity of water sent in during the year 1900-1901 averaged 56,344,681 gallons per day, viz.—From Loch Katrine Works, 51,777,999 gallons; from Gorbals Works, 4,566,682 gallons. The consumpt is equal to 54½ gallons per head per day, viz.—For domestic consumpt, 34 gallons; for trade purposes, 20½ gallons.

The limits of supply under the Glasgow Corporation Waterworks Act of 1855 at present cover an area measuring about 12 miles from east to west, and 16 miles from north to south, and include the royal burghs of Rutherglen and Renfrew, the burghs of Govan, Partick, Pollokshaws, Barrhead, Milngavie, Kinning Park, and the towns or villages of

Nitshill, Thornliebank, Cathcart, Cardonald, Mount Vernon, Carmyle, Tollcross, Shettleston, Millerston, Bishopbriggs Auchinairn, Strathblane, Bearsden, Yoker, and Scotstoun.

SUMMARY OF CAPITAL EXPENDITURE ON GLASGOW CORPORATION WATERWORKS as at 31st May, 1901.

I.—Value of the works taken over from the Glasgow Water Co. and the Gorbals Gravitation Water Co.	£597,374 6 6
II.—Cost of first aqueduct from Loch Katrine, Mugdock Reservoir, and distributing main pipes, including land, etc., and Parliamentary expenses	1,515,690 2 11
III.—Cost of new filters at Gorbals works, pumping stations at Springburn and Hogganfield, buildings used as offices, stores, and cottages for inspectors, and new roads	88,125 12 1
IV.—Cost of second aqueduct from Loch Katrine, Craigmaddie Reservoir, including land, and distributing main pipes	1,491,097 18 0
V.—Cost of Hydraulic Power Works in High Street, including land	113,008 0 9
VI.—Cost of River Supply Works at Westthorn, including land	102,281 15 9
	£3,907,577 16 0

GAS DEPARTMENT.

Gas was first supplied to Glasgow in 1818 by the Glasgow Gas Light Company. No record of the quantity manufactured was kept until 1827, when meters were first introduced. In that year the total quantity made was about 80,000,000 cubic feet. In 1843 this had increased to 217,000,000, and in that year a rival company, called "The City and Suburban Gas Company," was inaugurated. Both companies continued to supply gas in competition within the same area until the year 1869, when the Corporation acquired by Act of Parliament the works of both companies.

The following table shows the development in gas manufacture during the last forty years:—

Year.	Gas made in Cubic Feet.	Price per 1000 Cubic Feet.	Total Revenue, including Gas, Coke, Residuals, etc.
1860	769,241,000	5s. 0d.	£153,585
1870	1,295,863,000	4s. 7d.	£235,701
1880	1,859,582,000	3s. 10d.	£341,274
1890	3,058,277,000	2s. 6d.	£417,589
1900	5,969,111,000	2s. 2d.	£770,002

The Corporation now supply an area of 15 miles in extreme length and 9 miles in extreme breadth. The number of consumers is 201,878. The price is the same over the whole area. No meter rent is charged. There are five works within the area of supply—two small suburban works and three large works. The Dalmarnock Works (formerly the City and Suburban Gas Company's works) are situated at the East End of the city, and are capable of manufacturing about 7,000,000 cubic feet per day. The Tradeston works (formerly the Glasgow Gas Light Company's works) are on

the south side of the river, and were built in 1838. In 1869 their manufacturing capacity was one and a half million cubic feet per day, and in 1888 it had been increased to four and a half million cubic feet per day. The extension of the district supplied by these works was, however, so rapid that in that year it was determined to reconstruct the works, so as to enable the producing power to be largely increased. In order to carry out the reconstruction, it was necessary to acquire additional ground, to shut up and utilise a street which separated the two portions of the works, and connect the latter by bridges across the Caledonian Railway Company's main line. By this reconstruction the manufacturing capacity of the Tradeston works has been increased to 10,000,000 cubic feet per day.

The Dawsholm works were erected in 1871. The portion first erected had a manufacturing capacity of 3,000,000 cubic feet per day. In 1883 this was increased to 8,000,000. In 1891 the adjoining works of the Partick, Hillhead, and Maryhill Gas Company were acquired by the Corporation. These works are separated from the Dawsholm works by the Forth and Clyde Canal, and to enable the works to be combined a tunnel has been constructed under the canal, through which the gas mains are laid, and railway and foot traffic carried on. In 1892 an additional retort house, containing 512 retorts, was erected. Four years later another retort house of similar dimensions was constructed, and the Dawsholm works have now a manufacturing capacity of about 19,000,000 cubic feet per day. Both Tradeston and Dawsholm works are fully equipped with machinery for manipulating the coal and coke.

There being no room for further extensions at the existing works, and as the demand for gas continued to increase, the necessity for the erection of new gasworks became evident, and the selection of a suitable site had to be carefully considered. In 1898 a site was selected at Provan, on the eastern boundary of the municipal area, as being, on the whole, the most suitable, and in 1899 an Act of Parliament was obtained to empower the Corporation to purchase the lands included in this site, and to erect new gasworks thereon. The area of the site is 131 acres. It is conveniently situated for both railway and canal communication. The levels are somewhat irregular, but advantage is being taken of the difference in levels to facilitate the transference of material. The coals, lime, etc., will be brought in at a high level, and the coke and other materials sent away at a low level. The works, when completed, will be in four sections, each section forming an independent work, which will be capable of manufacturing 12,000,000 cubic feet per day, or a total of 48,000,000 cubic feet. The works have all been designed, and mechanical appliances will be introduced wherever possible, so as to reduce the cost of manufacture in every department. Railway siding accommodation will be provided sufficient to deal with 4000 tons of material daily. The total length of railway lines inside the works will be about 8 miles, and, in addition, there will be about 5 miles of 2 feet 6 inches gauge lines for conveying coke, waste lime, etc.

The following statistics for the last financial year will give some idea of the business carried on by the Gas Department:—Coals used, 666,769 tons; coke sold, 259,679 tons; revenue from sale of tar and ammoniacal liquor, £121,347; maximum number of men employed in mid-winter—in gasworks, 2466; in workshops, 655—total, 3121.

The companies held two kinds of stock, one entitled to a maximum dividend of 10 per cent. and the other 7½ per cent. Under the Corporation's

Act, holders of the former received perpetual annuities of 9 per cent., and of the latter 6¾ per cent., these annuities being secured by a lien on the gasworks, on the revenue derived from the manufacture of gas, and by a guarantee rate of 6d. per £, leviable from the inhabitants of Glasgow in respect of rental.

The amount at the credit of the sinking fund at 31st May last is £388,664 16s. 8d.

SUMMARY OF CAPITAL EXPENDITURE ON GLASGOW CORPORATION GASWORKS as at 31st May, 1900.

I.—DALMARNOCK GASWORKS—		
Amount expended	£257,708 12 0	
Deduct Property realised	15,599 10 6	
		£242,109 1 6
II.—TRADESTON GASWORKS—		
Amount expended	£335,687 2 2	
Deduct Property realised	7,168 7 2	
		328,518 15 0
III.—DAWSHOLM GASWORKS (including Temple and Old Kilpatrick Gasworks, taken over by Corporation in 1891)—		
Amount expended	£783,349 17 7	
Deduct Property realised	17,153 12 1	
		766,196 5 6
IV.—WORKSHOPS AND OTHER PROPERTIES—		
Amount expended	£98,910 18 2	
Deduct Property realised	18,037 1 1	
		80,873 17 1
V.—PIPES, METERS, STOVES, ETC.—		
Amount expended	£1,094,210 10 2	
Deduct Property realised	15,779 14 6	
		1,078,430 15 8
		£2,496,128 14 9

NOTE.—In addition to the above, there has already been expended upon the new Gasworks at Provan, now in course of erection, the sum of £71,526 9s. 8d. The above £2,496,128 14s. 9d. includes the value of the works taken over from the Glasgow Gas Light Co. and the City and Suburban Gas Co.

ELECTRICITY DEPARTMENT.

Comparatively little had been done in the way of general electricity supply in Glasgow before 1890. By the Corporation Gas Bill of 1882 it was proposed to take statutory powers to supply electricity, but the clauses were struck out before the bill came before any Parliamentary Committee for consideration. The nearest practical attempt towards a general supply was made by the British Electric Company, Limited, who laid down Gramme dynamos to light the G. and S.-W. Railway Company's St. Enoch Station in 1879, and by the firm of R. E. Crompton & Company, Chelmsford, who laid down plant in 1879-80 to supply the North British Railway Company's Queen Street Station with electricity at a stated charge; but these attempts did not develop into a general supply, the railway companies

ultimately purchasing the plant and lighting the stations themselves. The next attempt towards a general supply was made by Messrs. Muir & Mavor, who, in 1879-80, laid down temporary plant on the area now covered by the Municipal Buildings, afterwards removing it to the basement of the General Post Office. Later, in 1884, they placed in Miller Street permanent plant to supply the General Post Office in George Square, the cables from Miller Street being carried over the tops of the intervening buildings.

In regard to the last-mentioned supply, it is interesting to note that the Glasgow Post Office was the first Post Office in the kingdom to be lighted by electricity; and it has been stated that it was owing to the attention of the Post Office authorities being called to the improved health of the Glasgow officials by the use of this new system of lighting that electricity was introduced into London and other Post Offices.

On 6th June, 1888, the company of Muir, Mavor & Coulson, Ltd., was incorporated, and purchased from the firm of Muir, Mavor & Coulson the plant in the Miller Street station belonging to them. The new company also purchased ground in Little Hamilton Street, off John Street, City, and laid down plant for a general supply. The supply from the Miller Street station was on the low-tension continuous current system (100 volts), while the Little Hamilton Street supply, which was also conveyed by overhead wires, was on the high-tension alternating current system (2400 volts), transformed on the consumers' premises to 100 volts. The company, in 1890, applied for a Provisional Order to supply Glasgow generally, as also did the Corporation, but the company withdrew their application in favour of the application by the Corporation, and the latter was duly sanctioned by the Board of Trade under the title of "The Glasgow Corporation Electric Lighting Order, 1890," and the Act of Parliament confirming this Order received the royal assent on 14th August, 1890. Subsequently the Corporation agreed to purchase the company's undertaking for £15,000.

On 1st March, 1892, the Corporation entered upon possession of Messrs. Muir, Mavor & Coulson's undertaking. The supply on the high-tension overhead system having only been sanctioned by the Board of Trade to continue until August, 1893, the Corporation proceeded forthwith to lay down a central generating station for low-tension supply. The Corporation, acting under the Gas Acts, having been constituted the undertakers of the new department, the Gas Committee were entrusted with carrying out the scheme, and in 1891 active steps were taken for putting the powers obtained by the Corporation into execution.

The Corporation purchased ground in Waterloo Street for £8000, and commenced to erect thereon a generating station in the spring of 1892. They also, on the advice of Lord Kelvin, adopted the low-tension continuous current three-wire system, at 200 volts pressure, to save the cost of altering existing consumers' installations, which could be connected to the new system without exchanging the lamps. It should be noted that the cost of incandescent lamps was then four or five times what it now is. But for this consideration, the pressure of supply might have been at least 115 volts in consumers' premises, thus facilitating the use of a three-wire system at 230 volts pressure, as was done in Edinburgh a few years afterwards. The pressure allowed by the Board of Trade regulations then in force was considerably lower than is allowed by the existing regulations.

On 25th February, 1893, the lighting of some of the public streets by arc lamps, supplied from high-tension continuous current Brush dynamos,

to which they were connected by long series circuits, was publicly inaugurated, and on Saturday, the 22nd April following, the general supply for private lighting was switched on. In August, 1893, the John Street high-tension alternating plant was shut down, all the consumers being transferred to the new low-tension underground mains, supplied from Waterloo Street.

Owing to the rapid growth of the undertaking, it soon became evident that the space occupied by the special and separate arc lighting plant in the Waterloo Street works would be required for extensions of plant to meet the demands of private consumers. The committee then decided to remove the Brush dynamos from Waterloo Street to John Street, and there to utilise them for street lighting purposes in connection with the engines originally put down by Messrs. Muir, Mavor & Coulson, Limited, the high-tension alternating current dynamos having in the meantime been disposed of. The John Street works, when reopened and utilised for the purpose of street electric lighting, only supplied about 100 horse power. Matters continued in this position until 1897, the plant at Waterloo Street being increased from time to time, until, during that year, the whole available space was fully occupied with boilers, engines, and dynamos to a total of 3300 h.p., which at that time provided a small margin of reserve power.

The street lighting being so inconsiderable, it was decided to alter the arrangements so that these lights could be run from the same plant in Waterloo Street as the private supply, with a resultant saving in cost. The John Street plant was thus again shut down, and the whole of the electric lighting, both public and private, was carried on from the Waterloo Street works.

The committee soon found the necessity for extensions, and in order to meet these and the increasing demands for the supply of current from so wide an area as Glasgow Cross on the one hand and Park Circus on the other, two temporary accumulator sub-stations were erected—one in Tontine Lane, Trongate, and the other in Claremont Street. The object of these sub-stations was partly to avoid transmitting heavy loads through the mains during the longest lighting hours—a matter involving considerable loss at the low pressure of 200 volts, or a very large expenditure in extra heavy copper mains—and partly to relieve the maximum load upon the generating plant. The arrangement of working is to charge up these when both plant and mains are under easy load, and to discharge them during the two or three hours of the afternoon or evening maximum load, the discharge current, of course, going to feed the local districts around each sub-station.

The committee then turned their attention to the question of purchasing sites for entirely new works, one for the north and another for the south side of the river; and during the year 1897 arrangements were made for the purchase of about 4¼ acres of ground at Port-Dundas, adjoining the Forth and Clyde Canal at Spiers' Wharf, and about 2 acres of ground close to Eglinton Toll or St. Andrew's Cross, in Pollokshaws Road.

There had been a considerable overload on the plant in December, 1897, during an extended period of very thick fog, which caused a demand upon all the plant, including the accumulator sub-stations, for so long a time that the accumulators, which were only intended for some two or three hours' discharge per day, were exhausted, and could not be recharged until night, as the engines and dynamos were all fully occupied in endeavouring to supply the demand made directly upon them.

It was clear that, as no more plant could be placed in the Waterloo Street works, urgent steps must be taken to get new plant of some kind delivered and fixed on the new site at Port-Dundas, so as, if possible, to be in operation for the winter of 1898-99. Tenders were accordingly invited for such plant as manufacturers might be able to deliver quickly. As some time, however, would necessarily elapse before the permanent buildings could be erected, it was found necessary to erect a temporary wooden shed over the engines and dynamo foundations, to contain the 2000 h.p. plant which was purchased as the result of the tenders referred to. Part of this plant was put into use in December, 1898. It was, however, impossible entirely to avert overloading the Waterloo Street plant during times of heavy demand.

In laying out the extensive scheme which it is intended should ultimately supply current throughout the whole area of Glasgow, it was decided to take advantage of the altered Board of Trade regulations, and to make the pressure of supply in consumers' premises 250 volts, by the use of a three-wire 500 volt continuous current system, instead of the then existing 200 volt three-wire system, as this would result in a very large saving in the cost of mains, and, consequently, in the ultimate cost of electricity to consumers. The only drawbacks to this departure are that the mains from the Waterloo Street works and those from the new stations cannot be connected together, and that all parts of the original area, which it is desired to relieve, have first to be cut off from the Waterloo Street works, all consumers' lamps changed for 250 volt ones, and often other sundry alterations made at the same time, and then to be connected to the new supply. The process is a tedious one, causing some amount of annoyance to consumers and a great deal of wear and tear on the staff, but the result, when all is completed, will be a more uniform light at a reduced cost, in spite of the fact that longer distances have to be traversed.

The new supply has made considerable progress, and there are now some 2773 consumers supplied from the Port-Dundas and Pollokshaws Road stations.

The works and whole undertaking of the Kelvinside Electricity Company were taken over by the Corporation in August, 1899, at the price of £37,000, the supply in that district then being at 100 volts only. This has now been altered to the new pressure, and three Willans engines of 360 horse power each, with Bruce-Peebles dynamos, and an 1100 horse power Babcock & Wilcox boiler have been added.

At the present time the Port-Dundas works are supplying current from Bridgeton Cross, on the east, to Whittinghame Drive, Kelvinside, on the west, and from Springburn Park, on the north, to the Victoria Infirmary on the south, and to Pollokshields and Dumbreck on the south-west, except during the evening hours from dusk to 11 p.m., when the Kelvinside and Pollokshaws Road works take up the supply to their respective districts.

When the electric lighting supply was commenced by the Corporation, probably no one had any idea of the magnitude which the undertaking would so rapidly attain. The tabulated statement appended hereto shows at a glance the progress of the undertaking since the date of its inauguration in 1893, and there is no indication of any abatement in the demand for current in the near future. On the contrary, everything points to that

demand increasing from year to year, and to the rate at which this increase is taking place being steadily augmented.

The demand for electric motive power is also rapidly growing, and now amounts to over 1894 horse power in motors of all sizes, which are used for many different purposes.

TABLE SHOWING RATE OF INCREASE IN DEMAND FOR SUPPLY OF ELECTRICITY FROM 1893 TO 1901.

Year ending 31st May	Total Maximum Supply Demand.	Total Capacity of Plant.	Maximum Load.	Quantity Generated.	Quantity Sold.	Revenue.	Number of Consumers.
	Kilo Watts, 8 c.p. Lamps.	Kilo Watts.	Kilo Watts.	B.T. Units.	B.T. Units.	£ s. d.	
1893	790 = 24,687	800	570	408,529	287,712	7,784 5 4	108
1894	1,684 = 52,625	1,250	894	854,766	702,248	18,015 19 2	378
1895	2,090 = 65,312	1,700	1,140	1,022,730	901,287	21,196 11 4	586
1896	2,638 = 82,438	1,700	1,440	1,279,687	1,090,959	25,862 8 6	855
1897	3,366 = 105,188	2,150	1,776	1,729,483	1,497,842	30,474 16 1	1,090
1898	4,800 = 150,000	2,150	2,232	2,619,019	2,114,036	36,360 14 10	1,437
1899	6,114 = 191,062	2,600	3,096	3,401,731	2,824,350	44,141 4 7	1,858
1900	7,732 = 241,625	6,402	4,258	5,226,818	4,250,669	59,762 2 0	2,852
to 31st May 1901	11,787 = 368,342	10,848	6,308	8,254,146	6,813,991	79,450 0 0	4,031

The new Port-Dundas and Pollokshaws Road works will be found worthy of a visit. The former contains engines and dynamos of both American and British manufacture, and of both high-speed and slow-speed types, and in various sizes, from 200 h.p. to 2400 h.p. each unit. One of these largest sets is now completed, and a second is in course of erection, the engines being by Messrs. Willans & Robinson, and the dynamos by the Westinghouse Company. The remaining engines are by the Balland Wood Co., Messrs. Matthew Paul, Messrs. Mirrlees & Watson, Messrs. Belliss, and Messrs. Willans & Robinson, and the dynamos by the Walker Co., the Schuckert Co., Crompton & Co., and the British Thomson-Houston Co. The condensing plant is all driven by electric motors, the air pumps being of Edwards' patent design. The switchboards and recording gauges are of considerable interest, being specially designed for the purpose, and containing some departures from ordinary practice. They have been constructed by Kelvin & James White, the Holland House Manufacturing Co., Messrs. Mechan & Sons, and Messrs. Laing, Wharton & Down. They are mostly, therefore, of local production.

Current is being supplied from the Port-Dundas works to the Glasgow International Exhibition through two concentric feeders, each of one square inch section, at a pressure of 500 volts continuous current. Two engines, of 1200 horse power each, by Messrs. Willans & Robinson, will be found in the Exhibition, one driving a Crompton and the other a Schuckert dynamo. These engines and dynamos have been built for the Corporation, and will be removed to one or other of the new works during the autumn, after the Exhibition is closed.

The total cost of the electricity works of the Corporation, including mains, up to the present time, has been £897,564 8s. 11d. This expenditure does not, of course, include the cost of the Corporation Tramways electrical system, which will be dealt with separately.

SUMMARY OF CAPITAL EXPENDITURE OF GLASGOW CORPORATION ELECTRICITY DEPARTMENT as at 31st May, 1900.

I.—JOHN STREET, WATERLOO STREET STATIONS, ETC.—		
Amount expended - - - - -	£96,730 8 8	
Deduct Capital realised - - - - -	2,316 18 11	
		£94,241 19 9
II.—PORT-DUNDAS STATION—		
Amount expended - - - - -	£171,773 18 2	
Deduct Capital realised - - -	100 0 0	
		171,673 18 2
III.—POLLOKSHAWS ROAD STATION—		
Amount expended - - - - - - - - - -		93,850 9 9
IV.—KELVINSIDE STATION, BATTERY STATIONS, ETC.—		
Amount expended - - - - - - - - - -		30,098 13 7
V.—MAINS, METERS, ETC.—		
Amount expended - - - - -	£513,497 10 4	
Deduct Capital realised - - -	5,798 2 8	
		507,699 7 8
		£897,564 8 11

BATHS AND WASH-HOUSES.

