CHAPTER III.

YORKSHIRE—NORTH-RIDING (CLEVELAND DISTRICT) IRON INDUSTRIES.

Geology of—Analyses, production and average prices of Ore—Output of the more important Mines—Magnetic Iron ore of Rosedale—Mines in Cleveland District—Ironstone Mining—Distribution of Ironstone—Population employed in Iron Mining—Barrow's Views on the Mineral Resources of the district—Pig Iron Manufacture—Early history, production, distribution, and average prices of Cleveland pig—Coal and Ironstone used in manufacture—Malleable Iron and Steel Works—Production and average prices of rails, plates, bars, and angles—The Thomas Gilchrist process of Steel manufacture.

Yorkshire, North Riding (Cleveland District).—The existence of an iron ore on the North-Eastern coast of Yorkshire appears to have been long known; indeed the constant discovery of iron slag on the hills of Cleveland shows clearly that ores were worked in a remote antiquity. About thirty years since some local iron-masters began to employ the Cleveland ore, to supplement the supply of ores to their furnaces. It answered well, and when the increased demand for iron ore stimulated inquiry, it was found that the Cleveland Hills were full of iron. Then began that remarkable development of the district which can scarcely find a parallel in the history of any British industry. The area of the Cleveland Hills containing the deposits of iron ores, extend on the northern escarpment from Ormesby, near Middlesborough, to the coast, and southernly to the Eskdale and Rosedale valleys; the workable portion of the iron ore being found most fully developed in the north-west portion of the area, diminishing both in the thickness of the beds and the quality of the ore in the south and eastern part of the area.

The main ironstone seam of Cleveland occurs at the top of the "Middle Lias," or marlstone rock, and consists of a bed of ironstone with beds of shale above and below; a lower seam, known as the "Bottom Seam," of fair quality also occurs. This seam is comparatively unimportant in the area of greatest development of the main seam, but acquires considerable importance in the neighbourhood of Grosmont, south-east of Whitby, where it contrasts favourably with that bed. At Eston, near Middlesborough, on its northern outcrop, the main seam attains its greatest thickness, varying from 12 to 17 feet. Throughout the main seam occurs the well known (Pecten æquivalvis), from which it is called Pecten bed.

The same strata in the south, in the neighbourhood of Grosmont, attain a thickness of 12 feet of ironstone, but with shaly partings of nearly 30 feet in thickness, the ironstone thinning out towards the south, where at Felixkirk, three miles north-east of Thirsk, it has been proved to exist in beds of six and seven inches, with shale partings of three feet.

The main seam at Upleatham is 13 feet in thickness and undivided; it however exhibits various appearances throughout the mass, not as separate bands, but one structure graduating into the other. In the Yorkshire Lias the following detailed section of the ironstone series at Upleatham is given, which may be generally regarded as a standard of reference.*

Top Block or Roof, 3 feet thick, consisting of:—

1. A brownish compact argillaceous ironstone with diffused oolitic green grains.

2. Rather more oolitic than No. 1, the argillaceous matter more diffused; small phosphatic nodular particles scattered through the mass.

3. Similar to No. 1 but more oolitic.

4. Sulphur bands.—A rock composed of oolitic grains, consisting chiefly of iron pyrites. An analysis gives 30·25 per cent. of sulphur—corresponding to 56·71 per cent. of bisulphide of iron.

   (This band was formerly worked at Eston, and applied at the Chemical Works at Washington, and subsequently at Middlesborough as a substitute for ordinary pyrites. It generally separates in loose ground from the underlying main block in the process of mining, and when sound makes an excellent roof; but its extreme liability to disintegrate on the action of moist air necessitates caution in placing reliance upon it.)

Workable Main Seam, 10 feet thick, consisting of:—

5. Top part of main block.—A greyish to bluish stone colour, not uniform, somewhat compact, with pebble-like lumps of an earthy substance of a much lighter colour than the ore and zinc blende, occupying centres of the more argillaceous parts, very fossiliferous.

* "The Yorkshire Lias." Tate and Blake, p. 119.

6. Middle part of main block, about 5 feet thick.—A light blue stone, oolitic in structure, but the grains of variable size, with crystals of carbonate of iron and carbonate of lime. The dissolution of the crystals having left cavities in the stone, imparts a cinder-like aspect to this part of the seam by which it may easily be recognised.

7. Lower part of main block.—A greenish blue stone, rather close in texture, and of a finely oolitic structure. A strong parting separates it from the underlying stratum near the outcrop.

8. Bottom block of main seam, 2 feet thick.—A compact earthy splintery rock of a dark green colour, partaking of the character of a hard mudstone, and perfectly devoid of oolitic structure, which prevails in all the higher parts of the seam.

   (Analysis shows it to be rich in alumina and silica, but the percentage of iron does not fall much below the average of that of the main block; it is however rejected by most iron smelters. It is called by the miners "black hard.")

9. A bed of shale 1 foot thick, which underlies and is called from the prevalence of Rhynchonellæ, which are occasionally aggregated in stony lumps, the "cockle bed." It yields as much as 21 per cent. of metallic iron, the other chief matter being alumina, silica, and lime.

10. Hard shale 4 feet.

11. Bottom seam of ironstone.—A dense blue clay ironstone, speckled with white and green—2 ft. 8 in. Fossils not abundant. Pecten Aequitalvis and others.

12. Shale.

The main seam, near Guisborough, at the Chaloner Mines, has a thickness of 13 feet; at the Normanby Mines, near Middlesborough, it is 11 feet; while at the Whitecliffe and the Liverton Mines, near Loftus, it is 9 feet 6 inches, with a shale parting in the middle. Again, at Ailesbury, near Swainby, it varies from 5 feet 6 inches to 6 feet 6 inches.

Below the Middle Lias, at the top of which is the ironstone main seam above referred to, succeeds the Lower Lias, and immediately above occur the shales of the Upper Lias, in which exist the beds of alum shale and jet, which have given rise to these important industries, of which Whitby may be regarded as the centre.

Above the Upper Lias, and situated at the base of the sandy estuarine beds of the Inferior Oolite, occurs the top seam of ironstone, known as the "Dogger bed," and which has, and still is, acquiring much importance from its highly magnetic character, in the Rosedale Abbey Mines, where the seam is upwards of

20 feet thick. This top seam is regarded as the equivalent of the Northampton sand, and yields a much higher percentage of metallic iron than that of the main seam of Cleveland. The Cleveland district has an area of not less than 500 square miles, and reliable authorities affirm that every acre of this vast area contains ironstone, though it remains to be proved what proportion is workable. The system of working is both by drifts from the outcrop and by shafts, which are sunk in places dependant upon the position of the ironstone, which is usually wrought by the bord and pillar system.

Analyses of the Ironstone.—The Cleveland ore of Eston, examined in Dr. Percy's laboratory in the Royal School of Mines by Mr. A. Dick, is thus referred to.* "Description: chiefly a carbonate of protoxide of iron; lustre, earthy; colour, greenish grey; streak, similar; fracture, uneven; showing here and there small cavities, some of which are filled with carbonate of lime. Throughout the ore are diffused irregularly a multitude of small oolitic concretions, together with small pieces of an earthy substance resembling the ore but lighter in colour. When a mass of the ore is digested in hydrochloric acid till all carbonates and soluble silicates are dissolved, there remains a residue having the form of the original mass of ore. It is extremely light, and falls to powder unless very carefully handled. It contains the oolitic concretions or else skeletons of them, which dissolve completely in dilute caustic potash, showing them to be silica in a soluble state. Under the microscope some of them are seen to have a central nucleus of dark colour and irregular shape, but none of them present any indication of organic structure or radiated crystallisation."

"If the residue, after having been digested in caustic potash, be washed by decantation, there remains a small number of microscopic crystals; some of these, which are white, are quartz, and others, which are black and acutely pyramidal, consist chiefly of titanic acid. Professor Miller, of Cambridge, succeeded in measuring some of the angles of the crystals containing titanic acid, and found that they correspond to similar angles in anatase. The green colour of the ore seems to be due to a silicate con-

* Memoirs of the Geological Survey, "Iron Ores of Great Britain," Part I., p. 95 (out of print).

taining peroxide and protoxide of iron, but this could not be exactly determined, because it was not found possible to dissolve out the carbonates without at the same time acting upon the silicate of iron. The constituents are as follows:—

RESULTS TABULATED.—ORE DRIED AT 100° C.