In the year 1869 the initial steps towards the establishment of public baths and wash-houses in the city were taken, but nothing came of the movement at that time, and it was not till 1876—the year of the last visit of the British Association to Glasgow—that baths and wash-houses became an accomplished fact. In January of that year the Police Board accepted an offer to lease to them the site of the old washing-house on Glasgow Green for the erection thereon of public baths and wash-houses. In the same year the Water Department agreed to supply the baths and wash-houses with a free supply of water—an arrangement which has ever since remained in force.

Almost simultaneously the old London Road Baths were acquired by, and placed under the management of, the Corporation. These baths remained the only establishment of the kind controlled by the Corporation for about a year, when the Kennedy Street Baths—an institution similar in almost every respect to the before-mentioned London Road Baths—were acquired. Meantime, the premises now known as Greenhead Baths and Wash-houses were being erected on Glasgow Green, but were not formally opened to the public till 19th August, 1878.

While these three establishments were rapidly growing in public favour, the department of the Corporation in charge of this new scheme was arranging for sites in other districts of the city whereon to erect baths. By the year 1885 the districts now known as North Woodside, Cranstonhill, Townhead, and Gorbals, were all provided with baths and wash-houses.

The old baths in London Road and Kennedy Street (the pioneers of this department of Corporation enterprise) ceased to be used in 1883. The number of modern establishments under the control of the Corporation in 1885 was five, and the capital expenditure till that year amounted to about £120,000.

An interval of twelve years took place in the building operations of the department, viz., from 1885 to 1897. In the year last named a wash-house having a few hot rooms connected with it was erected in the Hutchesontown district of the city, and in the following year—1898—baths and wash-houses were built in the Springburn and Maryhill districts; in 1899 a wash-house was erected on the site of the old Kennedy Street Baths, and in the same year and the year following similar establishments were built on the areas behind tenement property owned by the City Improvements Department of the Corporation at Stobcross Street and Bain Square.

MARKETS, SLAUGHTER-HOUSES, AND FOREIGN ANIMALS WHARVES.

The markets at present belonging to the Corporation of Glasgow are—

(1) The Bazaar.
(2) The Cheese Market.
(3) The Bird and Dog Market.
(4) The Old Clothes Market.
(5) The Cattle Market.
(6) The Slaughter-Houses—
    (*a*) Moore Street,
    (*b*) Scott Street,
    (*c*) Victoria Street.
(7) The Dead Meat Market.
(8) The Fish Market.
(9) The Foreign Animals Wharves.

Of these, the first four form part of the General Department of the Corporation, and as such are administered by a committee popularly known as the Bazaar Committee, which is also entrusted with the oversight of the public halls, turret clocks, and city timepieces belonging to the Corporation.

(1) *The Bazaar* is the modern representative of the ancient vegetable market of Glasgow, and now occupies a site bounded by Ingram Street, Candleriggs, Bell Street, and South Albion Street. The Bazaar was laid out in 1817, and then embraced an area of 2377 square yards. Subsequent additions have increased the accommodation till now the Bazaar proper covers 7879 square yards, divided into 58 stances. Previous to 1886 the business done in the Bazaar was of a different character from that which has since been carried on there. In its early days, the stalls of the Bazaar were by no means restricted to dealers in fruit and vegetables. They were occupied by retail greengrocers, dealers in eggs, butter, cheese, poultry and game, and by second-hand booksellers, and there were also toy shops and undefined stores. Owing, however, to the establishment of large provision premises in the immediate neighbourhood of the Bazaar, and the large increase of retail shops throughout the city, miscellaneous trading in the Bazaar soon ceased.

In other respects, also, the Bazaar business has changed with the changing times. Retail trade is still carried on, but it is on the most insignificant scale, and steadily the tendency is towards dealing on a wholesale basis. The Bazaar is now recognised as the principal market for the sale of fruit and vegetables in the West of Scotland, and nearly all the stanceholders, of whom there are about two dozen, hold auctioneers' licences, and dispose of a large portion of their merchandise by auction-room methods. In summer, during the height of the fruit season, auction sales are held daily, beginning at nine o'clock, and during the winter months such sales are held only thrice a week, beginning at eleven o'clock in the forenoon. With increasing trade and restricted accommodation, there has arisen a strong competition for stances in the Bazaar, which has therefore become a highly remunerative property to the common good of the city. Within ten years the receipts for stances have increased from a little more than £2000 to over £3300. The stances are let on monthly occupancies, with rents payable in advance, but the Corporation reserves the right in lieu of rent to charge such dues on goods as they may fix. The Corporation are at present seeking power from Parliament to extend the Bazaar under a scheme which includes the appropriation of part of the *solum* of South Albion Street and the acquisition of the Central Police Office. This scheme if carried out in its entirety, would give an increased space of 3576 square yards, and would involve an expenditure of about £80,000.

(2) *The Cheese Market*, devoted to the wholesale cheese trade, is a portion of the Bazaar entirely distinct and divided off from the fruit and vegetable stances. It has its own entrance in South Albion Street, and on that side, including galleries carried round three sides of the north division of the vegetable market, has a floorage of 1500 square yards. The Cheese Market is open only on Tuesdays, Wednesdays, and Fridays, and the business is entirely wholesale. The market is, indeed, the modern representative of the ancient cheese market of Glasgow, which was held on certain days under magisterial supervision, and in which dues were charged according to the quantity offered for sale. The cheese sold is entirely of home manufacture, principally the kinds known as Cheddar, and Dunlop from Ayrshire. There is no allocation of stances or positions to dealers, and any one who has cheese to sell may have it placed on the racks in the market on payment of the prescribed dues. A rent charge is made at the rate of 4s. 6d. per ton for all cheese brought into the market. For a payment at that rate the cheese is weighed, and allowed to remain over two market days, but if not sold and removed within that time an additional charge of 1s. per week or part of a week is levied on every ton weight. Goods sold must be taken away within forty-eight hours; if left longer, a charge of 2s. per ton for every day or part of a day after the expiry of the forty-eight hours is made.

(3) *The Bird and Dog Market* is situated in Jail Square, opposite Glasgow Green, and covers an area of 720 square yards. It was opened for business in December, 1876, but prior to that date the market had been successively carried on in premises in Cochrane Street and Ingram Street. It is rented to a tacksman for £112 per annum. The market is held on Monday, Wednesday, and Saturday, and is divided into a wholesale and a retail department. The wholesale side is set apart for dealers who have stock to dispose of to stanceholders or other retailers. A charge of ½d. for each animal exposed in the market is made, and buyers other than stanceholders pay 1d. for admission to the wholesale market. In the

retail department stances 6 feet wide by 9½ feet high are let for not more than 3s. per week, and casual dealers are charged 1d. per day for each animal they bring in and ½d. for each cage space they occupy. Cages are supplied in the market when necessary for ½d. per day.

(4) *The Old Clothes Market* in Greendyke Street, an institution which exists for trafficking in old clothes, offers a very curious example of magisterial supervision. The market is really an outcome of purely humanitarian care for the very humblest stratum of the population. The present market was opened in July, 1875, and occupies a floor area of 2380 square yards. Prior to 1900 the market was rented to a tacksman, but in May of that year the Corporation took advantage of the expiry of the tacksman's lease to assume the control of the market, and to place it under the charge of the superintendent of the Bazaar. The stances in the market are let at a sum of not more than 5s. per day, and 1s. per day for the use of a lockfast store. Shopkeepers and retail dealers who have no stance or store in the wholesale market are required, when purchasing, to pay 6d. per day, and every person who enters the market with goods for disposal is liable to be charged 1d. The market is open every day at nine o'clock, closing in summer at eight, in winter at seven, and on Saturdays throughout the year at ten o'clock.

Prior to 1895 the markets after mentioned, viz., the Cattle Market, the Slaughter-Houses, the Dead Meat Market, and the Fish Market, were controlled by the Corporation in their capacity as Markets Commissioners, acting under the Glasgow Markets and Slaughter-Houses Act, 1865, but in that year (1895) an Act was passed unifying the several Corporation departments and creating the Glasgow Corporation (Markets) Department.

(5) *The Cattle Market.*—After successive changes of site the Cattle Market was removed in 1818 to its present site in the East End of the city. It has from time to time been extended, and now covers an area of 36,478 square yards, a large proportion of which is roofed over. It provides accommodation for showing for sale about 2000 cattle and 15,000 sheep in pens, and at the same time 1000 cattle can be kept loose in sheds, and 160 milk cows fed in byres within the market. *En suite* with the Cattle Market there is a horse bazaar, occupying an area of 980 square yards, with the necessary stables for putting up 112 horses. The slaughter-houses attached to the market extend over 13,695 square yards, and the Dead Meat Market, erected under the powers of the 1877 Act and opened for trade in 1879, covers an area of 4246 square yards. For many years the markets accommodation, especially the slaughter-house portion, has not at all been commensurate with the demand made upon it, and it is at present being reconstructed on more modern lines. The improvements, when effected, will greatly add to the lairage of the slaughter-house accommodation, provide facilities for the scientific inspection of carcases, and otherwise bring the resources and accessories of the market fully abreast of the most completely equipped institutions of the kind in the kingdom or on the Continent.

The principal cattle market day is Wednesday, but the market is open for business every day of the week. Under Act of Parliament, the maximum tolls leviable are—For oxen, cows, bulls, and heifers, per head, 9d.; for sheep and lambs, per head, 1d.; for calves, 2d.; for swine and goats, 3d. In the horse bazaar the rates are—For animals over thirteen hands high, 6d.; and under thirteen hands, 3d. In the year ending 30th May, 1900, there were exposed for sale in the market 75,066 cattle, 220 calves, 376,460 sheep and lambs, 22 goats, 6230 swine, and 17,028 horses.

(6) *Slaughter-Houses.*—There are at present three public slaughter-houses in the city, viz., Moore Street and the Cattle Market, in the eastern district; Scott Street off Dobbie's Loan, in the northern district; and Victoria Street, in the southern district. But as soon as the contemplated additions to the accommodation at Moore Street shall have been carried into effect it is intended to concentrate the whole of the business there. The sheds and yards at Moore Street presently provide accommodation for dealing with 560 cattle, 2500 sheep, and 240 pigs at one time; and the dues payable on animals killed in the public abattoirs are—For oxen, 9d. per head; for calves, sheep, and goats, 1½d. each; for lambs, ¾d.; and for pigs, 1s. The following comparison between the number of animals slaughtered in 1876 and 1900 is interesting, viz.:—

	Oxen.	Calves.	Sheep.	Lambs.	Pigs.	Goats.
1876 -	57,924	1741	175,060	43,016	9,315	17
1900 -	46,275	1793	204,701	53,462	55,577	19

(7) *The Dead Meat Market* in Moore Street was opened in 1879 as a necessary outcome of the successful inauguration of the ocean traffic in carcases during the previous decade. The facilities offered by the Dead Meat Market have exercised a marked influence over the retail butcher trade in the West of Scotland. The market may now be regarded as the central depôt of the wholesale meat business, and the butchers, instead of dealing in live animals, buy from the exposed carcases such portions and qualities as suit their requirements, and thus the trade is better and more economically supplied and is more expeditiously distributed than under the old system. The market covers an area of 4246 square yards, consisting of 45 stances, let weekly at the rate of ½d. per square foot per week. In addition dues are levied on carcases at the following rates, viz.:—For oxen, 6d.; for fat calves, 3d.; slink calves, 1d.; sheep and lambs, 1d. each; and pigs, 2d. There is also exigible for weighing meat a toll at the rate of ½d. per hundredweight or part thereof. The following comparison of the number of carcases dealt with during the first year of the market, viz., 1880, and during 1900, is suggestive of the great strides which have been made in the interval, viz.:—

	Cattle.	Sheep.	Lambs.	Pigs.	Calves
1880 -	42,434	68,007	10,275	5,416	199
1900 -	68,517	145,539	33,920	30,698	2,138

(8) *The Fish Market*, situated by the side of the river between East Clyde Street and Bridgegate, covers an area of upwards of 2000 square yards. Nominally it is divided into a wholesale and a retail department; but while it possesses conveniences for retail dealers, there is scarcely any retail business done in the market. The revenue of the market is derived from the renting of stances, of which there are 47, and from dues on goods brought into the market by dealers who are not stanceholders; but the latter source of income has completely dried up, showing that the whole trade is in the hands of the established dealers. The rents levied for stances are at the rate of 4s. 6d. per annum for each square foot of space occupied, payable weekly in advance; and casual dealers getting the use of a stance pay 4d. for each box or barrel of fish they bring into or buy within the market. During 1883 (the first year for which statistics are available), 213,621 packages of fish passed through the market, while in 1900, 715,076 packages passed through the market.

(9) *Foreign Animals Wharves.*—Under the Contagious Diseases (Animals) Act, 1878, the Corporation are the local authority having the control of the foreign cattle trade at the port of Glasgow. The local authority are also, under the same Act, entrusted with the duty of dealing with the outbreaks of contagious diseases among animals, with compensating owners for the loss of animals, and with the levying of rates to meet such compensation allowances.

Under the powers conferred by the Act of 1878, the Corporation erected in 1879, at Yorkhill, on the south side of the river, the first foreign animals wharf in Scotland. The building cost £3500, and had accommodation for 120 head of cattle. From time to time alterations and additions were made, until in 1894 the local authority carried out an entirely new scheme of reconstruction of the wharf at a cost of almost £50,000. The wharf now covers an area of 23,596 square yards, and provides slaughtering accommodation of the most approved description, including spacious chill rooms, in which meat can be stored and preserved in perfectly sound condition for any length of time.

The wharf at Yorkhill is reserved exclusively for foreign stock subject to slaughter at port of landing. In 1879 also the Corporation provided a landing-place at Plantation, on the south side of the river, for foreign stock not subject to slaughter, which comes principally from Canada. The accommodation there is capable of providing for 1500 cattle and sheep, and cost about £4000. In 1886 provision was made at Shieldhall, also on the south side of the river, for 2000 cattle and 6000 sheep, at a cost of £27,000. This latter wharf is at present unoccupied owing to the orders of the Board of Agriculture that all foreign animals landing in this country must be slaughtered at the port of landing, so that all foreign stock for Scotland must now be discharged at the Yorkhill wharf.

The following table shows the number of foreign animals landed in Glasgow during the years 1880, 1885, 1890, 1895, and 1900:—

IMPORTATION OF LIVE ANIMALS—CATTLE, CALVES, SHEEP, AND PIGS—FROM THE UNITED STATES, CANADA, SOUTH AMERICA, FRANCE, SPAIN, AND IRELAND.

	Cattle.	Calves.	Sheep.	Pigs.
1880 - -	7,460	4	1,677	407
1885 - -	39,642	18	10,514	73
1890 - -	66,397	50	1,301	—
1895 - -	48,024	1	56,484	58
1900 - -	48,421	—	26,023	—

The great increase in the importation of frozen and chilled meat accounts for the decrease in live stock.

SANITARY DEPARTMENT.

The Sanitary Department of Glasgow dates from 2nd May, 1870. Previous to that time the sanitary matters, so far as they were attended to at all, were divided between the Police and Office of Public Works. At the inauguration of the department the staff consisted of 1 medical officer and 5 district medical assistants, 1 chief sanitary inspector, 5 district inspectors, 5 lodging-house inspectors, 7 infectious disease inspectors, 18 nuisance inspectors, 5 female inspectors, 1 indoor inspector, 2 clerks, 1 boy, and 1 cleaner—a total of 51. By 1876 (the date of the

last visit of the British Association) the staff had been increased to 60. It has since grown gradually to the present strength of 225.

The Sanitary Chambers are situated at the corner of Montrose Street and Cochrane Street. The building was opened about three years ago, and the cost, including the price of the ground, amounted to about £30,000. It contains accommodation for the chief sanitary inspector and his staff and the medical officer of health and his staff.

The chief sanitary inspector is an official with a plurality of offices. He is sanitary inspector under the Public Health (Scotland) Act for administering that Act so far as it applies to general nuisance and the regulation of common lodging-houses; he is appointed inspector under the Sale of Food and Drugs Acts, 1875 to 1899; inspector under the Dairies, Cowsheds, and Milkshops Orders, 1885-89, for the regulation of all byres, dairies, and milkshops; inspector under the Sale of Margarine Act, 1887; inspector under the Horse Flesh Act, 1889; inspector of nuisances and sanitary inspector under the Glasgow Police Act, 1866, and the Amendment Act of 1890; he is the official responsible to the local authority under the 3rd and 4th sections of the Factory and Workshops Act, 1878, and the 1st, 2nd, 3rd, and 4th sections of the Factory and Workshops Amendment Act, 1891—in a word, all the sanitary powers with regard to factories and workshops which beforetime were vested in the inspector of factories, have now been placed under the charge of the sanitary inspector; he is also responsible for the carrying out of the provisions of the Shop Hours Acts, 1892-95, and the Seats for Shop Assistants Act, 1899. In addition to these duties, he is required to report upon all applications to keep cows in dairy premises and to keep swine in piggeries; and is responsible for the officials who are placed in charge of the open spaces and playgrounds for children in the city. Recently the detection of public work chimneys emitting black smoke in the city was transferred from the police, and entrusted to the sanitary inspector. Two inspectors, with technical knowledge of boilers and furnaces, have been appointed, and submit their reports, sketches, etc., daily to the chief inspector, who advises as to the means to be adopted for the abatement of smoke nuisance.

For nuisance removal work the city is divided into seven districts. Five of these are the Central, Northern, Eastern, Southern, and Western, and constituted the city of Glasgow up to the year 1891. In that year, however, a large extension of the city took place, and two new districts were constituted, viz., the North-Western, covering Maryhill, Kelvinside, and Hillhead, and the South Suburban, covering Mount Florida, Govanhill, Crosshill, Strathbungo, Shawlands, and Pollokshields. A further extension of the city has taken place in the latter district since that time, embracing Craigton and Halfway House, equidistant between Glasgow and Paisley. The North-Western and South Suburban, like the other five districts, have a district or foreman inspector, with a number of assistants, but they do not come in daily to the central office, there being a branch office situated in these districts, with a clerk, and telephonic communication with central office, to which details of the work are daily transmitted for the purpose of being recorded in the books there.

The district inspectors' duties are generally to confer daily with the chief, report to, and receive directions with regard to notices, letters, complaints, and any matter in which there is difficulty. The district

inspector examines the assistant inspectors' note-book, checking the work, if necessary, and drawing out specifications of remedies in cases of defective drainage, etc. He personally inspects important nuisances, or those presenting special difficulties of a structural nature, or where there are personal differences between landlord and tenant, or between the author and complainer. He also supervises the female inspectors and smoke testers' work, meets owners on the ground in cases of proposed alterations or extensions of property, and attends the Police or Sheriff Court to give evidence in cases of prosecution.

The assistant nuisance inspectors have a particular sub-division or sub-divisions allotted to them, averaging 3000 to 4000 houses, and they are either daily on the track of nuisances or inquiring into complaints, attending smoke tests, tracing vaccination defaulters, obtaining certain information for death cards kept by the medical officer, such as the size, surroundings, and conditions of the house wherein a death has occurred; inspecting, measuring, and registering all houses let in lodgings, which it is considered for sanitary reasons necessary to place on the register; inspecting bakehouses on behalf of the medical officer, etc., etc. With regard to the assistant nuisance inspectors' work for the years 1876 and 1900 respectively, we find the following:—

	1876.	1900.
Nuisances recorded, - - - - - -	13,406	44,148
Prosecutions before the Sheriff or police magistrate in connection with nuisances,	119	20

It will be seen from the foregoing that, whilst more work is done, there is now not the same necessity, as was the case in 1876, for legal proceedings being taken for the removal of nuisances.

There is one inspector who devotes his whole time to the inspection of common lodging-houses, that is, lodging-houses charging less than sixpence per night. There were 69 such houses at the end of 1900, giving accommodation for 9497 persons. There has been a gradual diminution in the number of common lodging-houses during recent years, and, at the same time, those erected have been larger and better equipped. In 1887 there were 101 houses, giving accommodation for 6273 lodgers; whilst there were in 1900 only 69 houses, but the accommodation was for 9497 lodgers. It may be mentioned that the Corporation own seven of these common lodging-houses, which financially have been a success, and at the same time have been models for the private owner to copy and compete with. This, of course, was the original intention of the Corporation in erecting them.

There are six inspectors employed during the night throughout the whole year for the purpose of keeping down overcrowding in the smaller houses of the city. These inspectors work in pairs, as it is necessary they should corroborate each other when the prosecutions take place before the magistrates in the district Police Courts. For a first offence, and where the overcrowding is not of an aggravated form, the inspectors warn the householders implicated. In all other cases summonses are issued against the parties to appear in the Police Court, and fines ranging from 2s. 6d. to 10s. are imposed. In many cases, however, the magistrate merely gives an admonition. The night inspection of ticketed houses has tended to almost clear the city of typhus fever. There

were 72 cases of typhus fever throughout the whole city during the year 1900.

Six female inspectors are employed during the daytime inspecting the lower class dwellings. Their duties are, by persuasion principally, to induce the female householders to keep the interior of their dwellings in a clean and sanitary condition, and to advise them generally how this can be best maintained. They wear no uniform, but are provided with a waterproof. They, however, like all the male inspectors, have a warrant card of authority from the chief inspector. They report to the nuisance and infectious disease inspectors any cases they discover.