Protoxide of iron	39·92
Peroxide of iron	3·60
Protoxide of manganese	0·95
Alumina	7·86
Lime	7·44
Magnesia	3·82
Potash	0·27
Carbonic acid	22·85
Phosphoric acid	1·86
Silica soluble in hydrochloric acid	7·12
Sulphuric acid	trace.
Bisulphide of iron	0·11
Water in combination	2·97
Organic matter	trace.
Insoluble residue (of which 0·98 is soluble in dilute caustic potash) and consists chiefly of oolitic concretions	1·64
	100·41
Iron, total amount	33·62

INSOLUBLE RESIDUE.

Silica	1·50
Alumina, with a trace of peroxide of iron	0·10
Titanic acid about	0·03
Lime	trace.
	1·63

A note appended to this analysis states that "No metal precipitable by sulphuretted hydrogen from the hydrochloric acid solution of about 1,200 grains of ore was detected."

Other analyses of the main seam of ironstone worked at the Normanby mines of Messrs. Bell Brothers, and situated to the south-east of Eston, and at the Upleatham mines of Messrs. J. W. Pease and Co., situated about three miles to the north-east of Guisborough, where it is found under the most favourable conditions as regards richness of metal, give the following constituents, the metallic iron contained in the Normanby ore amounting to 31·42 per cent., and the Upleatham ore yielding 31·97 per cent.:—

B B

RESULTS TABULATED.

Constituents.	Normanby.	Upleatham.
Protoxide of iron	38·06	37·07
Peroxide of iron	2·60	4·48
Protoxide of manganese	0·74	...
Alumina	5·92	12·37
Lime	7·77	4·67
Magnesia	4·16	2·69
Carbonic acid	22·00	23·46
Silica	10·36	10·63
Sulphur	0·14	...
Phosphoric acid	1·07	1·17
Water	4·45	3·36
	97·27	99·90

The iron ore obtained from the Belmont Mines, near Guisborough, is very similar in character to the preceding, but from its greater density and compactness it would seem to have been derived from a lower measure. The ore employed at the South Bank Furnaces, Middlesborough-on-Tees, is described as: "A dull green, earthy, carbonate of iron, with silicate, containing abundance of small oolitic concretions, a few belemnite stems, and other fossil remains. Small crystals of quartz of zinc blende, and apparently also of titanite, were found in the specimen examined."*

The composition of these ores is represented by the following analyses:—

RESULTS TABULATED.

Constituents.	Belmont.	South Bank.
Protoxide of iron	39·00	43·02
Peroxide of manganese	3·50	2·86
Protoxide of iron	1·30	0·40
Alumina	7·46	5·87
Lime	7·44	5·14
Magnesia	3·82	5·21
Carbonic acid	23·06	25·50
Phosphoric acid	1·60	1·81
Silica (soluble)	9·46 (with Silica as quartz)	7·12
Silica as quartz		0·05
Titanic acid	...	traces. (with Sulphide of zinc)
Sulphide of zinc	...	
Water hygroscopic	3·66 (with Water in combination)	0·34
Water in combination		3·14
Organic matter	...	0·15
	100·30	100·61

* "Papers: Cast-Iron Experiments," 1858, pp. 40 and 34.

The metallic iron contained in the Belmont ore amounts to 32·78 per cent., and in the Cleveland ore, employed in the South Bank Ironworks, then belonging to Messrs. Samuelson & Co., 35·46 per cent.; it being observed of the latter ore that it does not contain any appreciable amount of sulphur nor of heavy metals.

The ironstone raised at Hutton Low Cross, near Guisborough, was examined by Mr. Crowder. The samples selected of the ore from three parts of the bed, are described: (*a*) as grey, hard, compact and heavy, and with very few oolitic grains; (*b* and *c*), as a softer stone, uneven in fracture, and containing many oolitic grains.

RESULTS TABULATED.

Constituents.	*a.*	*b.*	*c.*
Protoxide of iron	35·55	35·75	40·86
Sesquioxide	1·70	1·80	4·25
Alumina	3·79	4·95	3·44
Lime	4·20	7·39	3·80
Magnesia	1·12	2·98	3·70
Sulphuric acid	trace.	0·07	0·30
Silica	20·90	15·65	7·20
Carbonic acid	25·18	23·47	32·50
Phosphoric acid	2·66	5·05	0·96
Bisulphide of iron	trace.	trace.	1·60
Water	4·90	4·89	1·45
	100·00	102·00	100·06
Iron, total amount	28·84	27·45	34·75

An average analysis of the same ironstone, by Richardson, gives the constituents as under:—

RESULTS TABULATED.

Peroxide of iron	42·08
Protoxide of iron	0·68
Alumina	10·40
Lime	5·48
Magnesia	1·84
Silica	14·00
Sulphur	...
Phosphoric acid	...
Carbonic acid } Water }	24·22
	98·70
Iron, total amount	33·09

Mr. John Pattinson, of the Clarence Ironworks, gives the following as the results of his examination of the Cleveland raw ironstone, and of the same ore after calcination: *—

Constituents.	Raw Stone.	Calcined Stone.
Protoxide of iron	34·04	...
Peroxide of iron	3·74	58·30
Protoxide of manganese	0·38	0·53
Alumina	9·32	13·07
Lime	5·08	7·12
Magnesia	3·65	5·12
Carbonic acid	20·09	...
Silica	10·04	14·08
Sulphur	0·13	0·18
Phosphoric acid	1·13	1·59
Organic matter	0·36	...
Combined water	2·53	...
Water expelled by drying at 212°	9·50	...
	99·99	99·99

The amount of metallic iron in the raw stone giving 29·09 per cent.; concentrated in the calcined stone to the extent of 40·81 per cent., the loss by calcination being 28·71 per cent.

The magnetic ironstone of Rosedale has been wrought in two localities, namely, at Rosedale Abbey, East and West Mines, and at Sheriffs' Mines. The first two analyses are those of Mr. W. Crowder and Mr. J. Pattinson, and the third was made in the Clarence Laboratory of Messrs. Bell Brothers. The Rosedale Abbey stone is chiefly smelted at the Ferry Hill Ironworks, Durham, and to some extent as a mixture at other works. In quality the iron is stated to be like that which is obtained from the main beds of ironstone in Cleveland.

The Ingleby stone occurring among the oolitic rocks being thin and expensive to work has long since been abandoned. Mr. I. L. Bell states a few hundred tons were smelted without admixture at the Clarence Works. "The content of iron was verified as being superior to the ordinary Cleveland main seam, but the metal in quality did not differ from the usual make of the district."

* Transactions of South Wales Institute of Mining Engineers, vol. vi. p. 285.

RESULTS TABULATED.

Constituents.	ROSEDALE ABBEY.		Ingleby Stone.
	Black Stone.	Blue Stone.	
Protoxide of iron	...	33·85	41·14
Peroxide of iron	64·90	32·67	7·07
Peroxide of manganese	...	0·69	0·94
Alumina	9·25	3·15	4·71
Lime	3·53	2·86	3·32
Potash	...	...	0·20
Magnesia	0·99	1·59	3·34
Silica	5·70	6·95	7·37
Loss by heat	16·15	...	...
Carbonic acid	...	10·36	26·00
Phosphoric acid	...	1·41	1·36
Bisulphide of iron	...	0·03	0·08
Water	...	4·60	4·24
	100·52	98·16	99·77

The metallic iron contained in these ores amounts respectively to 45·43 per cent., 49·20 per cent., and 36·95 per cent. The Rosedale ore, employed some years since at the works of the Consett Iron Company in a calcined state, gave very satisfactory results: 632 tons 8 cwts. of calcined stone produced 344 tons 13 cwts. of pig-iron; and at the Park Gate Ironworks, near Rotherham, the raw stone was found to yield 45 per cent. of metallic iron.

The Pecten and Avicula beds of ironstone are worked by the Messrs. John and Thomas Bagnall, also the Dogger bed, at Grosmont. The two first-named beds are well developed at Grosmont Hall, about six miles south-west of Whitby, and one mile south-east of Eston, in the following section:—

SUCCESSION OF BEDS.*

	Ft.	In.
1. Shale and bands and doggers of ferro-argillaceous stone	27	2
2. "Main" or "Pecten Seam" of Ironstone	4	6
3. Shale and doggers	31	0
4. "Bottom" or "Avicula Seam"	3	9
Total thickness	66	5

These ironstones, examined by Mr. Charles Tookey, in Dr. Percy's laboratory, exhibit the following constituents: †—

* "The Yorkshire Lias," Tate and Blake, p. 147.

† Dr. Percy's Metallurgy, "Iron and Steel," p. 223.

RESULTS TABULATED.

Constituents.	Avicula Bed.	Pecten Bed.	DOGGER BED.		
			a.	b.	c.
Protoxide of iron . .	33·17	34·98	32·78	22·30	40·77
Protoxide of manganese .	0·50	0·48	0·45	0·50	0·67
Alumina	3·92	3·20	1·18	2·10	1·32
Lime	11·90	11·96	6·44	11·80	4·08
Magnesia	4·52	4·51	4·58	3·96	5·34
Carbonic acid . . .	28·00	29·20	26·13	24·40	31·80
Phosphoric acid . .	0·48	1·30	0·19	0·30	0·06
Water	3·65	3·30	2·80	3·20	2·70
Ignited insoluble solution	13·22	10·04	24·10	30·96	12·36
	99·36	98·97	98·65	99·52	99·10
IGNITED INSOLUBLE SOLUTION.					
Silica	9·42	8·00	18·12	23·10	8·80
Iron, total amount . .	25·80	27·21	25·50	17·34	31·71

In the following table will be found some of the more important localities in Cleveland in which ironstone is raised, and which has been examined, together with the name of the analyst and the amount of metallic iron :—

Name of Mine.	Analyst.	Metallic Iron per cent.
Eston	Mr. A. Dick	33·62
Normanby	Mr. I. L. Bell	31·42
Upleatham	,,	31·97
Belmont	Professor F. A. Abel	32·78
South Bank	,,	35·46
Hutton Low Cross (a.) . .	Mr. W. Crowder	28·84
,, ,, (b.) . .	,,	27·45
,, ,, (c.) . .	,,	34·75
Hutton Low Cross . . .	Mr. Richardson	33·09
Cleveland (Raw) . . .	Mr. John Pattinson	29·09
,, (Calcined) . .	,,	40·81
Rosedale (Black Stone) . .	Mr. I. Lowthian Bell	45·43
,, (Blue Stone) . .	,,	49·20
Ingleby Stone	,,	36·95
Grosmont (Avicula Bed) . .	Mr. Charles Tookey	25·80
,, (Pecten Bed) . .	,,	27·21
Dogger Bed (a.) . . .	,,	25·50
,, (b.) . . .	,,	17·34
,, (c.) . . .	,,	31·71
Spa Wood	Thomas Allison	31·00
Kirkham	...	34·00
Sleight's Bridge . . .	Mr. W. Crowder	29·83
Grosmont Tunnel . . .	,,	28·60

Production of Ironstone.—Originally it appears that the ironstone of Cleveland was collected on the beach, and this was done from an early date. Mr. I. Lowthian Bell mentions * that for the Whitehill Furnace, built in 1745 and abandoned before the end of the last century, ironstone was gathered in Robin Hood's Bay and conveyed by water to Picktree-on-the-Wear, near Chester-le-Street, and carted from that place to the works. Soon after the year 1800 the Tyne Iron Company obtained ironstone in a similar way from the beach between Scarborough and Saltburn; and according to Bewick, in his work on the Cleveland ironstone, the firm commenced between the years 1815 and 1820 to tear up the stone from its bed at different parts of the coast. It is stated that the discovery of the ironstone was due to a Mr. Wilson, then a partner in the Tyne Iron Company's Works, who pointed out its position at Grosmont, about five miles from Whitby, about the year 1836.

The seam being 4½ feet thick was cheaply worked, the stone sent down the railway and shipped at all seasons for the Tyne, where it would at that time cost about 9*s*. per ton. It is probable that ultimately as much as from 80,000 to 100,000 tons of it were annually smelted in the North-country furnaces.

The Whitby Stone Company commenced operations on the Grosmont Seam, known as the "Pecten Seam," and in May, 1836, sent their first cargo of 55 tons to the Birtley Ironworks. A second quantity was subsequently received by the same company but rejected; however the stone was again tried, and finally permanent contracts were entered into in 1838. About the same time this ironstone was also wrought at two villages, Kettleness and Staithes, the one about five and the other ten miles nearer the mouth of the Tees than Whitby; and about the year 1842 a blast furnace was erected at Walker, being the first specially constructed for smelting what was then known as Whitby or Yorkshire stone.

In the meantime, that is in the year 1840, Messrs. Bolckow & Vaughan established themselves as bar-iron manufacturers at the town of Middlesborough, and five or six years afterward, like others elsewhere before them, mistaken in the extent of local deposits of ironstone, were induced to erect four blast furnaces

* "Manufacture of Iron, Tyne, Wear, and Tees:" British Association Report, 1863.

on the South Durham Coal-field at Witton Park, about 25 miles west of their works at Middlesborough. A very short time sufficed to dispel the illusion, and about the year 1846 they also became dependent upon Whitby for their supplies of ore. The mineral was conveyed thence by vessel to their works on the Tees, unloaded, sent up by rail to Witton Park, and brought back to Middlesborough in the form of pig-iron; although a bed of stone identical with that from which it was worked lay within four miles of the wharf where they were unloading the sea-borne cargoes from Whitby. Previous to the ironstone being worked from the seams at Kettleness and Staithes, that which had been gathered on the beach consisted chiefly of water-worn masses. So far back as 1822 the series of beds of ironstone at Boulby were estimated by Young and Bird to have an aggregate thickness of 15 feet; but the main deposit itself appears to have been mistaken by those writers for limestone. Guided probably by detached masses which had fallen from the cliff along which it runs, the Great Cleveland ironstone was discovered about 1849 by John Roseby, a practical miner, in the valley of Skinningrove.

In September, 1850, the first ton of ironstone was worked from Eston Hill for trial at the Witton Park works. Previous to this the Valley of the Esk, and, to a small extent, the coast, furnished the necessary ironstone. Subsequently the quantity raised on the coast was increased a little in consequence of the seam near Skinningrove being recognised as containing more iron.

Commencing with the year 1854, when returns of production first appear, 650,000 tons of ironstone were raised in the Cleveland district, increased to 865,300 tons in 1855, and 1,148,488 tons in 1856. Additional quantities were obtained in each of the same years from the Esk Valley, and the coast, amounting in 1855 to 105,000 tons, and in 1856 to 98,124 tons; bringing up the total production of Cleveland in 1855 to 970,300 tons, and in 1856 to 1,246,612 tons. The detailed production of the mines for the year 1856 are thus given by Mr. John Marley in his paper.* This memoir contains much important matter, and gives an account of the ironworks then in operation, and the several mines in Cleveland from whence the works received their supply of ironstone:—

* "Memoir on Cleveland Ironstone, &c.," 1857.