Drain-testing forms an important branch of the work of the Sanitary Department. Several of the inspectors are daily employed at this work, assisted by a lad who works the machine. All newly erected properties must, in terms of the Glasgow Building Regulations Act, be tested and certified by the Sanitary Department before occupancy of the premises. All the houses in a tenement where a case of either enteric fever or diphtheria has occurred are also tested by the department, and a notice specifying any defects, and also the remedies required, is issued to the owner. Where there has been illness, or good grounds for believing that the drainage system is unsatisfactory, the owner is also asked to allow the test to be applied. During the year 1900 there were 3656 applications of the test at different times. Glasgow, it is believed, stands in the first rank in connection with this matter compared with other large towns; and it would be interesting to visitors to call any morning at the Sanitary Chambers about 9.30 and accompany the inspectors to their work, and see the *modus operandi*.

The sanitary condition of workshops under the Factory and Workshops Acts, with regard to registration, light, ventilation, lavatory accommodation, water supply, limewashing, and overcrowding, forms an important section of the nuisance inspectors' work. One inspector is set apart to measure and register in a book all the applicants, with details of number employed, cubic contents, etc. He also places on the register a sketch of the premises.

The smoke nuisance in the city was transferred on 13th March, 1899, from the supervision of the police to the Sanitary Department, and two specially qualified assistants were appointed under the direction and control of the chief sanitary inspector.

Four inspectors are set apart for the inspection of byres, dairies, and milkshops, detection of adulterated food, Margarine Act infringements, etc. One of these also daily inspects the public fruit and vegetable market.

Dead meat inspection was, until July, 1900, under the sanitary inspector, and three assistant inspectors devoted their whole time to the work; but they have now been transferred to a new section of the department under the veterinary surgeon, who has an office at Moore Street Market, and a large staff of assistants. In connection with this matter, it may be mentioned that at present there is a proposal to establish the clearing-house system, by which all meat will be brought to a central depôt or depôts for inspection previous to sale.

For a large number of years there has been carried out every summer from day to day the limewashing of privies and wet ashpits in the city as special cholera precautions. The entire cost (about £120 per annum) is borne by the Sanitary Department.

There are at present two permanent reception-houses for boarding the inmates of principally typhus-infected dwellings for a period of seventeen days. The oldest is a self-contained dwelling at 39 Weaver Street, opened in 1872. The inmates are boarded free, and also get the temporary use of clothing whilst their own is being treated at the disinfecting station. It has only accommodation for about 35 persons, and the building is old, and in many respects unsuitable. The Health Committee has decided to erect, on a site adjacent, an extensive new house, with accommodation for about 200 persons. In 1892 another house, at 339 South York Street, containing 48 beds, was opened. It had been previously an orphanage. An annexe with 40 beds was recently erected to the rear of the building. During the latest visit of the plague and smallpox the two existing houses were found quite inadequate, and temporary houses were opened at considerable expense at 134 Montrose Street and Tollcross House, in the extreme eastern boundary of the city, giving additional accommodation.

One inspector devotes his whole time to the inspection of shops under the Shop Hours Acts, 1892-95, and the Seats for Shop Assistants Act, 1899.

There are two wash-houses and disinfecting stations, viz., at Belvidere and Ruchill, adjacent to the hospitals. During the year 1900 the number of articles dealt with at Belvidere was 283,187, and at Ruchill 252,959. Each station has steam washing machines, dash wheels, dollies, drying stove, steam disinfector, carpet-beating machine, etc. The clothing from infected houses enters at one side, and is sent out at the other clean and disinfected. The staff comprises superintendent, engineer, fireman, machineman, stableman, vandrivers, clothing collectors, washerwomen, and a clerk. Infected houses are also fumigated and whitewashed by the Sanitary Department free of cost.

There are 11 children's playgrounds in the city, each having a caretaker, under the supervision of the sanitary inspector. These playgrounds contain 33,614 square yards. The cost of the ground was £26,471, and the cost of fitting up £11,454. Their upkeep during a year amounts to about £1000. They are furnished with swings, maypoles, and other gymnastic appliances, and are open from 9 a.m. to half an hour after sunset. The institution of these playgrounds or open spaces dates from the year 1889, when the first (a small plot at Braid Street) was leased by the Corporation. In 1893 the most extensive and beautiful of these open spaces, "The Phœnix," was acquired. It contains 11,802 square yards. The ground cost £20,205, and the fitting up £5219. The site at the time of its purchase was covered by dingy, disused, and dilapidated sheds of a defunct iron foundry. "It now smiles in the sunshine, and echoes with the laughter of happy children" of a densely populated district.

Many other branches of the work under the sanitary inspector's control might be described, but the foregoing will perhaps be sufficient to give a glimpse of his department. There is a bacteriologist, with assistants and laboratory, at the chambers, but as he is more immediately attached to the medical officer's department, a description of his work, as well as those particulars with regard to the population, death-rates, infectious disease, and other statistical information, will be found in another part of these volumes.

CLEANSING DEPARTMENT.

In the seventeenth century municipal cleansing had yet to be begun in Glasgow. In the absence of any obligations to attend to such matters the inhabitants could simply do as they pleased, and were practically a law unto themselves. The city, notwithstanding the absence of any recognised methods of cleansing, was nevertheless looked upon as a paragon of cleanliness as compared with other large towns in the kingdom. The condition of such towns must, indeed, have been unenviable when Glasgow, under such circumstances, was termed a well cleansed city. From ancient records it is apparent that numerous, but unsuccessful efforts were made to induce the inhabitants to introduce more cleanly methods.

In 1599 it was ordained that the middens, which were placed on the street near to the entrance to the houses, be removed under penalties or fines, or of escheating the "fulzie," which would, in that event, be removed by "ane common carter man," and the proceeds of the sale thereof devoted to charity.

In 1646-47, when the city was visited by the plague, special efforts were put forth. A second horse was purchased for "clenging" the streets.

In 1655 the inhabitants were found to be damming back with "fulzie" the water which found its way to St. Tenowes (St. Enoch's) Burn, the object being the enriching of the contents of their middens. In consequence thereof we find "that the current of water was stoppit, so that the people in the Trongait were forcit to mak brige stones for entrie to their housses." It was "thairfor enacted and ordained that every heretor or tenant be chairgit at all occasions to red the passadge of the water thair foiranent themselvis, and that onder the payne of fyve pundis how oft and swa of as they shall contravin."

Edicts of this description appear to have been issued frequently during the seventeenth century. It is therefore evident that people paid little attention to them, and that the authorities did not enforce them. According to minute of 19th January, 1656, an attempt at street sweeping was made by causing the inhabitants to "clat the calsay weeklie" in front of their premises under penalty of "fourtie schillings scottis."

It was not until the passing of the Police Act of 1800 that the removal of refuse and the sweeping of the streets was looked upon as a public duty. The cleansing of the city was added to the duties of the master of police or chief constable. No separate staff was set aside for the work, however, the night watchmen or policemen being entrusted with the cleansing, as well as the watching of the streets of the city. Their first attempt in the way of cleansing was to devote two hours twice a week to the sweeping of the street. Such an occupation would scarcely accord with the dignity of our blue-coated representatives of law and order of the present day.

In 1804 a new departure was made. Fourteen scavengers were appointed. But, while previously policemen acted partly as scavengers, these fourteen scavengers were now required to act partly as policemen. It is uncertain how long this dual arrangement continued, but in 1815 it is recorded that a cleansing staff existed. These numbered sixteen

men all told. They were paid at the rate of 11s. per week, with the exception of one—presumably the superintendent—who received the munificent salary of 15s. per week.

Up till this time the Town Council did not possess statutory powers in connection with the cleansing of the city, and it was in 1843 that the first Act empowered them to deal with the watering, sweeping, and cleansing of the streets, lanes, and passages. This was undoubtedly a step in the right direction, but it did not go far enough, for the inhabitants were still allowed to deal with the contents of their ashpits as they might think fit.

By the Act of 1862 all such refuse was vested in the Police Commissioners, so that henceforth the hoarding up of the contents of the middens was doomed. To undertake this portion of the work a contractor was employed. This functionary was not only paid for the collection and removal of the refuse, but had the privilege of disposing of it to the best advantage.

In 1866 power was obtained to cleanse private streets and courts, and impose upon the proprietors an assessment of one penny per £ of rental towards cost of doing so.

The contract system for collection of domestic refuse obtained until May, 1868, when the Police Commissioners took into their own hands the whole cleansing of the city, removal and disposal of domestic refuse, as well as the sweeping and watering of streets. It was at this point that the city cleansing department was instituted, and an inspector of cleansing appointed. According to statute, that official is "held responsible for the entire operations of the department, the keeping of books and accounts in connection therewith, the good conduct of all persons appointed by him, and generally for the efficiency of the department."

The wonderful expansion of the city during these thirty-three years and the consequent extension of the ramifications of, and work performed by, the department are shown by the following figures, viz.:—

	1868.	1876. Year of last B. A. meeting.	1900.
Area of city,	5791 acres	6033 acres	12,688 acres
Mileage of streets,	155 miles	175 miles	318½ miles
Inhabited houses,	97,000	108,730	157,406
Population,	455,000	515,000	755,730
Rental,	£1,986,911	£3,117,827	£4,970,399
Men employed in Cleansing Department,	723	795	1223
Horses employed in Cleansing Department,	118	156	273
Refuse dealt with,	Tons Cwts. 140,239 13	Tons Cwts. 181,572 14	Tons Cwts. 444,514 18½

The city is divided for cleansing purposes into fourteen separate districts, the largest of which are sub-divided into several sections. Each district is under the charge of a competent foreman, with sectional assistants for refuse removal, street sweeping, and close sweeping.

Street Sweeping.—This portion of the work is done chiefly during the night by rotary horse-brushes or sweeping machines. Prior to 1870 hand labour was entirely employed, first by means of old birch brooms, and latterly the bass brush, but that method was gradually reduced to a minimum by the introduction of sweeping machines. The change from manual labour to horse power enabled this work, which formerly had to be performed by day, to be done by night, when the streets are free from traffic. The streets are therefore swept every morning before business hours. In addition to being swept by night, the principal thoroughfares are "picked" during the day. The sweepings so collected are deposited in iron bins, which are sunk in the pavements at regular intervals. Of these there are about 1600. The contents of the bins are emptied during the night, and removed along with the sweepings collected by the horse-drawn brushes.

Street Washing.—All the improvements that have been introduced in connection with street sweeping have not been sufficient to satisfy the growing desires of an æsthetic public. During 1900 the process of hose-washing the streets was introduced. The apparatus used consists of a specially designed two-wheeled reel with 150 yards of 1¼-inch hose and a flat nozzle, which sends out the water in sheet form. To adapt the size of the pipe to the 2½-inch hydrants in the street a reducing piece has been introduced. This process has so far been confined to the streets in the centre of the city, but the result has been so satisfactory that it is intended during the present year to extend the system to the main arteries of traffic through the other districts to the suburbs. As compared with hand or mechanical sweeping, hose-washing is infinitely superior. It must be borne in mind, however, that the process should only be applied in streets where the paving is properly grouted with bitumen, or the surface done with a smooth impervious substance.

The sweeping of macadamised roads is done by the day staff, the mud collected being either deposited in convenient tips on the outskirts of the city or trucked to the farms of the department in the country. No portion of this material is sold as manure.

Snowfalls.—Snowfalls tax the resources of the department to the utmost. When necessary horses and carts are hired to assist in the removal of the snow, the cleaner portion of which is tipped into the rivers Clyde and Kelvin at different points. Large quantities are also deposited upon vacant pieces of ground around the city. When the snow has melted any residuum is carted away.

Cleansing of Private Streets and Courts.—Prior to 1866 the owners of property were responsible for the cleansing of back courts and closes. Since that year, however, this work has been attended to by a staff of the Cleansing Department, the cost being met by a special rate of one penny per pound payable by the proprietors. Under this arrangement the courts and closes of the city, with very few exceptions, are attended to daily, and in many cases twice or thrice as necessity requires. The dirtier courts are regularly hose-

washed. For this purpose there are fitted into the courts at the expense of the Corporation 1489 taps. To these a hose pipe 1 inch in diameter is attached. In addition to this attention the worst of the places are scoured out periodically by means of a 1½-inch hose pipe, which is carried on a reel, as described under street washing, the hose being attached to the fire-plug in the street. The cost of cleansing private streets and courts exceeded last year the amount derived from the assessment on proprietors by £546.

Watering Streets and Roads.—In connection with the watering of streets in the busier portions of the city watering carts of the ordinary barrel type are employed. For the quieter roads in the outskirts, however, the Willacy patent watering machines are used. These patent machines so spread the water as to cover on one run a road 40 feet wide, as against two, and in some cases three, runs of the ordinary water barrel for a road of the same breadth. Watering is also resorted to during the night in dry weather, so as to prevent dust arising from the operations of the sweeping machines.

Domestic Refuse.—The ashpits used for storing domestic refuse were at one time, as has been already stated, placed upon the front streets opposite the houses. Later on they were transferred to the back yards, and this is the system which practically prevails in the city. It should be stated, however, that owing to the abolition of conveniences in the back yards and the general introduction within recent years of water-closets instead, the nature of the contents of these pits has undergone a vast change. The nuisance which formerly was connected with them has now been practically abolished.

To ensure systematic removal of the refuse each district is sub-divided into six divisions, one of which is overtaken each night. In this way ashpits all over the city are emptied weekly, with the exception of those in the Central and Eastern district, where a twice-a-week service is in operation. In several of the better class districts, however, a daily morning dust cart service obtains.

To improve matters still further, it has been decided to introduce, in connection with the removal of domestic refuse, the portable bin system, the bins to be placed under cover in the back yards. The object of this change is to obviate the nuisance inseparable from the present method of emptying ashpits, involving, as it does, the throwing of the material out of the ashpit, the conveying of it over the court and close to the street, the depositing of the material loosely thereon, and thereafter shovelling it into an open cart. Instead of this anti-quated method, the portable bin will be carried to the street, and the contents of the bin emptied inside of a large covered vehicle. By this means neither court, close, nor street will be soiled, and the lighter portions of the material cannot possibly be blown off by the wind.

Refuse from Business Premises.—The refuse from offices, shops, ware-houses, and other business premises (not manufactories) in the centre or business portion of the city is removed daily by the morning dust cart service. For the convenience of occupiers of such premises the depart-ment supplies covered galvanised cast-iron bins at cost price.

Excrementitious Matter and Fish Refuse.—This material is collected in galvanised iron pails of a regulation pattern fitted with air-tight spring lids, the pails on removal being replaced by clean ones. Fish

refuse, until within recent years, was simply collected in barrels or anything handy, and thrown out, and removed along with the ordinary refuse, the mixture being anything but a pleasant or profitable product. A specially constructed covered van is used for the conveyance of these pails, so that the process is neither offensive to the sense of sight or smell.

Waste Paper.—The separate collection of waste paper is a new branch of the service recently inaugurated. It was introduced with the view of reducing, as far as possible, the nuisance caused by the scattering of waste paper on the public streets. Bags for holding the paper are issued to offices, business premises, and better class dwelling-houses, and are called for as often as necessary by youths wearing a distinctive uniform. Covered vehicles are used for the collection of the bags. By this system the paper is not only kept off the streets, but, being collected separately from the refuse, it forms a marketable commodity, and a considerable revenue is derived from its sale.

In addition to the ordinary city refuse, the department undertakes by arrangement the disposal of the manure from the abattoirs and from the stables of the Corporation Tramway Department and other horse owners in the city.

Treatment of Refuse.—Having described the methods of collecting the various classes of city refuse falling to be dealt with by the department, the next process to be explained is its treatment.

For a number of years after 1868, when the collection and disposal of city refuse was taken over by the Corporation from the contractor, there were no other means of dealing with the material than by tipping it in open depôts, or into railway waggons at loading banks round about the city. In those depôts there were stored at times many thousands of tons of refuse. In 1874 the quantity actually on hand in the heat of mid-summer was 28,860 tons. Little wonder that there were frequent and clamorous complaints as to the nuisance arising from these accumulations! With the advance of sanitary science, however, other and better means had to be devised, and the present effective system was gradually organised. In 1881 the first refuse despatch station was erected at St. Rollox. In 1884 similar works were constructed at Crawford Street, S.S. In 1890 Kelvinhaugh Works followed. In 1894 furnaces were put down at Bridgeton. In 1897 Haghill Station was erected, and a cremating station will shortly be erected at Maryhill.

The following figures show the rapid increase in the quantity of material dealt with by the department:—

1869 - - - - - - -	140,240 tons.
1879 - - - - - - -	187,669 tons.
1889 - - - - - - -	223,030 tons.
1900 - - - - - - -	444,515 tons.

The process generally adopted at the stations is uniform. Carts with soft sweepings from paved streets are tipped into a series of specially designed tanks. These are fitted with sloping bottoms and drainers for carrying off the water. After a day or two the material gets into a fit state to be handled, and is barrowed to a waggon. Ashpit refuse is shot through openings in the floor into revolving riddles placed

horizontally. The finer portions of the refuse pass through the meshes of the riddle into a mixing machine underneath, which also receives a regulated quantity of excrementitious matter from a tank above. The closet pails, already referred to, are emptied into this tank, thereafter washed in hot water, and disinfected ready for issuing again. Dry sweepings from paved streets are also passed through the riddle and into the mixer; the whole, after being thoroughly mixed by means of revolving blades, falls into a railway waggon on the siding below. The rougher portions, which cannot pass through the riddle, are forced from its bell-shaped mouth by the revolving process on to an endless carrier. When passing over this carrier articles of any value, such as iron, meat tins and fruit tins, glass, bones, etc., are picked off, while the remainder, chiefly light useless material, falls from the carrier on to a range of furnaces on a lower level.

The interior of the furnaces is very simple. An important feature in connection with these destructor furnaces is that the vitiated air from the works is driven by means of a powerful fan at the rate of 40,000 cubic feet per minute into pipes which lead into the chambers underneath, thus forming not only a strong forced draught, but at the same time burning the bad air. The smoke, which is light blue in colour, is carried off by means of a tall chimney.

It will thus be seen that the process is one of separation of the saleable from the unsaleable. The better portions which fall direct into the waggon forms a good fertiliser, and finds a ready sale among agriculturists. The rougher material, which is passed to the furnaces, is cremated, and a considerable revenue is derived from the residuum of the burning process.

The following table shows the cost of treatment of refuse at despatch works and loading stations for year ending 31st May, 1900:—

		Material treated.		Average cost per ton.
		Tons	Cwts.	
St. Rollox, -	Despatch works with furnaces	68,547	13½	10·93d.
Crawford St., -	Do. do.	111,820	9½	9·03d.
Kelvinhaugh, -	Do. do.	91,664	14	9·36d.
Haghill, - -	Do. do.	40,163	0	11·67d.
Dalmarnock, - -	Partly furnaces and partly loading bank	38,822	16	10·15d.
Ruchill, - -	Loading bank only	16,729	16	4·26d.
Pinkston, -	Do.	6,260	16	2·37d.
Total, -		374,069	5	9·53d.

In addition to the material shown on the foregoing table, the following was disposed of otherwise than at the works of the department:—

	Tons	Cwts.	Tons	Cwts.
Snow deposited in Coups, - - -	27,124	16		
Mud deposited in Coups, - - -	29,261	9		
Sludge put on rail by Sewage Department for disposal at spoil banks, -	7,567	0		
Manure loaded by Tramway Department at sundry stations, - -	6,492	8½		
			70,445	13½
Material treated at Despatch Works as per above table,			374,069	5
Total material disposed of, - - -			444,514	18½

Utilisation of Material Saved from Refuse.—As already stated, iron, glass, and bones are picked off, laid aside, and sold. Tins having solder are also saved, and passed through a specially designed furnace in order to extract the solder; the tins themselves, after passing through the furnace, are flattened out and sold also.

The most important source of revenue in this connection is from the sale of clinker from the destructor furnaces. Previous to 1896 this residuum was trucked to tips in the country at a cost of 8d. per ton. In that year, however, an endeavour was first made to find a market for it as a material for making concrete. To begin with, it was broken by hand labour, but as the demand increased it was found advantageous to use mechanical breakers. Screening machinery has more recently been erected at one of the stations, which produces the clinker in five different sizes, so as to meet the requirements of contractors. Instead, therefore, of paying for the disposal of this waste product a considerable revenue is now derived, and this may be considered altogether saved money, as the cost of breaking does not exceed the cost of the former method of disposal. The following figures show the rapidly increasing success of this new departure:—

1896-97—Clinker sold, 2133 tons, realising	-	£242	11	2
1897-98—	,,	5682	,,	,,	-	643	1	10
1898-99—	,,	7266	,,	,,	-	804	6	0
1899-00—	,,	9184	,,	,,	-	1089	11	2

Disposal of Refuse.—Within the city there are four stations at which the refuse is dealt with as described. The collection and treatment of the refuse of the city forms no light task, but the disposal of such a huge quantity of material, which averages 1443 tons per working day, is a question which taxes to the utmost the staff of the department. By the process of cremation the quantity of domestic and shop refuse is considerably reduced, the reduction last year being 20 per cent., but there still fell to be disposed of by railway 49,299 waggons. Of this quantity 57·20 per cent. was sold to farmers as manure, and the remaining 42·80 per cent., being the unsaleable portion, sent to the tips at the farms of the department at Ryding, Fulwood Moss, and

Maryburgh. The quantity sent to the country was distributed over fifteen counties as follows:—

	Tons.	Per Centage.
Lanark	152,944	46·74
Renfrew	69,111	21·12
Ayr	27,440	8·39
Stirling	16,044	4·90
Dumbarton	15,396	4·71
Forfar	12,873	3·93
Perth	11,410	3·49
Linlithgow	10,353	3·16
Fife	5,838	1·79
Edinburgh	3,213	0·98
Haddington	1,834	0·56
Kinross	455	0·14
Selkirk	133	0·04
Kincardine	112	0·03
Bute	87	0·02
	327,243	100·00

For the transit of city manure and refuse to the country 894 railway waggons, the property of the Corporation, are employed. Special rates are fixed by Act of Parliament for the conveyance of the city manure. The department pays carriage to the railway companies, and charges the purchaser a price delivered.