NAMES OF MINES.	QUANTITIES.
Eston	568,156 tons.
Hutton Lowcrop or Codhill	217,253 ,,
Upleatham	171,360 ,,
Normanby	131,575 ,,
Belmont or Belmont Bank	73,164 ,,
Rosedale Cliff and Staithes	23,500 ,,
South of Staithes	12,500 ,,
Raithwaite	5,916 ,,
Sleight's Bridge	11,250 ,,
Eskdale Iron Company	5,438 ,,
Whitby Stone Company	22,500 ,,
"The Quarry," Rosedale	4,000 ,,
Total	1,246,612

In the following year (1857) seven new mines were in operation, increasing the production in that year to 1,414,155 tons, of which 7,500 tons was magnetic ore obtained from the deposits at Rosedale Abbey. In 1857 and subsequent years the production of the Cleveland Hills will be seen in the annexed table, with the number of mines producing ironstone in each year:—

Year.	Number of Mines.	Ironstone Raised.	Year.	Number of Mines.	Ironstone Raised.
		Tons.			Tons.
1857	17	1,414,155	1869	16	3,094,678
1858	17	1,367,395	1870	17	4,072,888
1859	15	1,520,342	1871	21	4,581,901
1860	17	1,471,319	1872	31	4,974,950
1861	17	1,242,514	1873	35	5,617,014
1862	16	1,689,966	1874	35	5,614,322
1863	13	2,078,806	1875	39	6,121,794
1864	14	2,401,890	1876	36	6,562,000
1865	20	2,762,359	1877	33	6,284,545
1866	19	2,809,061	1878	29	5,605,639
1867	17	2,739,039	1879	29	4,750,000
1868	15	2,785,307	1880	29	6,486,654

Considerable difficulty stands in the way of getting the exact value of the ironstone raised in Cleveland, chief among them being the large proportion which is consumed in the furnaces of the mine owners, and in regard to which there is therefore no sale, and the further large proportion which is to be delivered under contracts made many years since and having many years to run, at prices which are no guide to the existing values. Ironstone was selling in Cleveland in 1860 at 6*s*. per ton, ten years later the average price was 5*s*., at which price it continued during 1871, rising in the following year to 7*s*. 6*d*. per ton, the highest average price ever reached. During 1874 it averaged 6*s*. per ton, and since that date has continued to fall.

In the year 1875 the question of value was carefully considered by "The Mine Owners' Association," and the average price given was 4*s.* per ton net at the mines. Again, in 1876, the average price was given as varying from 3*s.* 4*d.* to 3*s.* 9*d.* per ton; and in 1877, from 3*s.* to 3*s.* 6*d.* per ton; the same prices existing in 1878. When, in 1877, it became difficult to work the mines to advantage, and this, with a decreasing demand, led to the closing of many of them, prices again fell, and in 1879 the average prices given were from 2*s.* 9*d.* to 3*s.* 3*d.* per ton, increased in 1880 to from 3*s.* 3*d.* to 3*s.* 9*d.* per ton, these prices having been adopted as the nearest approach to the correct value that could be arrived at.

The detailed production of the mines in Cleveland in the year 1880 is given in the following statement, showing an increase over the previous year of 1,736,654 tons :—

No.	Names of Mines.	Quantities. Tons.	Cwts.	Value. £	s.	d.
1	Ailesbury (Swainley)	66,042	0			
2	Belmont (Guisborough)	110,148	15			
3	Boosbeck ,,	486,695	12			
4	Brotton (Saltburn)	510,302	4			
5	Chaloner (Guisborough	*260,000	0			
6	Cragg's Hall ,,	257,491	18			
7	Carlin How ,,	115,465	12			
8	Cliff ,,	58,332	10			
9	Eston (Middlesborough)	1,037,654	0			
10	Grosmont (York)	134,671	0			
11	Huntcliffe (Saltburn)	173,157	7			
12	Lane Head (Rosedale)	3,109	16			
13	Lingdale (Guisborough)	98,531	6			
14	Lofthouse (Loftus)	584,049	16			
15	Long Acres (Saltburn)	240,315	0	1,135,164	12	0
16	Normanby (Middlesborough)	160,405	6			
17	Ormesby ,,	144,609	12			
18	Kirkleatham (Redcar)	92,615	7			
19	Park Pit	393,787	6			
20	Port Mulgrave and Grinklo	170,576	0			
21	Rosedale West	6,079	0			
22	Slapewath (Guisborough)	47,114	18			
23	Spa ,,	108,055	19			
24	Spa Wood ,,	15,271	9			
25	Skelton (Marske)	117,182	19			
26	Skelton North (Saltburn)	247,735	3			
27	Stanghow (Saltburn)	29,541	16			
28	Upleatham (Marske)	794,886	15			
29	Sundry Mines	22,826	12			
	Total of North Riding of Yorkshire	6,486,654	18	1,135,164	12	0

* Estimated.

As showing the extent of production in some of the mines wrought for a quarter of a century, the following have been selected, viz., Eston, Normanby and Upleatham, giving the total output in each year since 1856:—

Year.	Eston.	Normanby.	Upleatham.
	Tons.	Tons.	Tons.
1856	568,156	131,575	171,360
1857	562,473	159,898	171,366
1858	507,265	166,785	190,306
1859	638,620	204,260	265,524
1860	613,391	186,152	391,410
1861	565,285	83,471	288,191
1862	608,420	235,758*	433,139
1863	633,206	140,348	573,613
1864	639,404	148,417	689,940
1865	685,980	139,417	719,998
1866	710,156	147,213	753,022
1867	665,975	†	840,577
1868	715,248	169,769	872,335
1869	761,594	†	892,771
1870	831,787	215,615	959,648
1871	532,821	256,023	1,034,530
1872	†	254,272	811,579
1873	705,228	221,485	711,360
1874	569,240	224,821	585,416
1875	571,621	238,107	640,905
1876	581,978	199,254	662,200
1877	592,478	238,152	613,744
1878	557,982	228,430	732,139
1879	540,749	239,098	714,075
1880	1,037,654	160,405	794,886

The mines above referred to belong respectively to Messrs. Bolckow & Vaughan, Messrs. J. W. Pease & Co., and Messrs. Bell Brothers, who also possess many other mines in the district.

During the past few years the mines in the neighbourhood of Saltburn-by-the-Sea and Guisborough have produced ironstone in the following quantities:—

SALTBURN-BY-THE-SEA.

Year.	Brotton.	Cragg's Hall.	Huntcliffe.	Skelton.	North Skelton.	South Skelton.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1872	392,783	196,508	180,473	...	166,419	4,034
1873	375,334	169,507	173,221	157,755	165,279	133,492
1874	337,783	198,000	184,425	158,636	157,755	182,253
1875	384,436	217,539	145,487	148,776	137,133	314,237
1876	403,309	179,639	121,613	206,003	278,097	437,872
1877	458,163	175,211	166,326	20,549	297,193	379,112
1878	481,631	171,992	190,716	...	191,732	236,582
1879	410,334	167,675	198,895	10,029	201,843	133,403
1880	510,302	257,492	173,157	...	247,735	117,182

* Including Skelton. † Included in other returns.

Those named around Guisborough being as follows, in each of the years since 1872 :—

Year.	Boosbeck.	Chaloner.	Slapewath.	Spa.	Spa Wood.	Belmont.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1872	...	15,831	47,547	...	...	181,068
1873	4,785	100,513	52,000	...	...	134,965
1874	133,316	150,393	25,000	...	...	172,805
1875	222,637	207,694	51,368	111,861	83,536	161,185
1876	237,978	207,894	73,298	91,270	69,301	117,000
1877	265,870	234,995	78,001	75,662	45,303	57,301
1878	288,210	322,332	80,542	60,825	83,536	8,967
1879	318,659	261,392	26,236	64,556	3,698	34,352
1880	486,695	260,000	47,119	108,056	15,271	110,148

Other mines have exceeded the output of many of the above, notably the Kirkleatham at Redcar, the Loftus at Lofthouse, and the Liverton at the same place.

The Rosedale Abbey Estate, which has acquired some celebrity from its possession of rich and extensive deposits of magnetic iron ore, occurring in pockets, has an area of 5,530 acres, of which 2,830 acres are under cultivation. Of this estate a writer in the *Newcastle Chronicle* says: "Not until the North Yorkshire and Cleveland Railway had been transferred to the North-Eastern in 1859, and the latter company began to carry out to completion the line by extending it from Stokesley to Grosmont, and by forming the Rosedale Branch to Ingleby a year after the date last named, was there any likelihood of enlarged mineral traffic from the dale. In 1861 the Rosedale Branch was completed, and from that date, for years, the mineral output of the mines began to increase." This development appears in the following table, the output of the year 1857 amounting to 7,500 tons :—

Year.	Quantities.	Year.	Quantities.
	Tons.		Tons.
1861	79,786	1871	314,394
1862	219,123	1872	303,205
1863	224,889	1873	560,668
1864	297,580	1874	473,140
1865	250,000	1875	383,914
1866	230,382	1876	383,827
1867	178,227	1877	344,487
1868	210,082	1878	234,150
1869	269,595	1879	25,592*
1870	317,000	1880	9,188

* Mines closed in March, 1879, and operations resumed by a new company in 1880, when the above quantity was raised, the value at the pits being about 3*s.* per ton put in trucks.

The ironstone mines of Cleveland, their situation and proprietors, were as follows in the year 1881:—

CLEVELAND AND WHITBY DISTRICT.

No.	Name of Mine.	Situation.	Name of Proprietor or Company.	Name of Manager or Agent.
1	Ailesbury	Swainby	Carlton Iron Ore Co., Limited	Robt. Bell.
2	Huntcliff	Saltburn-by-the-Sea	Bell Brothers, Limited	Thomas Bell, junr. A. L. Steavenson.
3	Cliff	"	"	"
4	Carlin How	"	"	"
5	Normanby	Middlesbro'	"	"
6	Park, in Cleveland	Skelton	"	"
7	Skelton	Marske-by-the-Sea	"	"
8	Chaloner	Guisborough	Bolckow, Vaughan & Co., Limited	Thomas Lee.
9	Eston	Middlesbro'-on-Tees	"	J. Thompson.
10	Longacres	Saltburn	"	George Robinson.
11	Skelton, North	"	"	"
12	Cragg's Hall	"	J. W. Pease & Co.	Wm. France.
13	Lingdale	Guisborough	"	Christopher Heslop.
14	Lofthouse	Loftus	"	Wm. France.
15	Tocketts	Guisborough	"	Wm. Walton.
16	Upleatham	Marske-by-the-Sea	"	W. Moore.
17	Whitecliffe	Saltburn	"	William France.
18	Liverton	Loftus	Liverton Ironstone Co., Limited	G. Lee. Francis Fox.
19	North Loftus	Saltburn	Skinningrove Iron Co., Limited	J. Westray.
20	Port Mulgrave and Grinkle	Near Saltburn-by-the-Sea	Palmer's Shipbuilding and Iron Co., Lim.	A. S. Palmer.
21	Rosedale Abbey, East	Pickering	Rosedale and Ferryhill Iron Co., Limited, Martin Morrison, manager	John Roscamp.
22	" West	"	"	Charles Parkin.
23	" Sherriff	"	"	"
24	Grosmont	Grosmont (York)	Charles and Thomas Bagnall, junr.	W. Armstrong. Francis Lord.
25	Brotton	Saltburn Brotton	Morrison & Co.	D. W. Dixon.
26	California	Grosmont	..	..
27	Belmont	Guisborough	Weardale Iron and Coal Co., Limited	Thos. Allison.
28	Spawood	"	"	"
29	Kirkleatham	Redcar	Kirkleatham Ironstone Co.	William Walker.
30	Boosbeck	"	Stevenson, Jaques & Co.	"
31	Slapewath	Guisborough	B. Samuelson & Co.	Wm. Charlton.
32	Ormesby	Middlesboro'	Cargo Fleet Iron Co	William Walker.
33	Skelton, South	Saltburn	The Owners of Clay Lane Iron Works	John Thompson.
34	Spa	Guisborough	Gjers, Mills & Co.	John Tate.
35	Lane Head	Rosedale Abbey	Robt. Hansell	Robt. Hansell.
36	Wintergill	Egton Lythe	J. Foster and Son	..
37	Stanghow	Saltburn	Stanghow Ironstone Co.	E. Hamilton.

Having considered the vast deposits of ironstone in the Cleveland district, it will now be a fitting time to refer generally to some of the difficulties met with in ironstone mining, and of the machinery employed to aid the miner in the operation. A writer in the *Colliery Guardian*,* well acquainted with the district and quoting from Mr. A. L. Steavenson's interesting paper "Ironstone Mining in Cleveland," † says that, "owing to the irregular

* Nov. 26th, 1880. † "Journal of the Iron and Steel Institution," 1874, p. 329.

character of the strata in some parts and the configuration of the country in others, the mining of these immense deposits of ironstone is carried on under various conditions. At the outcrop of the main seam at Eston it is 300 feet above the level of the sea, and dips thence at the rate of three inches to the yard until it is 100 feet below sea level under the centre of the hill, whence it rises as rapidly till it crops out again at the other side of the hill, not to mention several faults or dislocations of considerable magnitude. In other parts, such as at the Kilton Winning, large feeders of water, amounting sometimes to 1,000 gallons per minute, make both sinking and working an operation of more than ordinary difficulty. Perhaps the largest feeders of water have been encountered at the North Skelton Mines. At a depth of 64 fathoms the 'Top seam' was reached, 3 feet 6 inches thick, but even at that depth the water had to be forced at the rate of 3,000 gallons, or nearly 15 tons a minute. Incidentally it may be observed, that towards the end of 1880 the depth attained at this mine exceeded 720 feet, when the ironstone was reached and is now worked."

"When the extraction of ironstone began in 1850 at Eston it was only necessary to uncover the outcrops and then quarry it out in large quantities, but as the covering increased in thickness as the working proceeded, drifting became necessary; and ultimately as the water feeders increased deep shaft sinking had to be adopted. Both drifts and shafts are now extensively in use, the expediency of adopting the one or the other being determined by the nature of the local circumstances. The getting of the ironstone is mostly accomplished by blasting, and for this purpose gunpowder is the best explosive. Many other kinds of explosives have been tried, but the oldest is still considered the best. The operations of the miners are facilitated by the occurrence, often at short distances apart, of joints called 'backs.' The mode of operation is as follows: Cylindrical holes are drilled, varying from two to five feet deep. The boring of these holes is the chief work of the miners, less skilled men being employed to break up the stone and fill it into waggons. A good miner can drill a hole of 5 feet in an hour. Different kinds of machines have been tried for the purpose of drilling these holes, but none of them have been so successful as to entirely supersede hand labour. Probably 15,000 tons of gunpowder are consumed yearly in blasting the ironstone of Cleveland. The use of such large quantities of this explosive adds considerably to the impurity of the atmosphere in the mines; hence various mechanical appliances are generally employed to improve the ventilation."

The importance of suitable machinery to aid the miner in his labour of getting the ironstone is a point of especial interest. Mr. Windsor Richards recently, in his address to the members of the Cleveland Institution of Engineers, remarks, "There is no industry of more importance to this district than that of the ironstone mining, and the economical production of ironstone can scarcely be over-rated when it is remembered that about 3¼ tons are necessary for the manufacture of a ton of pig-iron. Machinery has already been introduced for winning the stone, and its improvement and extension are well worthy of careful attention." Mr. Richards continues his observations by the following interesting sketch of rock drills and their adoption at the North Skelton Mines. He says, "I believe that Mr. William Walker, of Saltburn, was the first to introduce machinery into the Cleveland mines. He adopted the ordinary rotary spiral drill, driven by a pair of small engines worked by compressed air. Before deciding on the kind of drill to be adopted at the North Skelton Mines, where the ironstone is extra hard, he carefully investigated many of the rock drills in use, and finally determined upon the percussive system, the drills being of simple forms, requiring such slight repairs as can be effected by the ordinary blacksmith at the mine. At the North Skelton Mines there are at present seven machines at work, which are distributed over certain districts. Each district consists of ten working places. A direct-acting horizontal engine, fixed on the surface, having 20-inch steam and 22-inch air cylinders, 4-feet stroke, supplies air to the machines at a pressure of about 70 lbs. per square inch. The engine is sufficiently powerful to work twelve machines. The compressed air is forced down the shaft and along the main roads, east and west, in 6-inch pipes. The pipes along the roadway are 4-inch diameter. The machines have 2-inch and the working places 1-inch wrought-iron galvanised pipes. At present each machine only produces about 50 tons of ironstone per shift of eight hours, but a machine has occasionally got 75 tons, and in a few instances 96 and even 107 tons in eight hours. For 50 tons of ironstone got, about 25 holes 1 inch in diameter have to be bored to a depth varying from 3 feet to 5 feet, according to the hardness of the stone, or about 100 feet depth of ironstone pierced per machine per eight hours. After being placed in position the drill bores the stone at the rate of 16 inches per minute, or a hole 4 feet deep can be readily made in six minutes, including the time for changing the drills; whereas an ordinary miner would take fully sixty minutes to put in a hole 4 feet deep by 'tamping' or 'jumping' with a bar in the usual way; so that the machine does easily the hardest and most fatiguing work of the miner. One machine employs two miners and a boy, who attend to the drilling and blasting, and four labourers, who break up and fill the stone into the tubs or waggonettes. Ironstone mining by machinery is comparatively new in the district, and the miners have not yet got well into the way of using it; but there can be no doubt that with ordinary diligence one machine can produce from 70 tons to 80 tons of stone per eight hours' shift. The kind of machine adopted at North Skelton is that known as the 'Burleigh,' the principal parts of which are the cylinder, piston, the cradle, with guide stays in which the cylinder travels, and the drills. The piston travels backwards and forwards at a rate which gives 300 blows per minute, and for eighteen blows given it revolves once. The cylinder moves along the cradle, and is fed by a screw worked by hand, automatic gear for this purpose having been found so far unsuitable, owing to the various degrees of hardness of the stone to be bored. As soon as the drill has been fed in the 2-feet length of screw it is withdrawn, and a longer drill substituted. Drills are made of different lengths, and the points of various forms. The half-moon shapes are very suitable for the first and second drills to a depth of 3 feet. The air exhausted from the machines has a beneficial effect in ventilating the working places. The success of this machine, or, indeed, of any other, depends upon the handiness and simplicity of the carriage on which it is mounted. The carriage has received very careful attention from Mr. Chisholm, the engineer of the mine, and is very ingeniously arranged and well adapted for its work. The carriage must be constructed so that it can be very quickly brought up to its work, and be quickly removed to another working place. It must allow the drills to work at any angle, and to drill at any point of the working face."