Farms.—In consequence of the difficulty of disposing of such large quantities of material the Cleansing Committee found it necessary to acquire land on the different railway systems. The first venture in this direction was made in 1879 by the leasing, on a thirty-one years' improvement lease, of 98 acres of bog land, viz., Fulwood Moss, near Houston, Caledonian Railway, 10 miles from the city. In 1889 other 25 acres adjoining were added, and in 1896 another field of 19 acres was taken in, thus making 142 acres in all. The ground was originally a bog, and yielded no return whatever to the proprietor. The first step taken was to have the land thoroughly drained, and a railway siding run through the property. The total capital outlay in connection with this project is being cleared in equal payments, so as to be liquidated at the expiry of the lease. For some years potatoes were the principal crop, the varieties grown on the Moss finding a ready sale as seed. In recent years the chief products have been hay and oats, all of which are used in the stables of the department in town. The Moss is now a first-class agricultural subject, the only regret being that it reverts to the proprietor on the expiry of the lease. Apart from providing an outlet for immense quantities of refuse annually, the cropping account of the farm has always shown a profit.

The Cleansing Committee, with this instance before them of the folly of taking land on lease, decided to purchase outright in future. When therefore it was found necessary to obtain land as an outlet for surplus refuse on the North British Railway system they purchased the estate of Ryding, near Airdrie. This property, which was acquired in 1891,

is situated about 11 miles from the city, and originally comprised five farms, containing in all 575 acres, and costing only £22 5s. 4d. per acre. Two adjoining farms have since been added at a cost of £24 and £19 14s. per acre respectively. The whole estate now contains 817 acres. The soil of this property is, as a rule, poor and clayey, and capable of much improvement. The undulating nature of the surface lends itself admirably to the laying down of the surplus and unsaleable refuse of the city, and provides accommodation in this connection for many years to come. The ground has since the date of purchase been thoroughly drained, and suitable railway sidings have been formed. Suitable buildings have also been erected. The crops grown on this estate are, like Fulwood Moss, chiefly hay, oats, and turnips, which are used in the stables of the department in town. On the estate there are two whinstone quarries, which last year yielded in rent and royalty £298 18s. 4d.

Maryburgh is a small farm, 31 acres in extent, situated on the Caledonian Railway between Glenboig and Cumbernauld. It was purchased in 1895 for £1000, the object being to provide an outlet for surplus refuse loaded on the Caledonian north line.

Hallbrae Farm, which adjoins Maryburgh, and extends to 45 acres, could not be purchased, but was leased in 1895 for nineteen years. The object of the leasing of this farm was to give more complete railway connection with Maryburgh and provide siding accommodation for the delivery of city manure to farmers in the neighbourhood.

Altogether, at these farms the Cleansing Department owns and leases 1035 acres of land. To this land and the tips thereon there were sent during the year ended 31st May, 1900, the enormous quantity of 140,041 tons of refuse. The combined profit on cropping account in connection with the farms amounted to £579 17s. 5d.

A suitable place of deposit has, by means of these farms, been found for immense quantities of refuse, which, if not satisfactorily disposed of, would undoubtedly become a nuisance and a menace to public health in the city. Now, instead of these immense accumulations of refuse which in former years were to be found within the city boundary, every cartload of refuse which is collected during the night is either burned or despatched by rail to the country by ten o'clock the following morning.

Workshops.—The workshops of the department are situated at Charles Street, St. Rollox, contiguous to the destructor station. Here the vehicles and harness used by the department are made and repaired, and the railway waggons kept in running order. A railway siding runs right into the waggon repairing shop, and all waggons requiring repairs are sent thither by arrangement with the three railway companies. Labour-saving machinery of the most modern description is provided and driven by power derived from the adjoining destructor works. The tradesmen include joiners, cartwrights, waggon builders, blacksmiths, engineers, turners, painters, and saddlers. Horse-shoeing is the only portion of the work which is not done by the employees of the department. Owing to the rapid extension of the city and the consequent necessity of erecting stables in the outlying districts it is more convenient to have the horses shod by local horse-shoers than to send them from all points of the city to a central shoeing forge.

Granary and Stores.—The granary and general stores of the depart-

ment are centrally situated in Græme Street, quite near Glasgow Cross.

The granary is a building of four storeys; is fitted with the most modern machinery, and arranged on the most up-to-date principles. The grain is elevated by means of a hoist to the upper floor, where the various kinds are fed into large hoppers. The material passes automatically from flat to flat through the processes of measuring, cleaning, sifting, bruising, mixing, and finally bagging ready for despatch to the different stables. By means of this mechanical process all dust is removed from the grain, while magnets extract all nails or other pieces of iron or steel.

The farms of the department furnish all the hay required for the stud. It is baled at the farms, railed to town, and cut in the granary, all dust being removed. The straw and grain grown on the farms do not altogether meet the requirements of the department, and it is therefore necessary to purchase from dealers in town. The cost of feeding and bedding the horses of the department during year ended 31st May, 1900, was 10s. 0·65d. per horse per week.

The general stores are also at Græme Street. All material and implements required in the different districts are issued by the storekeeper, who has also charge of the granary. The materials required by the department are of a very varied description. They are purchased under thirty-four different contracts, which are fixed annually.

The heritable and movable property of the department in 1868, when it was first organised on the present footing, amounted to £19,162. In 1876 the property was valued at £43,064. Now the figure is £262,545. The total sum dealt with in 1868 was £55,924, in 1876 £82,052, and for the year ended 31st May, 1900, £160,000.

The cost of these varied and far-reaching operations in connection with the cleansing of the city on modern principles is of necessity considerable. During the year 1899-1900 the expenditure on general cleansing was £119,627 14s.; the revenue from manure sold and other sources was £40,372 7s. 5d., leaving a net cost against the general rates of £79,255 6s. 7d.

The cleansing of private streets and courts, which is work done for proprietors, and for which a special assessment of 1d. per £ is charged, cost £14,492 4s. 10d. Apart from the cleansing of private streets and courts, which work is not done by the Corporations of other cities, the cost of carrying on the various branches of the cleansing of the city during the past year was equal to a rate of 3·83d. per £ on the rental. This rate compares favourably with Dundee, 4·49d.; Edinburgh, 5·05d.; Liverpool, 6·40d.; Leeds, 8·20d.; Sheffield, 8·48d.; and Manchester, 9·63d.

GLASGOW CORPORATION CITY IMPROVEMENTS DEPARTMENT.

The department of the Corporation of Glasgow, popularly known as the "City Improvements Trust," was constituted under the Glasgow Improvements Act, 1866. The condition of matters which gave rise to, and the objects contemplated by, the constitution of the Trust cannot be better described than in the words of the preamble of the Act, which state—"Whereas various portions of the city of Glasgow

are so built and the buildings thereon are so densely inhabited as to be highly injurious to the moral and physical welfare of the inhabitants, and many of the thoroughfares are narrow, circuitous, and inconvenient, and it would be of public and local advantage if various houses and buildings were taken down, and those portions of the said city reconstituted, and new streets were constructed in and through various parts of said city, and several of the existing streets altered and widened and diverted, and that in connection with the reconstitution of those portions of the city provision was made for dwellings for the labouring classes who may be displaced in consequence thereof. . . . "

The congested areas referred to were situated in or immediately contiguous to that portion of the city known as "Old Glasgow," including Gallowgate, High Street, Trongate, and Saltmarket, and also in the precincts of Main Street, Gorbals.

The Lord Provost, Magistrates, and Council, and their successors in office were appointed as Trustees for executing and carrying into effect the provisions and purposes of the Act. The scheduled lands extended to about 90 acres. The Act, *inter alia*, empowered the Trustees (1) to form thirty-nine *new* streets, and to alter, widen, or otherwise improve twelve *existing* streets; (2) to purchase lands by agreement; (3) to take down the whole or any part of the buildings situated on any part of the lands acquired, to lay out the said lands of new in such way and manner as they might deem best, to sell or dispose of the ground or buildings, or lease or feu the same, or to erect buildings thereon, or dispose thereof, or lease the same, and generally to deal with the lands and houses acquired by them under the Act as absolute proprietors; (4) to erect and maintain on any of the lands acquired by them such dwelling-houses for mechanics, labourers, and other persons of the working and poorer classes as from time to time they might think expedient, and to let the same when so erected and fitted up to the class of persons mentioned at such weekly or other rents, and upon such terms and conditions as might be thought fit, or to sell or dispose of the same; and (5) to acquire, by agreement, ground for, and to form and lay out, a public park in the north-eastern district of the city at a sum not exceeding £40,000.

The amount which the Trustees were authorised to borrow on mortgage or otherwise for carrying out the purposes of the Act was £1,250,000, but by the Glasgow Improvements Amendment Act, 1880, this amount was increased to £1,500,000. An assessment was also authorised to be levied upon *occupiers* only, for defraying the expenses to be incurred in carrying out the objects of the Act, which was not to exceed 6d. per £ for the first five years, and 3d. per £ for a further period of ten years. By the Act of 1880 these restrictions as to the time during which the assessment was to be imposed were removed, and the maximum rate was fixed at 2d. per £ for an indefinite period.

The provision in the 1866 Act, putting the assessment wholly upon occupiers, was afterwards regarded as a blot upon the statute, having regard to the fact that the owners as well as the occupiers of property all over the city were equally interested in, and would derive mutual benefits from the improvements to be carried out within the scheduled areas. In 1892, therefore, an attempt was made to have this defect in the 1866 Act removed, but Parliament refused at the stage at which

the operations under the Act had then reached to make any change in the incidence of the assessment.

The period given for the compulsory purchase of the lands scheduled under the 1866 Act was five years, but as regards the lands not then acquired this period was extended for five years longer by the Glasgow Improvements Act, 1871.

Armed with the extensive powers thus conferred upon them by the Legislature, the Trustees, as soon as possible after the passing of the 1866 Act, proceeded to acquire by compulsion or agreement all the properties comprehended within the scheduled areas. In addition to acquiring those properties, the Trustees, in 1871, under the powers of the 1866 Act, purchased by agreement (1) the lands of Kennyhill, in the north-eastern district of the city, extending to 89 acres, at the price of £40,000; and (2) the lands of Overnewton, in the western district of the city, for £35,433 12s. 4d., and the lands of Oatlands, in the eastern district of the city, on the south side of the river Clyde, for £23,950. These prices do not, of course, include the sums which were subsequently expended by the Trustees in forming streets and sewers and laying out the lands at Oatlands and Overnewton for feuing purposes. Upon a portion of the lands of Kennyhill, containing 63 acres, there was formed what is now known as the Alexandra Park, which was completed and handed over to the Parks Trustees in 1872, and the remainder of the lands were conveyed to the Parks Trustees to be appropriated by them for building purposes.

Although the Act of 1866 authorised the Trustees themselves to erect, and seemed to contemplate that they would erect, new buildings upon the lands acquired by them, this power practically remained unexercised until 1889, the only buildings which the Trustees had erected up to this time being two model tenements in Drygate and the Model Lodging-Houses in Greendyke Street, Portugal Street, Clyde Street (Calton), North Woodside Road, Hydepark Street, and East Russell Street, to which special reference will afterwards be made.

It would appear that the Trustees, after clearing the lands acquired by them within the compulsory areas of the dilapidated and insanitary buildings standing thereon (which, to a large extent, they did as soon as possible after acquiring the same), and forming new, and altering, widening, and otherwise improving the existing, streets as provided for in the Act, expected that the lands within the said areas, as well as the feuing lands of Overnewton and Oatlands, would be taken up by private enterprise for the erection thereon of modern dwelling-houses and business premises, and that at prices which would largely recoup the ratepayers for the expenditure which they would be called upon to bear by way of assessments in carrying out the purposes of the Act. This expectation was to a large degree being realised, both as regards the feuing grounds at Overnewton and Oatlands and the cleared ground within the scheduled areas, when it was abruptly terminated by the commercial crisis that occurred in 1878, which brought about a complete collapse of the property market, and, so far as Glasgow was concerned, culminated in the failure of the City of Glasgow Bank. After this panic builders ceased either to purchase or to feu the ground remaining in the hands of the Trustees, even although it was publicly advertised for disposal at prices far below the normal value. At this period also

a great many of the old properties acquired for demolition were still standing, and as the maximum assessment leviable under the Act was now limited to 3d. per £, the Trustees were forced to conserve a considerable number of those properties, by making repairs and alterations thereon, in order to derive a certain amount of revenue therefrom. In this way the scheme for reconstructing the scheduled areas sanctioned and contemplated by the Act of 1866 was for a time, to a large extent, arrested.

As already mentioned, the whole of the seven model lodging-houses referred to (one being for females and the remaining six for males) had by this time been opened. The erection of these houses was largely, if not entirely, brought about in this way. Within the scheduled areas there existed at the date of the passing of the Act of 1866 a great number of what were designated *common* lodging-houses, conducted by private enterprise, where men and women were huddled together promiscuously, in dark and unventilated rooms, without any of the conveniences requisite for decent living, not to speak of healthful existence. These houses, besides being hotbeds of vice and misery, were also centres for the propagation of disease. To destroy such insanitary and unsavoury abodes, however, without providing accommodation of a higher and healthier kind for the classes who, either from choice or necessity, frequented them, would have been not to remedy, but to intensify the evil. The Trustees accordingly, at a very early date after obtaining their Act of 1866, took this matter in hand, and in rapid succession constructed and equipped the seven model lodging-houses, which are still retained and successfully carried on by them, even from a financial point of view. The houses are all provided with a common dining-room, a kitchen with utensils and fire available for cooking at any hour of the day, a large recreation room, and ample lavatory and bathing conveniences. Each lodger has a separate cubicle, with spring mattress, pillow, sheets, blankets, and bedmat. The charges range from 3½d. to 6d. per night. A provision shop is attached to all the homes, except one, where uncooked food can be purchased at outside market prices. Each house is managed by a resident superintendent and warders, and all the houses are visited by members of the Improvements Committee once a fortnight. The seven houses give accommodation for 2430 persons nightly, and rarely are the houses, taken all over, unoccupied to an extent exceeding 3 per cent. The total cost of the seven houses (including the sites and equipment) has been £109,343, and on this amount, in addition to writing off as depreciation the sum of £16,685 15s. 2d., there was a return for the financial year ending 31st May, 1900, of £4 17s. 1½d. per cent. on the original cost of the seven houses, and £5 14s. 7d. per cent. on their cost, as reduced by the sum written off for depreciation. The best evidence that the erection and conduct of those houses by the Trustees has been a complete success is to be found in the fact that the example has been followed both by private enterprise and by other municipalities in the towns and cities where the model lodging-house has been established. It may be of interest to mention that the model lodging-houses some time ago established in London under the auspices of Lord Rowton, who was private secretary to the late Earl of Beaconsfield, are upon the lines of the houses erected by the

Trustees, and that Lord Rowton personally visited and inspected several of these houses prior to commencing his operations in the metropolis.

Any narrative of the operations of the Trustees would be incomplete without reference being made to "The Family Home," situated in St. Andrew Street, off Saltmarket, and which was opened on 14th March, 1896. The construction and equipment of this building have cost £17,609. It was designed and erected to afford accommodation for deserving and respectable widows or widowers belonging to the working classes having one or more young children with no one to look after them. The house contains 160 single bedrooms, plainly furnished, each capable of accommodating one adult and three children, a common dining-room, a kitchen with gas fires and steam cooking boilers, a nursery, recreation rooms, baths, and lavatories, and the building throughout is lighted by electricity, and warmed by a hot water heating installation. The rent of a bedroom varies from 4s. to 5s. per week, according to the number of children occupying the room along with the parent, and regular meals are cooked and supplied to the inmates at the lowest possible charges. The Home is managed by a superintendent and matron, with a staff of nurses and other servants. The children who are under school age are tended by the nurses during the day while the parents are at work, and the older children are sent to school. The Home has steadily grown in favour with the class of persons for whom it was intended. So far the working expenses have each year since the opening resulted in a loss, but this loss is being gradually reduced in proportion to the increased number of residents, and it is expected that the establishment will ere long be at least self-supporting.

For about ten years after 1878 the action of the Trustees in dealing with the vacant ground and old properties still in their possession seems to have been paralysed by the fear of having to call upon the ratepayers for an increased assessment. Even necessary repairs upon these properties were delayed as long as possible, and, when executed, were kept down to a minimum. At the end of this period of *laissez faire* the properties still in the hands of the Trustees were probably the worst and most insanitary in the city.

In 1888, however, active measures were recommended by the Trustees for the demolition of the remaining old properties and for the erection upon the sites thereof, as well as upon the other vacant ground held by them, of new and improved dwellings. The first two blocks erected were on the east side of Saltmarket, and consisted of tenements of shops and dwelling-houses. After having once again put their hands into the mortar tub, the work of demolition and reconstruction proceeded apace, with the result that practically the whole of the areas scheduled under the Act of 1866 and the surplus lands taken over by the Trustees from the Police Commissioners in 1893 have now (1st May, 1901) been covered with buildings of a substantial and modern character. In two or three instances only have old properties been remodelled and improved, and it is intended that these should be left standing for a few years yet.

In order that as little loss as possible might accrue to the ratepayers, the Trustees, in all cases where the lands to be dealt with had valuable street frontages, erected thereon buildings with shops, and other business premises on the ground floor, while the upper floors

were devoted to dwelling-houses for the working classes. Upon the less valuable sites tenements consisting exclusively of dwelling-houses, also suitable for the working classes, were erected. In all 46 blocks of buildings have been constructed upon the lands in question. There are 200 shops and 1455 dwelling-houses in these buildings. Of the latter 402 are one-apartment, 890 two-apartment, and 152 three-apartment houses, and there are only 11 houses of a larger size. The old properties reconstructed by the Trustees, and still standing, contain 116 one-apartment, 123 two-apartment, and 93 three-apartment houses, and there are only 10 houses of a larger size. The total population provided for by the Trustees in these houses, the seven model lodging-houses, and the Family Home may be taken at 11,875. The minimum rents charged for the one-apartment houses is £4 10s.; for the two-apartment houses, £6 16s.; and for the three-apartment houses, £12 9s. per annum, while the maximum rents are £8 15s., £14, and £21 per annum respectively.

The lands of Overnewton and Oatlands had before this time all been feued out, and many of the annual feu-duties or ground rents in respect of which the feus were given out had been sold for prices equal to twenty-three years and upwards. The only portion of the lands of Oatlands retained was a small piece of ground close to the riverside, which has been formed into an open space and children's playground.

There are two special matters connected with the city improvements scheme which may now be briefly referred to. In 1876 the Trustees took the opinion of counsel (Lord M'Laren) as to the legality of inserting in the charters of all the lands which might be feued by them a clause prohibiting premises for the sale of intoxicating liquors from being erected thereon. Counsel entertained great doubt as to the validity of a resolution of this kind if made applicable to the whole estate vested in the Trustees by the Act of 1866, but advised that if the prohibition were confined to any one particular area, and constituted a real burden upon the ground, it would, in his opinion, be legally binding and operative. Acting upon this advice, the Trustees selected what is known as the "Calton area" as the one upon which the prohibition should be imposed, the result of which has been that not a single public-house has been, or can be, established in any of the new properties erected within that area upon ground feued from the Trust. As a step further in this direction of social reform, the Trustees, in 1890, adopted a resolution to discontinue all licensed premises exising in the properties belonging to them at the end of the then current leases, and to grant no new leases for such premises, either in these properties or in any new properties which they might erect. The result of this resolution has been that not one public-house now exists in the very numerous properties of which the Trustees are the owners. From time to time as the properties within the scheduled areas were acquired they were put into the hands of outside factors, who, until the subjects came to be demolished, attended to any repairs requiring to be made thereon, collected the rents, and accounted periodically for the same to the treasurer of the Trust. This system continued for about twenty-six years. At the end of this time the number of old and new properties belonging to the Trust was so great that a correspondingly large number of factors had to be employed to look after them. In

1892, however, it was resolved to inaugurate a new system by dispensing with the services of outside factors and appointing a general manager for the Trust. Mr. W. C. Menzies was accordingly appointed to this office. His duties are to take a general supervision of the whole properties of the Trust, including the lodging-houses and Family Home, to collect the rents and other revenue receivable therefrom, and to see that all necessary repairs are at once attended to and properly executed. Under the manager there are a number of caretakers, to each of whom is allocated a certain share of such properties as more particularly need to be supervised in this way, and in one of the houses situated in the properties assigned to him the caretaker has his residence. This new method of management has proved very satisfactory. It has resulted in a financial saving, and brought all the properties and the tenants occupying the same more directly under the control of the Trustees.