Distribution of Cleveland Ironstone.—The great bulk of the ironstone raised in the Cleveland Hills is reduced to the metallic state in the furnaces of Cleveland and those of Durham and Northumberland, ample facilities for its transport being afforded chiefly by the North-Eastern Railway and its numerous branches. The total quantities of Cleveland ore carried in each year by the above-named railway include those hematite ores carried from the north-west coast of Lancashire and Cumberland, and other districts, while the annexed statement, showing for a few years the quantities used in the furnaces of Durham and Cleveland, and the total quantities of all kinds of iron ore carried by the North-Eastern Railway, will indicate generally the distribution of the ironstone :—

Year.	Cleveland Furnaces.	Durham Furnaces.	Total carried by North Eastern Railway.
	Tons.	Tons.	Tons.
1872	2,955,000	2,100,000	4,652,052
1873	2,920,000	2,392,000	4,928,458
1874	2,980,500	2,280,000	4,904,279
1875	3,296,824	2,050,852	5,305,113
1876	3,524,962	2,030,000	5,426,576
1877	3,980,770	1,972,395	5,547,821
1878	3,850,045	1,642,149	4,999,448
1879	3,380,015	1,253,850	4,190,050
1880	4,463,229	1,603,905	5,785,724

Considerable quantities of iron ore will also have been carried direct from the mines to the furnaces without passing over the North-Eastern system.

Population Employed in Iron Mining.—Until the year 1873 our information of the number of persons employed in the North Riding of Yorkshire or Cleveland district was not accurately known. In 1873 it was, for the first time, ascertained that the number of persons engaged in iron mining amounted to 9,350, of whom 6,947 were engaged in underground operations, and 2,403 above ground; producing* 5,435,233 tons of ironstone, or an average of 581 tons per person. Since 1873 the numbers employed, the ironstone raised, and average output per man, have been as follows :—

* Reports of H.M. Inspectors of Mines.

Year.	Persons Employed.		Total.	Ironstone Raised.	Average per Man.
	Under Ground.	Above Ground.			
	Nos.	Nos.	Nos.	Tons.	Tons.
1873	6,947	2,403	9,350	5,435,233	581
1874	7,571	2,274	9,845	5,428,487	551
1875	7,660	2,128	9,788	6,085,541	623
1876	7,810	2,041	9,851	6,564,101	667
1877	6,983	1,586	8,569	6,289,745	735
1878	5,654	1,137	6,791	5,316,477	784
1879	6,031	1,128	7,159	4,714,535	695
1880	6,500	1,472	7,972	6,441,783	808

In the last named year there were 44 iron mines in the district comprising 53 separate pits or drifts, but of the mines 8 were standing, compared with 18 in the previous year.

Resources of the Cleveland Ironstone District.—According to Bewick, who first directed attention to this subject, the estimated area of the main bed of Cleveland ironstone was 420 square miles, and taking the average yield per acre at 20,000 tons, he estimated the contents at 5,000,000,000 tons. In 1863 Mr. I. Lowthian Bell, in his paper on "The Manufacture of Iron," read before the British Association,* basing his calculation on the researches of Messrs. Hugh and J. T. Taylor and T. Young Hall, &c., estimated the resources of the Durham and Northumberland Coal-field at six thousand million tons for future use, so that there is sufficient fuel in the one district—reserving it for that purpose exclusively—to smelt the ironstone of the main seam of the other. The subject was again considered in the year 1871 by the "Iron Ore Committee of the Iron and Steel Institute," who reported as follows. They said, "It is now tolerably well known that after leaving the Eston Hills, the ironstone in which has occupied three square miles, the district from which the chief supply of stone is to come for the next century comprises a length of nearly six miles from the vicinity of Guisborough, south-east to the coast, with an average width of four miles. It has been proved that over the greater part of this area the main seam occurs in an unbroken state, varying in workable thickness from 9 to 13 feet, and having about the same

* "British Association Papers, 1863," p. 60.

per centage of metallic iron throughout. Towards the south the stone does get slightly leaner however, by from one to two per cent., and it also steadily thins off; but for the purposes of this estimate the whole district may be taken collectively, and the stone regarded as uniform throughout. The total area of this tract, including the Eston Hills, is 27 square miles, or 17,280 square acres. It is calculated that from the discovery of the Cleveland ironstone to the end of 1870, the total quantity of stone smelted has been 45,000,000 tons, which at 30,000 tons per acre, gives 1,500 acres worked out in twenty years, of which the greater portion has been in the locality a few miles of Middlesborough. The present rate of working is at the rate of 150 acres per annum, and this will be rapidly increased. But the mining-field under notice yet contains say, 16,000 acres untouched, so that at the rate of extraction prevailing in 1870 there is a supply of stone, in this part of Cleveland alone, sufficient to last 100 years, without taking into consideration the iron ores of Rosedale and other places outside the locality in question. But there is every reason to believe that beyond the boundaries of this known district the main seam extends underneath the whole country as far as Whitby and the Valley of the Esk, although it is impossible to speak with any certainty as to the changes that may occur in the quality or thickness of the seam in the direction indicated."

Now, accepting the estimates of the "Iron Ores Committee" and making necessary deductions for production of the past ten years, the acreage now available (1880) would not exceed 14,000 acres of the main seam of Cleveland, which at the present rate of exhaustion would afford supplies for seventy years to come.

Recently the resources of the Cleveland district have been treated in an exhaustive paper read before the Cleveland Institution of Engineers, Middlesborough,* and the results arrived at generally coincide with those of the Iron Ores Committee as to the contents of the main seam. Mr. Barrow's investigations are embodied in the following account. He says:—

"There are, in Cleveland, two distinct classes of iron-stone, the better being blue, very oolitic, and comparatively free from aluminous matter, yielding about 30 per cent., or rather more,

* By Mr. George Barrow, F.G.S., of the Geological Survey of England and Wales.

of metallic iron; the second-class stone is of a dull yellowish tinge, not so oolitic, and contains alumina in place of the iron, which is lost, 28 or 29 per cent. being as much iron as is usually extracted from it. This deterioration in quality of the stone is accompanied by a serious drawback to its being cheaply worked, for, towards (slightly below) the middle of the seam, a band of shale gradually comes in, thickening in a southerly direction till it reaches its maximum thickness of 2 feet, which is the amount of shale between the upper and lower parts of the main seam at Grosmont, the seam being quite unworkable in that district.