Before passing on to notice the additional powers granted to the Corporation by the Act of 1897 some further reference may be made to the assessment sanctioned by the 1886 Act. The maximum and the minimum rate and the period during which it might be imposed have already been mentioned. The maximum rate of 6d. per £ was only levied for the first year. The following year it was fixed at 4d. per £, and remained at this rate till 31st May, 1871. Thereafter it was gradually further reduced to 3d. per £ for two years, 2d. per £ for eleven years, 1½d. per £ for three years, 1d. per £ for five years, ½d. per £ for three years, and ¼d. per £ for each of years 1895-96 and 1896-97. Since the last-mentioned year the financial position of the Trust has been such that it has not been necessary to impose any assessment under the 1866 Act.

The total amount of assessment received from the ratepayers from 1866 to 1897, when it ceased, was - - - -	£597,003 0 11
As at 31st May, 1900, the net free assets over liabilities amounted to - -	17,129 12 2
The total cost of the schemes under the 1866 Act to the ratepayers from first to last may therefore be stated at -	£579,875 8 9

For this they have obtained:—

1. The Alexandra Park;

2. 98,929 square yards of ground applied in the formation of thirty new streets and in the improvement of twenty-six existing streets, being 34,259 square yards of street surface beyond what was contemplated in the original scheme; and

3. The sanitary and social amenities produced by the street, sewer, and other public works, which have cost £106,279 0s. 9d.

No sinking fund was provided for in the Act of 1866. By section 6 of the Amendment Act of 1880, however, it is provided that so soon as the Trustees have completed the works authorised by the 1866 Act, and shall have sold and realised the various properties acquired and held by them, the powers of assessment under the 1866 and 1880 Acts shall be leviable and applicable only to meet the expenses of carrying

on and managing the Trust, and to provide and set aside as a sinking fund such an annual sum as shall, by accumulation with compound interest thereon at the rate of 4 per cent. per annum, be sufficient to pay off in twenty years the whole of the money then owing by the Trustees.

Looking, however, to the financial position of the Trust, as shown by the following balance sheet, it does not appear that the provisions of section 6 of the 1880 Act will, so far as the sinking fund thereby provided for is concerned, require to be put into operation.

SUMMARY OF BALANCE SHEET UNDER ACT OF 1866 as at 31st May, 1900.

LIABILITIES.

Cash held on loan,			£1,276,784 17 11
Open accounts,			6,960 15 11
Sinking fund,	£3,747 2 10		
Reserve fund,	3,747 2 10		
		7,494 5 8	
Balance of free assets,			17,129 12 2
			£1,308,369 11 8

ASSETS.

Tenement buildings erected,			£298,259 17 8
Tenement buildings acquired from Streets Improvements Committee and others,			75,305 17 6
Tenement buildings under construction,			5,237 10 0
Ground valued by city engineer,	£493,181 12 0		
Less Capitalised value of unredeemed burdens,	14,702 18 9		
		478,478 13 3	
Lodging-houses, including Family Home,	£130,442 6 6		
Less Allowance for depreciation,	16,685 15 2		
		113,756 11 4	
Capitalised value of feu-duties and ground annuals,			322,780 2 11
Security, stock, cash, and outstanding accounts,			14,550 19 0
			£1,308,369 11 8

In 1896 the Corporation promoted in Parliament an Omnibus Bill, the principal objects of which, so far as relating to the City Improvements Trust, were (1) to obtain compulsory powers over six congested areas on the north side and one similar area on the south side of the river Clyde for the purpose of removing the old and insanitary buildings and reconstructing the areas; (2) to widen Nelson Street from Trongate to Bell Street, which had been authorised by the 1866 Act, but never carried out; (3) to purchase by agreement any lands not exceeding on the whole twenty-five acres, either within the city or within a radius of half a mile from the boundaries of the city, for the purpose of erecting thereon houses for the poorest classes; and (4)

to impose a new assessment equally on landlord and tenant to carry out these objects. The portion of the bill relating to these matters was keenly opposed by, *inter alias*, the Glasgow Landlords' Association, Limited, and the Wine, Spirit, and Beer Trade Association—by the latter for the reason apparently that there were a number of public-houses within the scheduled areas. Notwithstanding this opposition to the measure, it was successfully carried through Parliament without any clause whatever being obtained by either of the opponents named, and on 6th August, 1897, it received the royal assent under the title of "The Glasgow Corporation (Improvements and General Powers) Act, 1897."

The amount authorised to be borrowed under the 1897 Act for the improvements and other operations before referred to was £560,000, and of this amount £100,000 was to be applied exclusively in the purchase of the 25 acres of ground and the erection thereon of dwellings for the poorest classes, provided for in section 12 of the Act.

As the price (£103,245 18s) paid to the Police Commissioners for the lands and ground annuals taken over from them in 1893 had been met out of the £1,500,000 authorised to be borrowed by the Trustees under the Acts of 1866 and 1880, the borrowing powers under these two Acts were by section 15 of the 1897 Act increased to the extent of the first-mentioned amount.

The new assessment authorised by the 1897 Act was limited to 1d. per £, and, in contrast to the assessment under the 1866 Act, which was entirely on occupiers, was to be levied equally upon landlord and tenant. A sinking fund was also provided for of such an amount as to secure that the capital sums borrowed should be paid off within a period not exceeding sixty years.

The seven congested and insanitary areas scheduled under the 1897 Act contained in all about six acres. The whole of the properties within these areas were acquired either by agreement or arbitration within a considerably shorter time than the three years allowed by the Act. The amount which has been paid for these properties, and also for those required for the widening of Nelson Street, including claims for business disturbance and expenses, may be stated in round numbers at £300,000.

Considerable progress has already been made with the reconstruction of the areas scheduled under the 1897 Act. On the portion of the King Street area, north of Parnie Street and abutting on Trongate, new buildings, consisting exclusively of business premises, are reaching completion, and the covering of the portion of this area south of Parnie Street with buildings of a similar character is about to be commenced. It is estimated that the cost of the buildings on both sites will be £46,583 6s. The reason which led the Trustees to confine the new buildings on these two sites solely to business premises was the commercial value of the ground, and this action was quite within the discretionary powers given to them by the 1897 Act.

Plans for the reconstruction of the two areas on the east and west sides of High Street, north of George Street, were also some time ago adopted by the Trustees. The buildings on the west side of the street, which consist of warehouses, shops, and dwelling-houses, are now being erected, but it is not intended to demolish the existing, and proceed

with the erection of the new, buildings on the east side (which are to be of a kind similar to those on the west side) until the last-mentioned buildings have been completed. The reconstruction of these two areas includes the widening of High Street north of George Street to 55 feet. The cost of the buildings on both sides of High Street is estimated at £65,400.

Designs have also been selected for the reconstruction of the Nelson Street area, which comprehends the entire east side of that street and portions of (*a*) the north side of Trongate, (*b*) the south side of Bell Street, and (*c*) the west side of High Street between Bell Street and Trongate. So far as fronting Nelson Street and Trongate, the new buildings will be wholly business premises, but as regards those fronting Bell Street and High Street, dwelling-houses will be included. The total cost of the buildings when completed is estimated at £88,231. The erection of the first instalment of these buildings will be commenced within the next two or three months. After the east side of Nelson Street has been finished the only thing that will remain to be done to complete the widening of it from a passage of 22 feet wide to a street of 50 feet wide will be the reconstruction of the north-west corner from Antigua Place to Bell Street. This portion will be proceeded with at the earliest possible date.

It may be mentioned that the plans for the reconstruction of the whole of the three areas before referred to were competitive designs invited from outside architects of well-known ability, and were selected by the Trustees after mature consideration and under the advice of a competent expert.

In the exercise of the powers given to them by section 12 of the 1897 Act, the Trustees have also already acquired from other departments of the Corporation at merely nominal prices close upon 25 acres of vacant ground for the erection thereon of dwellings for the poorest classes. The largest portion of the ground so acquired is situated upon the fringes of the Alexandra and the Springburn Parks, in the northern quarter of the city, while the remaining portions are located in Baltic Street and at Haghill, in the eastern district of the city.

The covering of the ground at Haghill with buildings of the character just described, from plans furnished by an outside architect, was completed in June, 1900. The buildings contain in all 69 houses of one apartment and 84 houses of two apartments. The former are let at an average rent of £4 19s., and the latter at £7 19s. 6d. per annum. The cost of the tenements has been £14,399.

Plans for the erection of similar tenements on the ground in Baltic Street have also been prepared by the same architect, and the work is to be commenced at once. The estimated cost is £9528.

In the case of the Haghill tenements it is calculated that, after allowing the usual 25 per cent. for taxes, management, repairs, and insurance, the rents charged will yield 5 per cent. on cost of ground (7s. per square yard), 3½ per cent. on cost of buildings, and 1¾ per cent. for sinking fund.

The committee in charge of the same have now under consideration the exact kind of buildings to be erected upon the remaining ground at Alexandra Park and Springburn Park. It is a question whether these should be more of the small cottage rather than of the tenement order,

but whatever is resolved upon, the buildings will be such as to conform with the requirements of section 12 of the 1897 Act.

It is to be hoped that what has been set down in the foregoing pages will convey in some measure at least an idea of the scope and value of the great work which has been accomplished by the City Improvements Trustees within the sphere of their past labours. So far as the central portions of the city are concerned, especially in the region of the Cross and the historic Saltmarket, very little now remains of old Glasgow as it existed prior to 1866. Indeed, so great have been the changes effected by the operations of the Trustees in this locality that if the shade of Bailie Nicol Jarvie were to revisit it he would fail to find any of the ancient landmarks, except, perhaps, the steeples of the Tolbooth and the Tron Church and the statue of King William, and as for the latter he would be puzzled to know why it had changed its *locus*. Although, however, the operations already carried out by the Trustees under the Acts of 1866 and 1897, and those still to be completed under the last-mentioned Act, have been and will be productive of great sanitary and hygienic advantages to the whole community, there are still a few "dark spots" within certain districts of the city for the clearance and reconstitution of which legislative sanction is required. It will be for the City Fathers of this, the beginning of the twentieth century, to take early and active measures for these remaining congested and insanitary areas being dealt with, and by doing so the Corporation of Glasgow will thus maintain the high reputation it has attained among municipalities of the world.

ENGINEERING AND ARCHITECTURAL DEPARTMENT.

The work carried on in the office of the city engineer is of a complex and important character, and includes not merely the design and construction of such works as fall within the ordinary practice of a civil engineer, but a large amount of architectural work as well. Apart from this, the city engineer is required from time to time to advise with the numerous committees of the Town Council regarding the various matters that engage their attention. These embrace a range of subjects too wide to enumerate, extending as they do from the intricate public interests that influence the policy of the Corporation in their Parliamentary business, to the adjustment of the details of a royal pageant. Intermediately the duty devolves on him of valuing the heritable estates of the Corporation, and determining, under the provisions of a special statute, the terms on which property may be transferred from one department of the public service to another.

The engineering work in itself is extensive and important, comprising the preparation of Parliamentary plans and sections for deposit, and the compilation of large wall maps for use in the Committee Rooms of Parliament, whether the action of the Corporation be the promotion or the opposition of private bills. There is also the duty of aiding in the preparation of cases for submission to Parliament, and the attendance to give evidence before the respective Committees of the Lords and Commons.

The revision of the Ordnance Survey of the city likewise falls under his charge, as does also the professional work necessary to the preparation of plans for the development and realisation of the lands belonging to the

several departments of the Corporation, and the construction of the streets, sewers, and other works required for these purposes.

The construction and repair of the river embankments above the harbour involve large expenditure, and for their more effectual protection a tidal weir, equipped with movable sluices, has for some time been in course of construction, and is now approaching completion. This complex and most difficult undertaking has been carried out according to a plan suggested by Sir Benjamin Baker, K.C.M.G. The work has occupied a longer time than was anticipated, mainly on account of the character of the river bed, below which the foundations of the weir have been constructed, under air pressure, in concrete, enclosed in steel caissons, 30 feet deep, which form a curtain wall extending from the northern to the southern bank of the river, to provide a rest for the mid-stream piers and the sills of the three sluices. The work was originally estimated at £70,000, but various modifications of the design, attributable to obstructions that could not have been foreseen, will add considerably to the cost.

The principal undertaking entrusted to the department of the city engineer is the scheme for completing the main drainage of Glasgow and the adjacent local authorities. Authorised by Parliament in 1896 and 1898, this great undertaking, whose dimensions exceed those of any similar work in this country outside of the metropolis, involves the construction of 30 miles of sewers varying in size from 3 feet to 10 feet diameter, by which the drainage of the city and the adjacent districts will be conveyed to separate sewage disposal works on the right and left banks of the river Clyde. The sewage derived from the right bank will be conveyed to a station at Dalmuir, situated about seven miles to the west of the river Kelvin, and the sewage collected on the left bank will be treated at Braehead, on a site about a mile eastward of the burgh of Renfrew.

The drainage on either side of the river will be conveyed partly in outfall sewers of large capacity which will deliver their contents by gravitation, and partly by low level sewers of less capacity, which will be pumped into the outfalls. The pump for the northern sewage is in Partick, and for the southern in Pollokshields. The dry weather flow of sewage included within the area drained by the works to be constructed on both banks of the river will, when the whole territory is developed, be about 94 million gallons per day, augmented occasionally by rainfall to 189 million gallons. The capacity of the different sewers has been so designed as to convey without surcharge a quarter of an inch of rainfall, over and above the dry weather flow.

The method of sewage treatment which the Corporation, after much anxious deliberation, have resolved to adopt, is chemical precipitation. It is not intended to make use of sludge presses, as the separate works are situated on the fairway of the Clyde, and the liquid sludge can thus be economically carried out to sea.

The Parliamentary estimate for this undertaking was £1,000,000, but the great increase in the rate of wages and the cost of material which has been experienced since 1896 will have a corresponding effect on the outlay involved in the construction of the authorised works.

The working drawings and specifications for the works on the right bank of the river were prepared three years ago, but various causes induced the Corporation to delay the commencement, so that at the present time only 4 miles of the outfall sewer have been actually constructed. Work has

however, been begun on the pumping station at Partick and the sewage works at Dalmuir, and arrangements are in progress for letting the contracts for the low level sewers and the remainder of the outfall. The design of the works authorised for collecting and disposing of the sewage of the left bank of the river is in active preparation.

The architectural work of the department is very extensive, including the design and construction of hospitals for infectious diseases and isolation houses for cases of suspected infection, baths and wash-houses, markets and slaughter-houses, public halls and libraries, lodges, waiting rooms and entrance gates for the public works, police offices, fire stations, and the erection of improved dwellings for the labouring and artisan classes, as well as the ordinary work of superintending and maintaining a vast extent of public property.

The outlay involved in the different buildings enumerated is necessarily very great, and cannot, without occupying undue space, be set forth in detail. It may be of interest, however, to state that the hospital for infectious diseases at Ruchill will cost upwards of £250,000. The work at present in hand in the Baths Department represents an outlay of £50,000. The work being carried on in connection with the markets and slaughter-houses exceeds £30,000; the extension of the fruit market, £60,000; public halls and libraries under design at present represent upwards of £30,000. The extension of the fruit market involves the erection of a new Central Police Office at a cost of not less than £30,000. The Central Fire Station cost upwards of £40,000, and the various blocks of improved dwellings at present in progress in different parts of the city, so far as these have been designed in the office of the city engineer, will cost upwards of £25,000.

The constructional work in the different public parks, including bridges, as well as buildings, entrance gates, and railings, also devolves on the city engineer, as does also the duty of aiding the several committees of the Corporation in protecting the amenity of the city wherever the structures of railway companies are carried over or along the leading thoroughfares of the city.

MASTER OF WORKS OR STATUTE LABOUR DEPARTMENT.

The Master of Works has charge of the public roads, bridges, sewers, and public conveniences, and is responsible for the carrying out of the provisions of the Police Acts for securing the safety, health, and comfort of the citizens in connection with the construction, alteration, and repair of buildings, private streets, pavements, courts, ashpits, and other works, the maintenance of which devolves upon proprietors. Along with other officers, he requires to inspect all factories, workshops, theatres, and music halls, and also the buildings requiring to be licensed under the Petroleum Acts.

Roads.—The city roads are divided into two classes—(1) Public streets, maintained by public assessment; and (2) private streets, maintained by proprietors whose property has a frontage thereto.

The public streets, previous to 1843, were, with a few exceptions, paved with rough whinstone irregular blocks or cobble, the exceptions being the principal or main thoroughfares—thirteen in number—which, for facility of traffic, were partly paved with square dressed whinstone setts, 4 to 6 inches broad and 8 inches deep, laid on a bed of sand 9 inches deep, the

other parts of those streets being paved with the rough blocks referred to. In 1838 a small portion of Jamaica Street was paved with granite setts from Inverary Quarries, and at the same time the rest of the street was paved with whinstone. Six years later it was found that, while the whinstone was much worn, the granite setts were as good as when first laid. According to a report made in 1844 by Mr. Carrick, the then Master of Works, it was calculated that at the end of twenty years the cost of whin paving, including repairs made during that period, would slightly exceed the cost of granite, and that, while the former material would be worn out and be unfit for relaying, the latter, with a slight redressing, would be practically as good as when first laid. The adoption of granite as a paving material for the principal streets was accordingly resolved upon, whinstone being used in streets where the traffic was light. Since that period portions of the rough rubble causeway have, year by year, been lifted and replaced with square dressed stones. For some years past the streets have, as a general rule, had a foundation of Portland cement concrete 4 to 6 inches deep, and the joists of the setts are grouted with Portland cement or coal tar pitch, whereas formerly the joints were grouted with sand, although occasionally lime was used.

The total sum expended on the paving of the public streets with square dressed blocks has been as follows:—

	Granite Paving.	Whin Paving.
From 1844 to 1876 -	£300,348 15 9	£33,524 9 9
From 1877 to 1901 -	274,009 1 6	146,166 13 3
	£574,357 17 3	£179,691 3 0

—a total of £754,049 0s. 3d., exclusive of the sums expended by the Corporation Tramway Department.

Experiments with wood blocks for paving purposes have not given very satisfactory results in this city. Soft wood rapidly wears out, while hard wood blocks only remain good for a period not exceeding seven or eight years. This is due partly to the excessive moisture in our atmosphere, and partly to the method of shoeing horses here.

Somewhat extensive experiments are at present being made with a comparatively new material called tar macadam, and in streets where the traffic is light it seems likely to prove a success.

Portions of certain streets have also been experimentally paved with alcatraz and seyssel, but so recently that no decided opinion can as yet be formed of their suitability as paving materials here.

In regard to cost and durability granite stands far ahead of all other materials. Its principal disadvantage—that of noisiness—is common to all stone pavings in a greater or lesser degree.

The rate of assessment for the maintenance of roads and bridges, and providing for a sinking fund of 5 per cent. for permanent paving, and 2 per cent. for bridges, is at present 4d. per £ on rental, one-half payable by the proprietor and one-half by the tenant; the assessment provided the sum of £83,056 16s. 6½d. for the year ending 31st May, 1900. The length of the public streets is 214½ miles, of which 106½ miles are macadamised.

Bridges.—The bridges forming part of the city roads are maintained out

of the assessment for the upkeep of roads and bridges, and are as undernoted:—

ROAD AND FOOT BRIDGES OVER THE RIVER CLYDE.

		Opened.	Width.	Cost.
Rutherglen Bridge,	Stone	7/8/96	60 feet	£75,547
Dalmarnock Road Bridge,	Iron	6/5/91	50 ,,	30,500
Polmadie Foot Bridge,	Wood	13/6/01	16 ,,	
Govan Street Bridge,	,,	13/6/01	50 ,,	
M'Neil Street Suspension Bridge,		1856	13 ,,	6,348
Albert Bridge,	Iron	21/6/71	60 ,,	62,328
Victoria Bridge,	Stone	1/1/54	58 ,,	46,206
*Portland Street Suspension Bridge,		1853	14 ,,	9,083
Glasgow Bridge,	,,	24/6/99	80 ,,	129,500

ROAD AND FOOT BRIDGES OVER THE RIVER KELVIN.

		Opened.	Width.	Cost.
Canniesburn Road,	Stone		25 feet	
Bridge Street, Maryhill,	,,		24 ,,	
Kelvindale Road Bridge,	,,		18 ,,	
Kirklee Bridge,	,,	13/6/01	60 ,,	£25,000†
Foot Bridge at Ford Road,	Wood	July, 1886	7 ,,	
Queen Margaret Bridge,	Iron	1870	34 ,,	
Belmont Bridge,	,,	1870	40 ,,	
Great Western Road Bridge,	,,	29/9/91	60 ,,	51,878
Woodlands Road Bridge,	,,	1895	60 ,,	
Dumbarton Road Bridge,	,,	1877	60 ,,	
Old Dumbarton Road Bridge,	,,	1896	50 ,,	

BRIDGES OVER CANAL.

		Opened.	Width.	Cost.
Castle Street,	Stone		60 feet	
Garngad Road,	,,		50 ,,	
Millburn Street,	Iron		50 ,,	£2431

BRIDGES OVER THE RIVER CART.

		Opened.	Width.	Cost.
Millbrae Bridge,	Stone	20/1/99	50 feet	£3850
Bridge at Cathcart,	,,	being built	60 ,,	

Sewers.—The sewers for the general drainage of the streets and buildings abutting on same are of two kinds—(1) Public sewers, for the drainage of public streets, the cost of the construction of which is paid for by the proprietors up to a size equal to that of a circular sewer 3 feet in diameter; the extra cost of any size above this is paid for by the city; (2) private

*Taken over from proprietors at £9083. Further sum of £6836 spent shortly afterwards on extensive repairs, including service bridge.
† Estimated cost.

sewers for the drainage of private streets, the cost and maintenance of which are paid by the proprietors of property fronting the street. The length of public sewers in the city constructed previous to 1849 was 40 miles. The length constructed between 1849 and 1876 was 48¼ miles, costing £111,216; and between 1876 and 1900, 35 miles, costing £187,790.

The cost of the maintenance and repair of the public sewers and street gratings is about £13,000 per annum.

Workmen.—The staff of workmen employed in the maintenance and repair of streets and sewers numbers 400 in all.

Contracts.—All new pavior work, extensive renewals, and the construction of new sewers are done by contract. The pavior work contracts extend from three to five years. All materials are supplied under yearly contracts, with the exception of granite and whin setts, the contracts for the supply of which extend from three to seven years. Separate contracts are entered into for the construction of each sewer.

Public Safety, Health, and Comfort.—The duty of the inspecting staff is to visit their districts and ascertain and note any defects in footpaths, streets, courts, drains, ashpits, washing-houses, or in the structure of buildings. When defects are found, notices are issued to the parties responsible, requiring them to make good such defects. Parties not complying with the requirements of such notices within the time specified for the execution of the works may be proceeded against, as provided in the Police Acts. The number of such notices issued to proprietors during the year ending 31st May, 1900, was as follows:—

For repairs on	streets, - - - -	927
,,	footpaths, - - -	3540
,,	drains, - - - -	1022
,,	wash-houses, - - -	105
,,	outhouses, - - -	382
,,	buildings, - - -	755
,,	areas and back courts, -	362
	Total, - - -	7093

Dean of Guild Court.—This Court was instituted in 1605 under a Letter of Guildry, its power from that date till 1862 being principally, so far as the structure of the city was concerned, confined to the securing of the proper lining of the streets and the protection of the rights of adjoining proprietors in regard to boundary lines, etc. The necessity for acquiring powers to regulate the laying out of new streets and securing that these should be of adequate width, for the securing of sufficient air space in front of and behind buildings, for regulating the minimum capacity of dwelling-houses, for securing proper drainage and sanitary necessities, etc., resulted in an application being made to Parliament for additional powers and in the passing of the Glasgow Police Act of 1862, under which authority was granted to the Dean of Guild to enforce the carrying out of provisions necessary for the public safety and health in connection with the erection of new and the alteration of old buildings. These powers and provisions have, by the passing of the Police Acts of 1866, 1890, 1892, and 1900, been largely extended.

Under the Police Act, as at present in force, application for authority to erect a new or alter an old building must be lodged with the Dean of

Guild, accompanied by complete and detailed plans of the intended operations. The Master of Works is called as a party in every case in the public interest, and the plans are carefully examined by him to see that the requirements of the Acts are complied with previous to warrant authorising operations being issued by the Dean. The works so sanctioned are periodically examined by the inspectors of the Master of Works, and when completed in accordance with the plans he reports to the Dean of Guild that they have been so completed, and the Dean then sanctions the occupation of the building. Cases of non-compliance with the requirements of the Acts are reported to the procurator-fiscal to the Dean of Guild Court, and proceedings may be taken against the offending parties in terms of the Acts. The total number of linings granted by the Dean of Guild Court in 1876 was 636, and in 1900 536.

Area of the City.—Since 1876 the area of Glasgow has been more than doubled, and it may be of interest to show how the area of the city has been extended from time to time.

The ancient Royalty, the charter for which was granted in—

1636	Contained - - - - - - - - -	1768 acres.
There were added in—		
1800	Part of Glasgow Green and part of the present centre of the city, between Ramshorn Church and St. Enoch's Burn - - -	96 ,,
1830	The area between St. Enoch's Burn and the burgh of Anderston - - - - - -	296 ,,
1843	The Necropolis, and the portion of the city between Castle Street and Garscube Road, south of the canal - - - - - -	213 ,,
1846	Areas including the burghs of Anderston, Calton, Gorbals, and portions of the counties adjoining, making the municipal boundaries correspond with the Parliamentary boundaries - - - - - - - - -	3418 ,,
1872	Areas including Glasgow University, Hundred Acre Hill, and part of Alexandra Park, etc. *Note.*—A portion of the ancient Royalty in the Springburn district was also added to the municipal boundary at this time.	242 ,,
1878	Coplawhill - - - - - - - - -	78 ,,
1891	Burghs of Maryhill, Hillhead, Govanhill, Crosshill, Pollokshields (West and East), Kelvinside, and portions of county of Lanark, and extensions at Belvidere, etc. - - -	5750 ,,
1896	Bellahouston Park, etc. - - - - -	450 ,,
1899	Blackhill and Shawfield areas - - - -	377 ,,
	Making total area of municipality now	12,688 ,,

THE FIRE BRIGADE.

One of the most interesting, as well as one of the most useful, departments of the Corporation is the Fire Brigade, which has had a most striking development. The earlier efforts in the direction of fire extinction, when

contrasted with the elaborate, extensive, and, it may be added, expensive organisations of to-day, appear to be crude, slow, and ineffective.

The records of the city disclose that a conflagration occurred on 17th July, 1652, which was far-reaching in its consequences, resulting, as it did, in the total destruction of about one-third of the city, and irreparable loss to more than one thousand families, who were rendered homeless. The loss was estimated at £100,000. Following upon this fire, in 1656, the Town Council ordered their first fire engine. It is unnecessary in this article to trace the fluctuating history of the Fire Brigade. Nothing further seems to be called for than to indicate the present position and scope of a department upon the efficiency of which so much depends.

The following summary may prove interesting:—

In 1870 Glasgow purchased its first steam fire engine. In 1871 two new manual engines were ordered. In 1872 other two steam fire engines were purchased and are still in service, though about to be placed in reserve, after twenty-nine years' service. In the same year it was agreed to purchase horses for the Fire Department, and the resolution was put into effect in January, 1873. The first of the street fire alarms was fitted up in 1878, and these were likewise the first to be used in Great Britain. In 1878 it was decided to convert the staff into a permanent one, and the staff soon after consisted of about 70 men and 50 police auxiliaries. The subjoined table contains some features of interest as showing the progress within the tenure of office of the present head of the department:—

	Staff.	Horses.	Steam Fire Engines.	Manual Engines.	Hose and Ladder Carriages.	Fire Escapes.	Hand Reels.
1884	127	11	3	15	6	1	14
1901	121	39	11	2	12	4	3

	Tool and General Purposes Carriages.	Butts or Water Carts.	Public Fire Alarms.	Private Fire Alarms.	Hose. Yards.	Fire Cocks, Valves, and Hydraulic Hydrants.
1884	1	9	82	6	9,213	3,562
1901	7	—	168	46	15,710	5,955

While the above shows the staff as 127 sixteen years ago, 50 of that number were police constables, the permanent staff being thus 77. The services of the constables as firemen were dispensed with in 1891. The net increase in the permanent staff during the last sixteen years is ·57, the increase in horses is 3·5, in steam-engines 3·7, the hose-carriages are doubled, fire-escapes increased fourfold, tool and general purposes carriages increased sevenfold, public fire alarms a little more than doubled, private fire alarms nearly eight times what they were, hose increased ·7, fire-plugs and hydrants increased ·67. The decreases in plant are in manual engines having 13 less, hand reels reduced from 14 to 3, and only one of the three, viz., the one at St. Enoch's, being now in use. There are now only two buildings used as fire stations which were in service sixteen years ago, viz., the south and west stations. The Corporation has dealt with the Fire Department on very liberal, nay, even generous lines. At present there is a very considerable extension being carried out on the fire alarm system, and during the current year there will be over 200 public call points spread over the city.

The department is very efficient. The plant, horses, etc., are the be[redacted]

that can be got, and with the exception of for river and riverside fires, the equipment is ample. The staff has no superiors and few equals in the country, the only fault—and it is not one for which the staff is responsible—is that their number is too few. The expenditure of the Fire Department sixteen years ago was £8400, and to-day it is over £17,000, exclusive of capital expenditure.

London has a staff of 1205, or ten times that of Glasgow; the population of London is as nearly as possible six times that of Glasgow. The number of fires in London is five times that of Glasgow. To have the same ratio of staff to population Glasgow should have 200 men instead of 121.

The strength, smartness, etc., of the New York Fire Department is often quoted, and it is not intended to dispute any or all of the statements made. The citizens of New York pay for all these qualities, and they are entitled to receive value in return.

New York Brigade costs, per head of the population, 5s. 6d.; London, 10d.; Glasgow, 5 2-5d. These figures are submitted with the view of showing that, as Glasgow is so often contrasted with New York and London, it may be made evident to all by comparison that Glasgow has a much cheaper service, and if the citizens are prepared to provide the necessary means, the Fire Brigade Committee can and will make the department superior to any in the country, and remove any grounds which hostile critics may have for cavil.

LABOUR BUREAU AND SERVANTS' REGISTRY.

This department of the public service was opened on 4th August, 1896. The Bureau has been established by the Corporation for the registration of workers of every kind, and to provide an easy and convenient means of bringing together employers and persons of both sexes in search of either temporary or permanent work. There are no fees payable by either the employer or the worker. The Corporation, while accepting no responsibility in connection with applicants, endeavours to assure itself of the character of those whom it sends to any situation. Since its inception the progress of the Bureau has been steady and continuous, as will be seen from the following table:—

Year.	Total Number Registered.	Number of Situations Offered.	Number who found Work with		Total Number who found Work.	Percentage of those Registered who obtained Employt.	Total Cost.	Cost per Head		
			Private Employers.	Local Authorities.				Of Number Registered.	Of Persons who found Work.	Of Persons Registered and Situations Offered.
1897	3818	1175	814	30	844	22·10	£250	1s. 3½d.	5s. 11d.	1s. 0d.
1898	4784	1816	1276	183	1459	30·5	£216	10½d.	2s. 11½d.	7½d.
1899	4365	1920	1515	59	1574	36·28	£237	1s. 1d.	3s. 0d.	9d.
1900	5224	2278	2089	101	2190	42·30	£240	9½d.	2s. 11½d.	7d.

As regards the males registered, almost every variety of occupation is included, excepting a few of the highly skilled trades, and even these are

occasionally represented. The entire number of males who found work were distributed over 43 different occupations. The female side of the work is very largely confined to the various classes of domestic servants.

TRAMWAYS DEPARTMENT.

The first tramway in Glasgow was constructed by the Corporation and opened on 19th August, 1872. In 1876 the total length of tramway lines laid was only 31 miles of single track. From 1872 to 1894 the lines were leased to the Glasgow Tramway and Omnibus Company, and on 1st July, 1894, the Corporation commenced to operate the tramways as a municipal undertaking. The lines now extend to 80 miles of single track, and, in addition, the Corporation have leased 8 miles of track belonging to the burgh of Govan. These lines are operated as part of the Glasgow system.

By the Glasgow Corporation Act, 1899, powers were obtained for the construction of extensions to Paisley, Cathcart, Rutherglen, Tollcross, and Shettleston. The work of making these extensions is now in progress.

In this session of Parliament, at the request of the residents, and with the consent of all the local authorities, further powers are being sought for the construction of tramways to Bishopbriggs, Clydebank, Renfrew, and Cambuslang. When all these lines have been completed, the total length will be about 137 miles of single track, forming connections between Glasgow, as the centre of the system, and all the surrounding communities.

When the Corporation took over the working of the tramways in 1894 fares were considerably reduced, and halfpenny fares instituted for half-mile stages. The result has been that the traffic has steadily increased from year to year.

During the year to 30th June, 1894, the lessees carried about 54,000,000 passengers. The following table shows the remarkable progress of the system since it became a municipal undertaking in 1894:—

	Average Cars and Buses (16-hour day).	Mileage.	Passengers carried.	Receipts.	Average per mile.
For 11 months to 31st May, 1895, - -	170·97	5,192,031	57,104,647	£222,121 11 0	10·26d.
For year to 31st May, 1896, -	227·66	6,932,650	86,462,594	328,827 8 8	11·38d.
,, ,, 1897, -	268·20	8,127,111	98,966,658	365,761 3 10	10·80d.
,, ,, 1898, -	280·96	8,483,012	106,344,437	389,216 9 6	11·01d.
,, ,, 1899, -	305·85	9,071,640	118,775,668	433,128 0 6	11·46d.
,, ,, 1900, -	316·96	9,657,429	127,628,484	464,786 15 2	11·55d.

Prior to July, 1894, the Tramways Committee considered the question of mechanical traction, and reported on various systems. The lines

ever, being in the hands of the lessees up to the last day of the lease, it was impossible to start with any other system than horse traction. In 1895, after the issue of the first annual report, a committee was again appointed to go fully into the question. In the course of their investigations they visited various continental and British cities. It was not, however, until May, 1897, after the general manager and engineer had visited America, and reported very fully on the different systems in operation there, that it was finally decided to equip the Springburn route, measuring 5 miles of single track, as a demonstration of the overhead system of electric traction. An electric service was started on this route on 13th October, 1898. So satisfactory in every way was this demonstration during the first two months' working that on 28th December, 1898, it was finally decided to convert the whole of the tramways to the overhead system.

The following is a summary of the revenue and expenditure of the electric traction routes from the start to 31st May, 1900:—

	13th October, 1898, to 31st May, 1899.			1st June, 1899, to 31st May, 1900.		
	Amount.	Av'rage per mile.	Average per K.W. hour.	Amount.	Av'rage per mile.	Average per K.W. hour.
Receipts, - - -	£23,03 5	13·91d.	10·13	£53,711 18 8	13·89d.	11·06
Expenditure—						
Power, - - -	2,145 3 5	1·30d.	·94	3,560 9 2	·92d.	·73
Traffic, - - -	5,001 10 2	3·02d.	2·20	11,615 19 8	3·00d.	2·39
General, - - -	1,021 13 8	·61d.	·44	2,709 1 7	·70d.	·56
Maintenance Renewals, - - - -	2,395 6 10	1·44d.	1·05	6,367 7 10	1·64d.	1·31
	£10,563 13 11	6·38d.	4·65	£24,252 18 3	6·26d.	4·98
Balance to Net Revenue Account, - -	£12,476 12 6	7·53d.	5·48	£29,459 0 5	7·63d.	6·08

The above results, although highly satisfactory, would undoubtedly have been still more so had the plant at the small power station been operated during the full period at its maximum output.

When it was finally decided by the Corporation to equip the whole of the tramways on the overhead system, no time was lost in getting the work of conversion in hand. Mr. H. F. Parshall, M.Inst.C.E., who had been requested to report on the whole question of generating and distributing the current, was appointed consulting engineer for the scheme, which provides for one high-tension generating station, with five sub-stations. An eminently suitable plot of ground at Pinkston was purchased as a site for the main generating station, and arrangements were made for erecting the sub-stations at five of the existing horse-car depôts. The ground purchased for the Pinkston generating station extends to 18,997 square

yards. It is bounded on one side by the canal, and is connected with both the Caledonian and North British Railways.

The work of excavation was commenced by the staff of the department in September, 1899, and in order to have all the concrete foundations upon the solid rock upwards of 50,000 tons of material had to be removed.

As this will be the largest generating station of the kind in Europe, the following short description of the different sections of the building and equipment may be interesting:—The main building consists of a framework of steel, on which the roof is supported. By adopting this method of construction, the brick walls could be proceeded with after the roof was completed and simultaneously with the erection of the machinery. The Ritter Conley Company, of Pittsburg, were the contractors for the supply and erection of the steel work, which weighed about 1300 tons. The building is 244 feet in length by 200 feet in breadth, and the height of the walls is 88 feet. There are two chimneys, 250 feet in height. The building is divided into three bays. The east bay, of 84 feet span, contains the steam generating plant. The centre bay, of 75 feet span, contains the main engines and generators, also the auxiliary engines and exciter engines with their generators. The switchboards are placed in this bay against the north gable. The west bay, of 40 feet span, which adjoins the canal, contains the condensing plant and feed pumps. In the boiler room there are 16 Babcock & Wilcox boilers, each capable of producing 20,000 lbs. of steam per hour at a working pressure of 160 lbs. per square inch. The mechanical stokers have also been supplied by the same firm. The coal is tipped from the waggons into outside coal bunkers having a capacity of about 3000 tons. These bunkers have been supplied by Sir Wm. Arrol & Co., Ltd. It is then conveyed by bucket conveyors to the storage bunkers on the top of the boilers. These storage bunkers can hold 2000 tons of coal. The conveyors can deal with 100 tons of coal per hour. From the storage bunkers the coal passes down through shoots into the furnaces, and, while doing so, is weighed. The boiler feed pumps can deliver 8000 gallons of water per hour against a pressure of 180 lbs. per square inch. Two storage tanks for water are placed between the two chimneys, and these can each hold 18,000 gallons. The pumps, as also the coal conveyors, have been supplied by the Mirrlees Watson Company, Limited, Glasgow. A reserve boiler feed steam pump is by Messrs. G. & J. Weir, Glasgow. The fuel economisers have been constructed by the Clay Cross Company, Derby. There are two of these, capable of dealing with 12,000 gallons of feed water per hour, and of raising its temperature from 90 to 160 degrees Fahr. In the engine room each of the four main engines is designed to work at 4000 i.h.p., but is capable of developing a maximum of 5000 h.p., while still running at its normal speed of 75 revolutions per minute. Two of these engines have been made by the E. P. Allis Co., of Milwaukee, and two by Messrs. Musgrave, of Bolton. They are of the vertical compound condensing three-cylinder type, with Corliss valve gear. Each fly-wheel weighs over 120 tons, and the weight of each engine complete is about 700 tons. Each engine is 43 feet long—or 52 feet including the fly-wheel and alternator—35 feet high, and extends to 24 feet below floor level. Each engine is directly coupled to a 3-phase generator designed for an output of 2500 kilowatts at a pressure of 6500 volts. These machines have been supplied by the British Thomson-Houston Company.

The auxiliary plant is used for driving the motors in the main station and for supplying power and light during the night to the sub-stations and car sheds when the main engines are shut down. The two auxiliary engines, which have been supplied by Messrs. Duncan Stewart & Company, Glasgow, are each 800 h.p., but are capable of developing 1000 h.p. Each engine is coupled to a 500-volt direct current dynamo of 600 kilowatt capacity, also supplied by the British Thomson-Houston Company. There are also four surface condensers, supplied by the Mirrlees Watson Company, for the main engines, each capable of condensing 60,000 lbs. of exhaust steam per hour. The water is pumped from the canal by four centrifugal circulating pumps, supplied by Messrs. Mavor & Coulson. There are four air pumps for the main condensing plant, and there is also a separate complete condensing plant for the auxiliary engines. The feed, air, and circulating pumps are electrically driven; also the mechanical stokers and coal conveyors, the current for which is supplied by the auxiliary sets. The main switchboard in the Pinkston Station, and the switchboards at the sub-stations, are the work of the Westinghouse Company.

Each of the two cranes in the engine room is capable of lifting 50 tons, and the crane in the auxiliary room is capable of lifting 30 tons. These are supplied by the Clayton Company, near Manchester. Each crane is fitted with three electric motors.

Distribution of Current.—From the feeder panels of the main switchboard in the generating station four 3-core cables are led to each of the five sub-stations, which are situated in the different districts of the city. These cables are carried out through the wall of the generating station into a main tunnel, and thence led in underground ducts to the sub-stations.

The five sub-stations are situated at Coplawhill and Kinning Park on the south side of the river; Partick in the west; Whitevale in the east; and Dalhousie Street near the centre of the city. The units in each of the sub-stations are of the same size, each static transformer being 200 kilowatts, and each rotary converter 500 kilowatts. There are at each sub-station separate 3-phase and continuous current switchboards. The high-tension 3-phase current, at a pressure of 6500 volts, is first of all transformed down to a pressure of 310 to 330 volts, and is then converted into low-tension continuous current at 500-550 volts. The overhead wire is fed at about 500 volts. On one end of the converter shaft is a continuous current booster designed for dealing with part of the return current from the rails. All the sub-station equipment has been supplied by the Westinghouse Company.

The feeder system is laid in cement-lined pipes. The pipes and cables have been supplied and laid by the National Conduit and Cable Company.

Permanent Way.—When the Corporation took over the lines in 1894 almost the whole of the system had been relaid with steel girder rails, weighing 79 lbs. per yard. The Corporation introduced a heavier section, weighing 89 lbs., and since 1898 all the rails used have been 100 lbs. per yard, and in 60-feet lengths.