"In order to fix the limits of the good stone, it is necessary to know its outcrop, and also the line marking the limit of the shale band in the middle of the seam. The former I have carefully mapped out on the six-inch maps of the district. The limit of the shale band, in the middle of the seam, may be roughly described by a line joining the road at Spa Wood, near Guisborough, to the north side of South Skelton shaft, thence on to Hummersea on the coast, a little more than a mile east of Skinningrove Beck. All the good stone lies north of that line in an area consisting of three distinct parts: Eston, Upleatham, and the Skelton and Huntcliffe district.

"Commencing with the Eston outlier, Eston may be considered as consisting of Eston Royalty proper, and the smaller Royalties of Normanby, Ormesby, and Dunsdale, calculating the seam as of so many 'foot-acres,' *i.e.*, acres one foot in thickness.

"Eston, then, consists of 24,000 foot-acres, very nearly. The specific gravity of the stone is about 2·6, and, as a cubic-foot of water weighs 1,000 ounces, a foot of stone weighs 2,600 ounces, and an acre one foot thick weighs 3,610 tons. Hence we have roughly 86,640,000 tons in Eston Royalty.

"Similarly, there are 2,300 foot-acres in Normanby, and 8,300,000 tons of stone. Also in Ormesby there are 720 foot-acres and 2,600,000 tons of stone. There are 900 foot-acres in Dunsdale, or 3,250,000 tons of stone. In order to tell how long these mines will last, it is necessary next to know the average amount of stone taken yearly out of each, and the total taken.

"In consequence of the Mining Record Office returns, prior to 1865, being incomplete, it is obvious that the total obtained from this source of information will be much under the mark, in the case of Eston, Upleatham, and Normanby, as in 1865 they were in full swing, turning out almost as much stone as at present. Still, I shall make the calculation from 1865, making a small allowance for cases when considerably more stone has been taken than is represented by this total."

"From such information, then, we arrive at the following result:—The yearly output of Eston is 800,000 tons; of Normanby, 225,000 tons; of Ormesby, 75,000. The total of ironstone removed in Eston, 16,000,000 tons; in Normanby, 5,000,000 tons; in Ormesby, 500,000 tons. Now, if we deduct the total taken out from the whole of the stone in a mine, and take away at least one-tenth for loss in working, we have for the quantity now left—

	TONS.
In Eston	60,000,000
,, Normanby	2,500,000
,, Ormesby	1,800,000

Hence, dividing these totals by the average yearly output, we find, for the continued duration of each mine,—

For Eston	75 years.
,, Normanby	8 ,,
,, Ormesby	15 ,,

"Proceeding in a similar way for the Upleatham district, the total stone amounts to 10,000 foot-acres, or 36,100,000 tons. The yearly output is 700,000 tons, and the total taken out considerably over 12,000,000 tons, so that its duration will be some 30 years, or rather less—between 25 and 30.

"The area of good stone left in Skelton and Huntcliffe districts consists of 48,000 foot-acres, or 173,280,000 tons. The yearly output is about 1,800,000 tons, and the total output 24,190,000 tons, or more. Hence the workable quantity left is about 145,000,000 tons, which would, at this rate, last 80 years. But, taking into consideration the increased call 30 years hence, 60 years would be a fair limit to put to the duration of the stone.

"Now, the main seam in the poorer districts may be said to consist of a strip 13 miles long, by about 2½ miles wide. South of this the seam is very poor and thin, and consists of 4 feet of stone, with a two-feet shale parting in the middle. Before it would pay to work this, other seams will be wrought; in fact, these seams will be worked before many years, because, though thin, their quality is better than any, except the very best stone. The total amount in this strip, then, of the inferior stone, which pays to work now in fairly good times, is, roughly, 375,480,000 tons, and, at the present rate of output, would last some 130 years; but this period would be much lessened, as in 30 years the output would be more than doubled to compensate for the exhaustion of the Upleatham and other mines."

Mr. Barrow subsequently considers, in detail, the district in which the main seam occurs, where it is at present regarded as almost valueless, "and defines the area of the poorer stone 13 miles long and 2½ miles broad, as extending in a line roughly drawn from Kildale, south of Guisborough, to Kettleness, north of Whitby, as its southern boundary. At Kildale, the section of the seam consists of 4 feet of stone, with a shale parting of 14 inches, and again, on the Commondale shaft the seam may be said to consist of three-two's. At Grosmont, the seam has become so thin as to be almost unrecognisable. It must be borne in mind that this bed is in all cases of a decidedly poor quality, and so up to Kettleness, where the average yield is 26·5 per cent. of iron. South-east of Kettleness iron has not been seen or proved.

"Taking into consideration the poverty of the seam in Hawkser, south of Whitby, where the seam is represented by a few doggers, it is evident it will not be used as a source of iron for many years to come, if ever. Coming to the consideration of the other seams of ironstone in Cleveland not usually worked, examining the main seam at Eston, it would be found, at the base as at present worked, to consist of a greenish, shaly stone, having a rather mottled appearance. Before reaching the south or east face of the hill, a shale-band comes in between the oolitic stone and green stone, but only the oolitic was taken up in a long drift which was made some time ago on the Chaloner property, the shale and underlying shelly bed being left. The shelly bed is contained over a very large area, and is in fact the Pecten seam at Grosmont, and in future it would be far safer to restrict the term to this bed, calling the thick, blue stone usually found the main seam. It is usually of a poor quality, yielding about 27 per cent. of iron, or slightly less. It is difficult to estimate the amount of ironstone in this seam, because it varies very much according to presence or absence of the shaley streaks. It probably cannot be worked separately under Eston, nor in the

Upleatham district, but at the Old Hutton mines it seems to have been taken near the outcrop, its thickness being 3 feet 6 inches, at a depth of about 4 feet from the base of the seam.

"Again, at Kildale the shale is 2 feet 6 inches thick, and this belt is exposed at Spa Wood railway cutting, where its thickness is 4 feet. At Huntcliffe, and at Brotton, it is very thin, but at Longacres Pit it is 3 feet thick. At Grosmont its thickness varies from 2 feet 4 inches to 2 feet 6 inches of stone, with a shale parting in the upper part. Calculating that it covered an area of 50 square miles, with an average thickness of 2 feet 6 inches, it was estimated that there should be a total of 400,000,000 tons of ironstone from this seam, which was, however, of poor quality, and not always reliable. About 5 feet 6 inches below the Pecten seam occurs a bed of stone, remarkable for its uniform thickness and its good quality. In many places, such as Normanby and Brotton, it seemed to be equally rich in iron with the main seam, its thickness usually being about from 1 foot 10 inches to 2 feet. It maintains this thickness over a very large area, being 2 feet 6 inches at Kildale; 1 foot 10 inches at Guisborough; and 2 feet 2 inches at Hob Hill.

"On the coast at Staithes the seam shows signs of thinning, being about 1 foot 8 inches, so that they might put its south-eastern limit about three; but it continues some distance in the Stokesley range of hills, being worked for some time in the Ingleby Mine, after the main seam had been abandoned. The estimated area of this seam would be about 60 square miles, with an average thickness of 2 feet. It is mostly a clean stone, and will yield a total of about 380,000,000 tons of first-class stone.

"Below this seam is the 'Avicula' seam so well known at Grosmont. The avicula seam is very permanent, but its thickness varies very much over the whole of Cleveland, ranging from 3 feet at Grosmont, to as little as 1 foot 6 inches at Staithes, its average yield of iron being about 27 per cent. This seam also extends into the Stokesley Hills down Bilsdale, but it would be hazardous to say that it could be worked for a great distance from any given point. Its estimated area would extend over 100 square miles, and the probable amount of stone would be somewhere about 600,000,000 tons, probably more, but its working, except where it could easily be proved first, would be very venturesome. This concludes the account of the seams of ironstone in the liassic beds, and it only remains to consider those ironstone seams in the oolitic beds. Of these there are but two, one being the Dogger, or top bed, and the other the Eller Rock. The Dogger occurs at the top of the Alum shale, and as a general rule it may be defined as a sandy ironstone or a ferruginous, impure limestone. It is always remarkable for the so-called pebbles in it. At Eston, Upleatham, Guisborough, &c., it may be practically said to be non-existent.