The rails are laid to a gauge of 4 feet 7½ inches on a bed of Portland cement concrete 6 inches in depth, and extending 18 inches beyond the outside rail. The 60-feet rails have recently been supplied by the Leeds Steel Works and Messrs. Bolckow, Vaughan & Co., Middlesbro', the dimensions being—depth, 7 inches; width of sole, 7 inches; width of head, 2

inches; width of groove, 1¼ inches; width of lip, ⅝ inch; width over all, 3¾ inches. The rails are fished by steel fishplates, weighing 74 lbs. per pair, and measuring 31 inches in length, and secured in place by eight 1-inch bolts. They are tied to a gauge, at intervals of 5 feet, by steel tie-bars 2 inches by ⅝ inch in section. The whole width of the track, including 18 inches beyond the outside rails, is paved by the Tramways Department with granite setts, and these are thoroughly grouted with bitumen and granite chips. For the purpose of lessening the wear and tear of the paving next the rail in the busier parts of the city chilled cast-iron paving blocks are laid on each side of the rails alternately with the granite setts.

Overhead Construction.—Throughout the whole system the trolley wires are supported in the centre of the track by means of span wires, with the exception of a portion of Great Western Road, where there are centre poles. A few centre poles have also been erected on two short portions of the Springburn route, where the street is exceptionally wide, and also on Glasgow Bridge. Wherever possible, the span wires have been attached to the buildings on either side of the street by means of ornamental metal rosettes. Where there are no buildings, or where the existing buildings are not suitable for this purpose, steel poles have been erected on the edge of the footpath. The trolley wire is double throughout, and consists of No. 00 Brown & Sharpe gauge, having a conductivity of 98 per cent. and a breaking strain of over 5000 lbs. The guard wires are placed 24 inches above the trolley wire.

Workshops.—The workshops of the department are situated at Coplawhill, on the south side of the Clyde, about a mile from the centre of the city. The ground in this locality has been in the possession of the Corporation of Glasgow for several centuries, and in 1894 the new Tramways Department took over at a valuation 14,000 square yards, on which the Coplawhill depôt and workshops were erected. In 1898 an additional piece of ground was taken over, making the total area about 28,000 square yards. The whole of the ground is now covered with buildings, except about 3000 square yards. The workshops consist of office, store, smith shop, sawmill, car building shop, iron working shop, car repairing shop, paint shop, etc. All these departments are fully equipped with the most approved machine tools for making and repairing cars. Nearly all the electric cars have been built in these workshops by the staff of the department.

About 400 electric cars are now ready for running, and for the extended system already indicated at least 650 cars will be equipped. Increased accommodation for the electric cars is being provided at several of the existing depôts, and two new car sheds have just been completed—one at Possilpark and the other at Langside. After a general start has been made with electric traction, a considerable number of the horse cars will be converted into electric cars.

The main generating station is at present being equipped with four units, with a total capacity of from 16,000 to 20,000 i.h.p., but room has been provided in the building for two additional units.

LIBRARIES.

The work of the Corporation in respect of public libraries has consisted almost wholly in the administration of the Mitchell Library.

This institution was founded in 1874 by the late Mr. Stephen Mitchell, tobacco manufacturer in Glasgow, who by his will directed that the residue of his estate should be devoted to the establishment of a large public library for the use and benefit of the citizens of Glasgow. In the volume dealing with the educational institutions of the city a more detailed account of the history of the library will be found. Here it may be sufficient to record that the library was opened in November, 1877; that it was at once obvious that it met a real want in the city; that both in respect of the growth of the library itself and of the advantage taken of it by the public it soon surpassed all previous British experience; and that it has now become the largest library in Scotland to which the public have a right of free access, and one of the most largely frequented reference libraries in the kingdom. It contains more than 144,000 volumes, and since its opening more than nine million and a quarter volumes have been consulted. Almost equal in amount to the use of the books in the library has been the reading of the current reviews and other periodicals in the magazine room, where about 450 selected serials of all kinds are placed on racks and tables, freely open for the perusal of all who come.

In addition to the administration of the Mitchell Library, the Corporation is represented on the directorship of Stirling's Library and of Baillie's Institution. Of the first-named institution the Lord Provost is *ex officio* President, and the Corporation nominate three of their number as directors, while one member of the Corporation is named a director of Baillie's Institution.

The near future will bring to the Corporation an increased responsibility in the matter of public libraries. By an Act passed in the session of 1899 they acquired powers to establish branch libraries and reading rooms in the various districts of the city, for the maintenance of which a rate may be levied, not exceeding a penny in the pound of rental, half to be paid by the occupier and half by the owner. A scheme which provides for eight branch libraries and five branch reading rooms has been generally approved by the Corporation, and a commencement has been made by the decision to place a library and reading room in the halls attached to the public baths in Main Street, Gorbals. Plans for branch libraries for two other districts are now under consideration. Mr. Andrew Carnegie, in a letter to the Lord Provost, has expressed his pleasure in providing the sum of £100,000 for the cost of buildings for the district libraries, and by this munificent gift has ensured the full and efficient completion of an adequate district library establishment for the city.

PARKS DEPARTMENT.

The extension and development of the public parks of the city is one of the most striking features of the civic administration of Glasgow within recent years.

In 1876 there were only four public parks, viz., the historic Glasgow Green (which for over two hundred years has been the jealously guarded open space of the citizens in the East End of the city); the classic Kelvingrove Park, rendered famous in Scottish song, and situated in the West End,

where the International Exhibition is at present being held; the Queen's Park, on the South Side; and the Alexandra Park, in the north-east. At present there are thirteen public parks, besides a number of recreation grounds and open spaces. Of these, no fewer than nine parks have been acquired since 1891, when a local Act of special significance, *i.e.*, the City of Glasgow Act, was passed, by which the boundaries of the city were extended so as to include a number of small suburban burghs.

Under that Act the Maxwell Park, which had been presented to the former burgh of Pollokshields by Sir John Maxwell Stirling-Maxwell, Bart., of Pollok, M.P., came to be administered by the Parks Department of the Corporation.

In 1891 the lands of Kennyhill, extending to 40 acres, were acquired as an extension of the Alexandra Park. Considerable additions were made to the parks of the city by the acquisition in the same year of (1) the Springburn Park, extending to 56 acres; (2) the Ruchill Park, extending to 53 acres; and (3) the Maryhill Park, extending to 5½ acres.

The next important purchase was in 1894, when the lands of Camphill, extending to 58 acres, were acquired from Hutchesons' Hospital as an addition to the Queen's Park. A smaller and relatively more expensive area was also acquired in 1894, when 4 acres of land were purchased as a juvenile recreation ground for the densely populated district of Govanhill.

In 1895 two important purchases were made, viz., (1) the Bunhouse Recreation Ground, of 6½ acres, and (2) the lands of Bellahouston, extending to about 178 acres.

In 1897 an opportunity arose to supply the clamant needs of the East End of the city by the purchase of the residential estate of Tollcross, extending to 83 acres. The mansion-house, which is beautifully situated in the park, is a magnificent specimen of the Scottish baronial style of architecture.

In the following year, viz., in 1888, 44 acres of land on the south side of the river Clyde opposite Glasgow Green were acquired, and is now known as the Richmond Park. The Park takes its name after Sir David Richmond, who was Lord Provost of the city from 1896 to 1899.

Whilst the area of the parks has been extended within the past decade from 371 to 1055 acres, there has been a still more striking advance in the equipment of the parks in the direction of providing healthy recreation and amusement for the people. In the Maxwell, Springburn, and Alexandra Parks ponds have been formed for the sailing of model yachts. These ponds, while affording facilities for the enjoyment of a popular amusement for many of the artisan class during the summer months, are also used in winter for skating.

Football and cricket are also provided for in certain portions of the parks, and provision is also made for the playing of golf in the Alexandra and Bellahouston Parks. The latest development in the direction of outdoor games is that of bowling, by the resolution to form two greens on Glasgow Green during the present session. A number of gymnastic appliances are also in existence in one or two of the parks for the use of the children of the city. The gymnasia are found to be largely taken advantage of by the junior population in the vicinity.

A striking feature of municipal enterprise has been the inauguration of what is popularly known as Children's Day. In 1897, on the occasion of the late Queen's Diamond Jubilee, the Corporation arranged a fête for all

the school children in the city in eight parks. So much interest was manifested in the event, as well by the adult as the juvenile population, that the Children's Day has become an annual institution. In addition to light refreshments provided to the children, entertainments of maypole dances, physical drill, etc., by selected teams of school children are provided. On each of the four occasions on which it has been held, 100,000 children have taken part, and it is safe to say that double that number of adults have been spectators. Notwithstanding the magnitude of these popular demonstrations, no serious accident has ever occurred at one of the celebrations.

To further popularise the parks, as well as with a view to bring the population from the crowded streets and lanes of the city to places where the change of scene contributes to health and enjoyment, music has for some years been provided in the various parks during the months of June, July, and August. The appreciation of the public of this scheme becomes year by year more apparent, and the Corporation have increased the amount expended for music from £504 in 1876 to £2345 last year. In addition to these payments, a sum of £135 was spent on musical performances given in the People's Palace in Glasgow Green and in the Winter Gardens at the Springburn Park.

The mention of winter gardens suggests a reference to the development of this feature of the work of the Parks Department.

When the management of the Botanic Gardens was taken over from the Royal Botanic Institution by the Corporation in 1892, the splendid range of conservatories and the magnificent winter garden known as the "Kibble Palace" immediately became popular resorts, the latter especially proving a delightful retreat and resting-place for hundreds daily. Under Corporation management, annual displays of chrysanthemums were inaugurated in the Kibble Palace, and have year by year been visited by thousands of interested citizens. The success which attended these displays, and the manner in which the Kibble Palace was taken advantage of, encouraged the Corporation to erect a winter garden as an adjunct to the People's Palace in Glasgow Green, and since this institution was opened by the Earl of Rosebery in January of 1898, it has been a favourite resort for the people of the East End. Similar success has attended the propagating establishment at Camphill, which was primarily erected for the purpose of propagating plants for the parks. This propagating establishment is open daily for inspection by the public, who have evinced the deepest interest in the range of glass-houses and their contents. When the late ex-Bailie A. G. Macdonald gifted his conservatories and collection of plants to the Corporation for Tollcross Park it was resolved to rearrange and enlarge the conservatories so as to allow the public more freedom when inspecting the plants. The result has been that these houses have also become exceedingly popular resorts. The same success has likewise attended the opening of the magnificent winter garden in Springburn Park, which was gifted to the city by the Messrs. Reid, of Hydepark Locomotive Works, Springburn, and erected last year at a cost of £10,000. There can be no doubt that the inauguration of winter gardens in Glasgow, which often enjoys a too short summer and a long spell of wet weather, will prove a decided success, and provide means of pleasure and enjoyment to thousands who would never have an opportunity of becoming acquainted with the wonders and beauties of plant life.

The following table shows the areas of the various parks and the cost of their acquisition:—

PLACE.	Area.	Acquired.	Cost.	REMARKS.
	Acres.		£	
Glasgow Green, - - -	136	1662-1792	...	
Kelvingrove Park, - -	66	1852-4	77,945	2a. With these additional lands the area of Kelvingrove Park is 85 acres.
Lands of Clayslaps, Overnewton, and Kelvinbank, -	19	1881	66,626	
Queen's Park, - - -	*90	1857	30,000	*53 acres of feuing land not included in Park measurement, but included in price. With Camphill lands added, the area of Queen's Park is 148 acres.
Camphill, - - - -	58	1894	63,000	
Alexandra Park, - - -	†79	1869	25,664	†11 acres of feuing land not included in Park measurement, but included in price, 3 acres of which, including streets, have now been sold to the Improvement Dept.
and				
Lands of Kennyhill, - -	40	1891	8,000	15 acres have now been sold to the Improvement Dept. With part of Kennyhill lands added, the area of Alexandra Park is 104 acres.
Cathkin Braes Park, - -	49	1886	...	Gifted by James Dick, Esq.
Botanic Gardens - - -	21½	1892	59,531	
and Banks of Kelvin incorporated therewith, - - -	18½	1892-96	9,360	
Maxwell Park, - - -	21	1891	...	Gifted by Sir John Maxwell Stirling-Maxwell, Bart., M.P.
Springburn Park, - -	56	1892	20,710	
Do. - -	19¾	1900	4,475	
Maryhill Park, - - -	5½	1892	2,089	
Ruchill Park, - - -	53	1892	35,700	
Govanhill Grounds, - -	4	1894	12,200	
Bunhouse Grounds, - -	6½	1895	30,000	
Bellahouston Park, - -	178	1895	50,000	
Tollcross Park, - - -	82¾	1897	29,000	
Do. - - -	¾	1900	417	
Richmond Park, - - -	44	1898	44,000	

MUSEUMS AND GALLERIES DEPARTMENT.

It is somewhat interesting to note that the present and the two previous meetings of the British Association in Glasgow have been coincident with three important stages in the history of its Museums and Art Galleries. Strictly speaking, in the year 1855, when the British Association paid its second visit to the city, there was nothing of the nature of a Museum or Art Gallery, but in that year the Town Council was negotiating for the purchase of the collection of pictures which had been formed by Mr. Archibald M'Lellan, and the M'Lellan Gallery became municipal property early in 1856. At the last meeting of the British Association in Glasgow in 1876 a new wing was added to the Industrial Museum, which meanwhile had been formed in the old Kelvingrove mansion-house, this addition being made at a cost of about £8000. The present year is to see the fourth meeting of the British Association in the city and the opening of the new Art Galleries and Museum, which have been raised at the cost of a quarter of a million. The development of the Corporation Museums and Art Galleries since their first inception forty-five years ago, when as yet no such institution existed, up to the present time when the Corporation are owners of museum property to the value of nearly three-quarters of a million sterling, has been entirely due to the enterprise of the city or to the generosity of its individual citizens, and has been done quite independent of any Government aid.

As has already been remarked, the beginning of the municipal connection with museums dates back to the year 1856, when the Corporation resolved to acquire the M'Lellan collection, which had really been dedicated to the public by its owner under a deed of bequest. The testator's affairs were, however, found to be in such a condition that the terms of the will could not possibly be carried out, and ultimately the Corporation resolved to purchase for the sum of £44,500 the collection and the heritable property, in which Mr. M'Lellan had erected a suite of galleries. Of this sum, £15,000 represented the supposed value of the pictures, whilst the remaining £29,500 was the value of the property. It may here be remarked that more than one single picture could be named in the M'Lellan collection which alone would probably now realise more than the sum paid for the entire series in 1856. The building (now known as the Corporation Galleries) is situated in Sauchiehall Street, between Rose Street and Dalhousie Street. About eleven years after the purchase of the structure by the Corporation the private tenants who still occupied part of it were expelled with the exception of the shopkeepers on the ground floor; the upper floors underwent considerable reconstruction so as to render them suitable for public purposes, and afterwards were let to several educational and scientific institutions. The Galleries in which the M'Lellan pictures were hung were at this time frequently let for public entertainments, concerts, bazaars, balls, and various social functions.

In spite of the apathetic interest and neglect with which the M'Lellan collection was treated for a long period after its acquisition by the Town Council, several valuable bequests and donations of pictures have been made by public-spirited citizens anxious to see in the city a gallery of art which would at once be a credit to Glasgow and a source of

pleasure and instruction to its citizens. Amongst these may be mentioned the donation and bequest by Mr. W. Euing, and the bequest of Mrs. Graham-Gilbert of Yorkhill, which included a most valuable collection of old masters formed by her husband, Mr. John Graham-Gilbert, R.S.A., besides a large number of pictures executed by himself.

Soon after this munificent bequest by Mrs. Graham-Gilbert, received in 1877, the Corporation awakened to the fact that the pictures in their possession were of great value, and that they were administrators of a most important public trust and heritage. It was then resolved to seek the advice of some outside authorities upon the condition and proper utilisation of their collections. Accordingly, Sir Daniel MacNee, President of the Royal Scottish Academy, Sir William Fettes Douglas, and Mr. Robert Greenlees were asked to make an examination of the pictures, and draw up a report regarding their artistic value. In the report which these gentlemen submitted it was recommended that certain works should be withdrawn from the permanent lists, but they expressed their satisfaction with the greater proportion of the pictures, which they considered were of great artistic value. A catalogue of the works was then prepared, approved of by these gentlemen, and when completed it was resolved to again submit the collection to the scrutiny of Mr. (now Sir) J. C. Robinson, F.S.A., H.M. Surveyor of Pictures, who made a further examination of the works, and whose report did much to reinstate them as works of art that ought to be carefully treasured.

From this time onwards a livelier interest has been taken by the city in their Art Gallery and its contents. The public bodies which had hitherto met in the Galleries removed elsewhere, and the Corporation obtained full control of their halls, enabling them thereby to further the interests of art in the city. In pursuance of this end a number of exhibitions were organised, which met with considerable appreciation from the public. In connection with these exhibitions many valuable loans of pictures and art objects were received and placed on show in the Galleries. The nature of the building made it particularly liable to risk from fire; in fact, fire had more than once broken out in contiguous shops whilst these loans were on exhibition. Eventually the committee resolved to cease such exhibitions owing to the great risk they involved. Out of these circumstances the desire to build a new Art Gallery and Museum specially suited for such purposes arose, with results which will be seen in the sequel.

Turning from the history of the city's art collections, we pass to a description of how its first municipal museum was founded. In 1870 a small collection was begun in the old mansion-house of Kelvingrove under the name of the City Industrial Museum. From the very first it was clear that the building was wholly unsuited for museum purposes, the principal and first felt want being that it was far too small. The limited nature of the space available was not lessened by the manner in which all sorts of objects begun to be accumulated. As implied by the name which it bore, the original purpose of the museum was the formation of a collection illustrative of the industrial arts, but this idea of forming a purely technological museum was soon

departed from, and collections were made of all sorts of objects—natural history, technological, ethnological, antiquarian, and others.

The smallness of the building soon became very obvious, and in 1874 an extension was resolved upon. With the sanction of the Corporation, an appeal was made to the public for subscriptions to defray the cost of the new building, whereby a sum of £7500 was raised, to which the Corporation added £500, and the new building was proceeded with. That extension was opened in 1876 with an exhibition of local industries, which had been arranged in connection with the meeting of the British Association in Glasgow that year. During the existence of this museum the space available made it quite impossible for any systematic classification or arrangement of its contents to be carried out, and it came ultimately to be looked on more as a store than a museum suited for educational or scientific purposes, yet it cannot be doubted that in some small measure it suited both these ends, and that there will be many who will miss it now that it is gone, and many that will remember it affectionately as the parent of its more pretentious successor.

From time to time, since 1883, district exhibitions have been organised and carried out by the Museums and Galleries Committee, a large series of these being held in the halls connected with the Corporation's baths and wash-house in the Gorbals. In 1891 it was sought to organise a similar exhibition in the Bridgeton district, but a hall could not be found suitable for such a purpose. The failure to find a hall in this locality ultimately resulted, after much investigation and deliberation, in the erection of the branch Museum and Winter Garden, known as the People's Palace, on Glasgow Green, at a cost of £30,000. This building was opened on the 22nd January, 1898, by the Right Hon. the Earl of Rosebery, K.G. Besides containing several valuable collections of pictures, art and industrial objects, as well as the geological collections belonging to the city, the People's Palace has from time to time since its opening received valuable loans of pictures and other objects of art. A special feature in this institution is the yearly exhibition of some section of craftsmanship or art industry, at which prizes and certificates of merit are awarded to works entered for competition. Three of these exhibitions and competitions have already been held, and have proved highly successful, a large and increasing number of exhibitors and competitors coming forward from year to year. The exceeding popularity of this institution is shown by the fact that during the opening year it was visited by 770,807 visitors, while the next two years show an average of 500,000. These figures, then, surely, more than justify the erection of this building, showing that it has truly become a palace for the people, and that it has done, and may yet do, much to infuse some sense of the beauty and mystery of this great world into the lives of many who have but few opportunities of rising above their daily round of toil.

In 1894 the Corporation acquired the grounds of Camphill, and with it the fine mansion-house which belonged to the property. From the first the Museum and Galleries Committee had their eye upon it as a most desirable position for a small district museum. After some structural alterations had taken place which were rendered necessary to make it suitable for museum purposes, the Camphill Museum was [redacted]gurated by a most successful photographic exhibition, and in this

way another district museum was added to the list. At present it contains a collection of art objects lent by the Victoria and Albert Museum, a collection of modern paintings, and a type collection of natural history specially designed for the use of schools and elementary classes, besides a miscellaneous collection of art objects.

The next phase which falls to be chronicled in the development of the Municipal Art Galleries and Museums is by far the most important and ambitious of all the schemes that have as yet been taken in hand. As has been already stated, the great risks to which the art collections of the city were exposed from the insecure nature of the Corporation Galleries made it imperative that something should be done. Therefore, in 1886, the suggestion was thrown out that by the holding of a great temporary exhibition in Kelvingrove Park a sum of money might be realised that would, at least, form a nucleus for the raising of an adequate fund for the erection of a gallery of art and museum worthy of the city. Accordingly, an International Exhibition was held in the summer of 1888, and proved such a complete success, that upon its close the sum of £46,000 stood to the credit of the Exhibition Association. Not content with this large measure of success, the Exhibition Association undertook to double the amount by public subscription if the Corporation would grant a site in Kelvingrove Park for a new building for Art Gallery and Museum purposes, and allow the administration of the fund, the adjusting of the scheme of building, the selection of an architect, and the execution of the work to devolve on an executive committee elected in the proportion of two-thirds from the Corporation and one-third from the Exhibition Association. This committee, under the new name of "The Association for the Promotion of Art and Music in the City of Glasgow," set vigorously about their work, and within the prescribed time—twelve months—they had gathered more than the minimum £46,000. A site was then claimed in Kelvingrove Park, and the first steps were taken towards the erection of the new building. After open competition, the plans submitted by Messrs. J. W. Simpson & Milner Allen, of London, were, in June, 1892, selected under the advice of Mr. Alfred Waterhouse, R.A. The estimate given by the architect for the completed building was £154,398, or, leaving the quadrangles uncovered, £119,775, while the local surveyors put these figures at £170,320 and £130,450 respectively. Even these larger figures, however, were discovered to be far below the amount of the contracts sent in for the work. Having, however, £113,000 in hand the work was proceeded with, the committee being assured that it would not greatly exceed £120,000. After contracts for the basement had been received, with some surprise it was found that the estimate for this preliminary section alone reached £22,225, and eventually it cost £2000 more. It was afterwards found that the superstructure could not possibly be raised for a less amount than £154,000, which so far exceeded the original amount collected by the committee that they found themselves in the somewhat awkward position of having spent £25,000 upon a building which, to partly finish in a second-rate manner, would cost £27,000 more than they were possessed of, while to completely finish it in a worthy manner would mean an outlay of £70,000 beyond the sum actually in hand.

In this somewhat difficult position the only resource left to the

committee was to approach the Corporation and ask them either to guarantee funds sufficient to carry the building to completion, or to take over the whole matter, and deal with it themselves. The latter alternative was accepted, and now the building has been completed in the most substantial fashion under the supervision of the Museums and Galleries Committee, aided by certain consulting members selected from the defunct Association for the Promotion of Art and Music.

As it stands, the building consists of a central hall, 125 feet by 56 feet, with two courts, each 102 feet by 60 feet, east and west of the hall. There are twelve galleries, arranged in two floors around the courts, with eight pavilions at the corners. The galleries average 100 feet long by 28 feet wide, the upper galleries being specially adapted for the show of pictures. Altogether the building is a handsome and most commodious edifice, and thoroughly worthy of the city. The new Art Gallery and Museum at present contains a unique collection of the pictorial art of the nineteenth century, extensive loan collections of British and continental sculpture and architecture, an adequate representation of engravings, etchings, and monochrome drawings, a series illustrating the present high level of photographic achievement, and a comprehensive collection illustrative of Scottish history and archæology.

Within these spacious and magnificently equipped walls, saloons, and galleries will fall to be arranged the art and science collections of the city when, at the close of the International Exhibition, the building reverts into the exclusive charge of the Corporation.

Within recent years many valuable additions have been made to the collections of the city, and foremost should be placed the munificent gift of the family of the late Mr. James Reid, of Auchterarder, who, in memory of that gentleman, presented to the Corporation ten modern pictures, which cost Mr. Reid himself more than £23,000. Another munificent bequest to the art section was that of the late Mr. Adam Teacher, who left 117 pictures, mostly by Scottish artists, which served to supply a long-felt want. Through the last thirty years or so there have been steadily accumulating numerous valuable archæological, ethnological, and technological collections, which will now have a proper chance of being displayed. The natural history collections, including the geological collection, have also been steadily progressing. The purchase of the Glen collection and that of the Glasgow Geological Society having a most valuable nucleus for future development, it is to be hoped that before the next meeting of the British Association in Glasgow has marked off another stage in our museum history, as it has evidently been wont to do in the past, Glasgow shall have progressed somewhat towards the realisation of these ideals which it has set before it, and, relying upon the past enterprise and liberality of citizens, it is hoped to form such a collection as shall stand second only in the kingdom to the great national collections, which none may ever hope to rival.

TELEPHONES.

The Corporation of Glasgow first considered the telephone question in February of 1893, when they remitted to a special committee to report on the Treasury minute of 23rd May, 1892. Following on the

report by the special committee, the Corporation resolved, on 3rd August, 1893, to apply to the Postmaster-General for a telephone licence. The Corporation based their application largely on the principle that whenever the carrying out of any undertaking necessitates the opening of streets and interference with drains, sewers, gas, and water pipes, the control of such undertakings should be in the hands of the municipality. The Corporation also believed that the service in Glasgow was not an efficient one; that the cost was excessive, and that an effective telephone service was an absolute necessity for such a business centre as Glasgow.

During the next two years a lengthened correspondence with the Postmaster-General took place, and evidence was given on behalf of the Corporation before a Select Committee of the House of Commons appointed "to consider and report whether the provision now made for the telephone service in local areas is adequate, and whether it is expedient to supplement or improve this provision either by the granting of licences to local authorities or otherwise."

The Corporation repeatedly renewed their application, and on more than one occasion interviewed the Postmaster-General, urging upon him the necessity of granting the licence applied for. So persistent were the Corporation in their demands that the Postmaster-General, in May of 1897, resolved to have an independent and local investigation in order that he might have sufficient proof that the circumstances were such as to justify the granting of a licence.

Mr. Jameson, Sheriff of Perthshire, was appointed Commissioner, and the questions to which he was authorised to direct his attention were—(*a*) Is the service, so far as it goes, sufficient? (*b*) Is it adequate? (*c*) Is the price charged for the service reasonable? The inquiry extended for a period of eleven days. Thirty-seven witnesses were examined on behalf of the subscribers, twenty-eight on behalf of the Corporation, twenty-three on behalf of the National Telephone Company, and one for the Clyde Trust. The Commissioner found that the service in Glasgow was not efficient; that the service, generally speaking, was adequate; that the rates charged were not unreasonable, except in some of the outlying districts. The Commissioner further reported that the continued inefficiency of the telephone service in Glasgow was in great measure due to the refusal of facilities to the National Telephone Company by the Corporation for constructing an underground metallic circuit system, and recommended that as there was no likelihood of the Corporation giving their consent to the National Telephone Company using the streets, the licence asked for should, in the interests of the public, be granted to the Corporation.

Following on the Commissioner's report, the Postmaster-General, on 16th March, 1898, intimated that he could not assent to the wishes of the Corporation and grant them a licence. On 10th May, 1898, a second Select Committee of the House of Commons was appointed "to inquire and report whether the telephone service is calculated to become of such general benefit as to justify its being undertaken by municipal and other local authorities, regard being had to local finance, and, if so, whether such local authorities should have power to undertake such service in the districts of other local authorities outside the area of their own jurisdiction, but comprised wholly or partially in the same

telephone area, and what powers, duties, and obligations ought to be conferred or imposed upon such local authorities." The Corporation also gave evidence before this committee. The Select Committee reported that they were strongly of opinion that general, immediate, and effective competition by either the Post Office or the local authority was necessary, and considered that a really efficient Post Office service afforded the best means for securing such competition. They further considered that when in an existing area in which there is an exchange—the local authority demands a competing service—the Post Office ought either to start an efficient telephone service itself, or grant a licence to the local authority to do so.

On 29th August, 1898, the Corporation renewed their application for a telephone licence for the city and suburban burghs and districts included in the Glasgow Telephone Exchange area. After some further correspondence, the Postmaster-General, on 23rd September, 1898, informed the Corporation that he was prepared to grant a licence to the Corporation, expiring at 31st December, 1911, on their securing from Parliament the requisite powers for working an exchange system.

The Corporation thereupon remitted to the Parliamentary Bills Committee to take the necessary steps for obtaining in the next session of Parliament the requisite powers to enable them to establish and carry on a telephone exchange within the Glasgow Exchange area.

The Corporation proceeded with their bill, and also opposed three bills which the National Telephone Company brought forward.

Before either of the bills above referred to had reached the committee stage, Mr. Hanbury, M.P., introduced the Telegraph (Telephonic Communication) Bill, which became law on the 1st of August, 1899. The Corporation bill and those of the National Telephone Company were accordingly dropped.

Immediately after the passing of the Telegraph Act the Corporation applied to the Postmaster-General for a licence, and proceeded to arrange for the establishment of their exchange. The licence in favour of the Corporation is dated 1st and 6th March, 1900, and the area covered by the licence extends to 143 square miles. Mr. A. R. Bennett, M.I.C.E., has been appointed engineer and general manager, and, along with an efficient staff, has already made considerable progress in the establishment of the system. Large and commodious premises, entirely new and specially fitted up to meet the requirements of the Corporation, have been leased for a period of twenty-eight years in Renfield Street, and suburban exchanges have been established in Hillhead, Bridgeton, Springburn, Govan, Strathbungo, Maryhill, and Kinning Park. The Corporation were authorised to start with an expenditure of £121,000 for the purpose of joining up 5250 completed lines and making provision for laying another 5250. The tariffs adopted by the Corporation are (1) £5 5s. per annum to cover unlimited number of calls for the whole extent of the telephone area; and (2) £3 10s. per annum and 1d. for each call made, payable by the caller only, also applicable over the whole extent of the area. The work of construction was commenced in June, 1900, and has been carried on without intermission since. 52 miles of trenching have been made in the streets, wherein have been laid 77 miles of iron pipes and 41 miles of cable, representing a total wire mileage of 16,500 miles, being equal to the route distance from this country to Australia. 81

manholes have also been built. Operating service began in the Central Switchroom on 28th March; since then Exchanges have been opened at the Exhibition, Hillhead, and Bridgeton, to which are now connected 1400 subscribers. Communication with the Government trunk lines commenced on 2nd June, the service on that day being placed in communication with all the other Exchange systems in the kingdom. The number of orders on the books on the 15th August was 5347. The metallic circuit system has been adopted throughout, and special attention has been directed to privacy of conversation between subscribers; while the switchboard has been so arranged that the operators cannot listen to conversations not intended for their ears.

INEBRIATES' REFORMATORY.

The latest undertaking of the Corporation is the establishment of a home for the reception and treatment of inebriates. The Inebriates (Scotland) Act of 1898 empowers Town Councils and others to establish and maintain a certified inebriate reformatory, and on the 4th of April, 1899, the Corporation remitted to a special committee, to consider what steps should be taken with this view, and to report. After submitting their report the committee were authorised to lease or purchase suitable premises for an inebriate reformatory, and to obtain the sanction of the Secretary for Scotland to their proposals.

The committee, after examining a number of country houses, at last fixed upon the mansion-house and estate of Girgenti, in Ayrshire, which they purchased for £7500. The house is distant 21 miles from the city, 4 miles from a town, stands 200 feet above sea level, is distant about 4 miles from the sea, and is open on every side. It is situated about 4 miles from Stewarton, from Kilwinning, and from Irvine, and 1½ miles from Montgreenan and Cunningham Head Stations, on the Dalry and Kilmarnock line. The mansion-house consists of three storeys, including the basement storey, which is partly sunk. On the main flat are a large entrance hall and a large drawing-room (30 feet by 20 feet), large dining-room, and two bedrooms, with dressing rooms, store room, pantry, etc. On the upper flat are six bedrooms and two dressing rooms, box room, etc. On the basement there are kitchen, cook's room, scullery, wash-house, servants' hall, two bedrooms, lumber room, and billiard room. Two staircases go from the top to the bottom of the house, and the basement is perfectly dry. There are two bathrooms and lavatories with earth closets. The outside offices are combined with a farm steading for the 55 acres of good arable land attached to the house. The offices consist of a two-stall stable, three loose boxes, coach-house, harness room, and engine-house, with gas engine for pumping the water supply, gasworks, and joiner's shop. The steading consists of two byres (one for six cows and another for twenty), piggery, granary, boiler-houses, dairy, dwelling-house of room and kitchen, stable (four stalls), three barns of corrugated iron, sheep-house, and a number of other erections. The ground is well fenced, and in good order. There is a walled-in garden of three-fourths of an acre, and there is a conservatory opening from the drawing-room. There are two lodges, consisting of room, kitchen, etc.

The water supply is obtained from a bore about 500 yards from the

house, and the water is pumped to the house by means of a gas engine.

The house has been altered and rearranged to meet the requirements of an institution, and accommodation provided for twenty-eight male and thirty female inmates.

The Home was licensed by the Secretary for Scotland on 18th December last, and formally opened on 12th January, 1901.

Under the Inebriates Act the Corporation have the right to say whether or not they will admit a person remitted to the Home by the Sheriff, and the following conditions indicate the class of persons to be received as inmates:—

"1. The inmates must be persons belonging to Glasgow, and must be sent for trial to the Sheriff of Lanarkshire through one of the city Police Courts.

"2. Preference will be given in every case to persons who, while habitual drunkards, are of such character and disposition that it may be reasonably expected, if cured of their intemperance, they would be able to take their places in society as self-supporting citizens.

"3. The persons admitted must not be known thieves, or otherwise belong to the criminal classes.

"4. In respect that other institutions are available for prostitutes, women of that class cannot be received.

"5. Persons suffering from infectious, contagious, or other serious disease cannot be received."

The work on which the inmates will be employed will be, as regards the female inmates, a thorough training in household and laundry work, sewing, knitting, etc., with outdoor work in the lighter form of gardening, and also in special cases, dairy work and poultry keeping, and, as regards the male inmates, they will be employed for a part of the day in any occupation which they may have previously followed, such as carpentry, shoemaking, painting, etc., for which facilities can be provided at the Home. All the male inmates will be trained in gardening or other outdoor work.

Up to the present time 21 inmates have been received. The institution is purely an experiment, and the erection and maintenance of an Inebriate Home on a much more extensive scale depends in large measure upon the success which it is hoped will attend the present venture.

CLYDE NAVIGATION,

BY

T. R. MACKENZIE,

General Manager and Secretary to the Clyde Navigation Trustees.

CLYDE NAVIGATION.

At the present day the Clyde Navigation consists of 18½ miles of the River transformed into a great navigable highway. Within the Harbour there are three tidal docks, providing, with the riverside quays, over 8½ miles of berthage. The annual revenue has reached nearly half a million sterling.

In giving a brief account of the port of Glasgow, the leading features of its rise and progress will be sketched under the following heads, viz.:—

I. Constitution of the Trust.
II. Powers of the Trustees.
III. The Undertaking.
IV. Trade of the Port.
V. Finance.
VI. Harbour Extension Schemes.

I. *Constitution of the Trust.*—The undertaking is, and has been since 1858, administered by an incorporated body of twenty-five statutory Trustees, who give their services gratuitously, consisting of—

The Lord Provost of Glasgow, *ex officio;*
9 Town Councillors of Glasgow; and
15 Members "representative of the Shipping, Mercantile, and Trading Interests of Glasgow," viz.:—
2 chosen by the Chamber of Commerce;
2 chosen by the Merchants' House;
2 chosen by the Trades' House; and
9 elected by the Shipowners and Harbour Ratepayers.

The earlier constitution of the administrative body is interesting. As far back as 1611 down to 1808 the Magistrates and the Town Council, as the municipality, were the River and Harbour authority. In 1809 an Act of Parliament was passed creating the Magistrates and Town Councillors *Statutory* Trustees of the navigation, which they continued to be exclusively till 1825, when, under an Act of that year, "five other persons interested in the trade and navigation of the River and Firth of Clyde" were added to their number, and directed to be appointed by them annually. The next change was made under an Act in 1840 which gave a representation of twenty-three members to the Town Council and of ten to outside bodies, viz.:—One to the Chamber of Commerce, three to the Merchants' House, two to the Trades' House, two to the barony of Gorbals, and one each to the two neighbouring burghs of Calton and Anderston—making the whole body of Trustees thirty-three in number. This remained the constitution till the passing of the Consolid[redacted]

tion Act of 1858, which gave to the Trust its present governing body, the changes then effected being the reduction of the total number of Trustees from thirty-three to twenty-five, and the distributing of that number by giving ten to the Town Council, six to the three Houses, and nine to the Shipowners and Harbour Ratepayers, who were then for the first time admitted to direct representation. The various Acts of Parliament referred to were promoted by the Trustees. A body of executive officers and servants, controlled by and acting under the Trustees, carry on the work of the undertaking.

II. *Powers of the Trustees.*—The powers of the Trustees have, beginning with an Act obtained by the municipality in 1758, been granted from time to time by numerous Acts of Parliament, and are mainly—

1. Works.
   (*a*) The deepening, widening, and straightening of the river, together with the buoying and lighting thereof.
   (*b*) The construction of riverside quayage, tidal basins, and graving docks, along with the equipment of the harbour with sheds, cranes, and other appliances, and tramways.
   (*c*) The maintenance of the whole undertaking.
2. Borrowing of money.
   The borrowing of money for capital purposes. The amount authorised by the Act of 1858, including all previous money authorised to be borrowed, was £1,504,000, and it has been increased till it is now £7,250,000.
3. Rating.
   The levying of dues on all vessels and goods, and for the use of the various appliances, all within prescribed maxima.

III. *The Undertaking.*—1. *The River.*—Although as early as the middle of the sixteenth century the citizens of the riverside burghs made some attempts to deepen the fords, and fifty years later the municipality began to improve the river, it was practically still in a state of nature in 1755. There were then in the 5¼ miles between Glasgow and Renfrew twelve shoals, one having only 15 inches at low water, and four only 18 inches each; but, carrying out an Act obtained in 1770 authorising deepening to at least 7 feet at low water, Golborne, of Chester, who had previously reported, got a contract in 1772 from the municipality to deepen the Dumbuck Ford to at least 6 feet, and actually accomplished a depth of 7 feet. This, on a visit made by him in 1781, was found to have become 14 feet through the increased scour of the river, produced by the contraction of the stream by jetties. Thus was fairly begun the deepening and improving of the river.

The next step towards further deepening was taken under the Act of 1809, authorising at least 9 feet at low water, and the third advance was authorised by the Act of 1825, sanctioning at least 13 feet at low water.

The next Act dealing with the improvement of the river was that of 1840, authorising the deepening of the harbour and river throughout to at least 17 feet at neap tides, and laying down lines for future widening.

The most serious natural obstacle in the later deepening of the river was the Elderslie Rock, discovered in 1854 by the grounding of a vessel. The rock, which was found at a depth of 8 feet below low water, and extended across the river, and along it nearly 1000 feet, was, after years of labour, and at a total cost of about £70,000, removed by 1886 to a depth of 20 feet below low water.

With the advantages of progressively improving dredging appliances, and the introduction forty years ago of steam hopper barges, the deepening has gone on continuously till the present waterway has been formed, affording a navigable channel deepened almost throughout to 22½ feet at low water, giving, with the tidal range of about 11 feet, 33½ feet at high water.

The magnitude of the work of bringing the river to its present condition—practically a great artificial waterway—and the result accomplished, will be realised when it is stated that during the last fifty-six years over 58 million cubic yards of material, including that excavated in the construction of the docks, have been dredged; that the bed of the river has been lowered from Glasgow to Dumbuck Ford between 24 and 29 feet, and is now practically level; and that a vessel drawing 27½ feet has come up to Glasgow on one tide.

Pilotage is compulsory within the jurisdiction of the Trustees.

2. *Tidal Docks.*—Of the existing three tidal docks the earliest, Kingston Dock, was opened in 1867, and has five acres of water space, with 830 lineal yards of quays; the next, Queen's Dock, opened partially in 1877, and wholly in 1880, has a water area of about 34 acres, with over 3300 lineal yards of quayage; and the last, Prince's Dock, partially opened in 1892, and wholly in 1900, has a water area of 35 acres, with 3737 lineal yards of quayage.

3. *Quayage.*—In 1792 the quayage of the harbour of Glasgow was only 382 yards in length, and the water area 4 acres. In 1840 the quayage was 1973 yards in length, and the water area 23 acres. In 1869 the quayage was 5604 lineal yards, or 324 yards more than 3 miles, and the water area 76 acres. In 1887 the quayage was fully 6 miles in length, and the water area 154 acres. The quayage is now 15,115 yards, or fully 8½ miles in length, 7263 yards thereof being on the north and 7343 yards on the south side of the river. The area of the existing quayage is 546,581 square yards, or about 113 acres.

4. *Equipment.*—The quays, except at some necessary open quays, have single and double storey sheds, the total floor area of the single storey sheds being 24 acres, and of the two storey sheds 22½ acres. Numerous cranes, partly hydraulic and partly steam, ranging from two tons to one hundred and thirty tons lifting capacity, are provided. There are 18 miles of tramways around the harbour connected with the various railway systems.

5. *Graving Docks.*—The harbour is provided with three graving docks, side by side, on the south bank of the river. Two enter off the harbour, and the third is entered from Prince's Dock. The first dock was opened in 1875, the second in 1886, and the third in 1898.

No. 3 dock has a pair of inside gates, whereby it can be divided, and so form an outer division 460 feet in length, and an inner of 420 feet.

6. *"Cluthas" and Ferries.*—Below Glasgow Bridge, which is the lowermost bridge across the Clyde, the ferry system belongs to, and is