"From the peak at Robin Hood's to Runswick Bay, on the coast all along Eskdale, Glaisdale, Muske, Esk, &c., it is a highly siliceous, oolitic ironstone, varying from 2 feet to 16 feet thick. It has often been tried at Eskdale, Grosmont, and Muske Esk, but has always failed. About Staithes, Boulby, Huntcliffe, and Liverton, the Dogger consists of a hard band of very fine clay ironstone, containing about 40 per cent. of iron, resting upon a ferruginous marl, often containing as little as 25 or 26 per cent. One of the most characteristic features of the top bed is its fickleness, being unreliable for any great distance. The per centage of impurity in the two marly beds will determine whether this seam can ever be worked, and the same remarks will apply to Huntcliffe, where the section is much the same. At Boulby Alum Works the seam is slightly thinner, but presents the same general characteristics; at Grinkle Park the seam is very thin and sandy; it is apparently absent at North Skelton Shaft, and is entirely wanting at the Hagg Alum Works, near Saltburn. The area, over which this seam may possibly be worked in Cleveland at some future time, is between four and five square miles, its average thickness being 3 feet 6 inches. In the Stokesley Hills the main seam occurs in cuticular patches, lying in eroded hollows in the alum shale. In all cases it contains much lime and silica, which in Bilsdale has been burnt for lime.

"At Limekiln Bank, over Swainby, it becomes 28 feet thick, valueless as a source of iron, and at Catcliff Bank, near North Allerton, the seam attains, in one place, a thickness of nearly 20 feet, but there are shaly partings in it, and most of the ironstone is of poor quality; in fact, it is of no value as iron ore. In Rosedale, however, a wedge of ironstone, formed similarly to that referred to in Bilsdale, occurs, in which all the lime has been probably replaced by iron, and where a rich iron ore has been found, but its extent has not hitherto been ascertained."

Pig Iron Manufacture.—The ironstone deposits of Cleveland were first developed about the year 1850, and the smelting of the stone in the district soon followed, and so rapidly, that in the year 1855 there were 23 furnaces built, 21 of which were in blast and produced 84,500 tons of pig-iron. The early furnaces erected in the district varied in height from 42 to 50 and 55 feet, their capacity varying from 5,000 to 6,000 feet; about the year 1861 furnaces of greatly increased capacity were erected at the Thornaby Ironworks by Mr. William Whitwell, three in number, each of a cubical capacity of 12,778 feet; these furnaces were 60 feet in height and 20 feet diameter in the boshes. Considerable economy was secured in the consumption of fuel in manufacture by these larger furnaces, so much so, that in 1866 the Messrs. Hopkins, Gilkes & Co., at their Tees Side Ironworks, erected two furnaces, each 75 feet in height and 24 feet in the boshes, and a capacity of 20,000 cubic feet.

The results attained by these large furnaces were so encouraging that still larger ones were erected, one having a height of 105 feet, and a cubical capacity of 41,150 feet. But it has since been determined that with these extraordinary dimensions the limit of economical working has been exceeded.

In the year 1855, above referred to, the works and firms in operation, with the number of furnaces built and in blast, were as follows, the make of pig-iron being, as previously stated, 84,500 tons:—

No.	Name of Works.	Name of Firm.	Furnaces.	
			Built.	In Blast.
1	Tees . . .	Gilkes, Wilson & Co. .	4	4
2	Eston . . .	Bolckow & Vaughan .	6	6
3	Cleveland . .	T. L. Elwen & Co. .	3	2
4	Middlesborough .	Cochrane & Co. . .	3	3
5	Ormesby . .	Bolckow & Vaughan .	4	3
6	South Bank . .	B. Samuelson & Co. .	3	3
		Total .	23	21

Several new works were projected and commenced about this period. The works of the Clay Lane Iron Company began the manufacture of pig-iron, towards the close of 1858, with one furnace, blowing in a second in the following year. The Tees Side furnaces of Messrs. Snowden & Hopkins followed in 1859, and in 1860 the furnaces of the Whitby Iron Company were put in blast; the total number of furnaces built in the district at this time being 33, of which number 25 were in blast, the works previously established in the mean time adding to their number of furnaces, and thus increasing their resources for production in the future.

The works at Normanby, of Messrs. Jones, Dunning & Co., commenced operations, in 1861, with two furnaces, followed in 1863 by the Grosmont Works, of Messrs. Charles and Thomas Bagnall, with two furnaces in the early part of the year; and the Newport Works, of Messrs. B. Samuelson & Co., with three furnaces in August of the same year.

The works at Cargo Fleet, of Messrs. Swan, Coates, & Co., were completed towards the close of 1865, and in June, 1866, two furnaces were blown in. These were succeeded by the Linthorpe Works, of Messrs. Lloyd & Co., where four furnaces were blown in about August of the same year. In the following year the Glaisdale Works, of Messrs. Firth & Hodgson, and situated near Whitby, were put in operation. Other works followed: the Ayresome, of Messrs. Gjers, Mills & Co., in 1870; the Carlton, of the Industrial Iron Company, and the Norwegian, of the Titanic Iron Ore Company, with one furnace; and those at Ayresome and Carlton with two each in the same year, when the total number of furnaces in the Cleveland district was 74, of which number 67 were in blast, producing in that year 916,970 tons of pig-iron.

In 1871 the Lackenby Iron Company, with two furnaces, commenced the manufacture of pig-iron, a third being in course of erection; and in 1873 the Coatham Works, of Messrs. Downey & Co., with two furnaces; these were followed, in 1874, by the Acklam Works, of Messrs. Stevenson, Jaques & Co., with four furnaces; the Loftus, Redcar, and Stockton Ironworks; and in 1875 by the Thornaby Ironworks, of Messrs. William Whitwell & Co., each with two furnaces. The Loftus Ironworks have recently been acquired by a new company, and are now known as the Skinningrove Works, the company being incorporated on the 8th June, 1880, since which date a few changes of proprietorship have occurred in other works. In the annexed table is given the numbers of furnaces built and in blast, the make of pig-iron, and the average yield per furnace in each year since 1855:—

Year.	Furnaces.		Pig-Iron made.	Average per Furnace.
	Built.	In Blast.		
	Nos.	Nos.	Tons.	Tons.
1855	23	21	84,500	4,024
1856	31	23	179,400	7,800
1857	32	23	179,838	7,816
1858	30	20	189,320	9,466
1859	30	23	216,127	9,400
1860	33	25	248,665	9,946
1861	33	26	234,656	9,025
1862	32	28	283,398	10,121
1863	42	33	315,197	9,551
1864	47	41	409,106	9,979
1865	65	53½	486,421	9,011
1866	67	55½	546,091	9,839
1867	67	50½	640,892	12,699
1868	69	50	699,494	13,989
1869	69	51	766,410	15,027
1870	74	67	916,970	13,686
1871	75	70	1,029,885	14,713
1872	81	73¾	1,122,114	15,215
1873	78	76	1,156,431	15,216
1874	97	85	1,158,471	13,629
1875	87	73	1,240,243	16,990
1876	86	75	1,261,013	16,813
1877	89	75	1,374,582	18,314
1878	90	67	1,358,442	20,275
1879	90	70	1,210,091	17,287
1880	91	72	1,666,156	23,141

The apparent want of constancy in the average yield per furnace in 1879 is due to the fact of several of the furnaces being but partially in operation during that year. Bearing upon the production per annum per furnace of this district, Mr. Windsor Richards, recently in his address to the Cleveland Institution of Engineers, refers to the Cleveland furnaces in these words; he says, "Some years ago this district took the lead in blast furnace construction and practice, and may still be proud of its best examples of blast furnace plant, but latterly few improvements have been made. In 1876 the output of Cleveland pig-iron per furnace per week amounted to 330 tons; in 1877, to 317; in 1878, to 406 tons; and in 1879, to 417 tons; and this year (1880) the output will be about 427 tons, showing but small progress. Some few furnaces in the district have made regularly over 500 tons per week. The manufacture of Bessemer pig-iron, Spiegeleisen, and ferro-manganese, is becoming a large industry in Cleveland. Before 1876 there was no separate account kept of Bessemer pig-iron made in the Cleveland district. Since that date the production has been as follows:—

YEAR.	TONS.
1876	125,000
1877	200,000
1878	339,131
1879	274,939

"The falling off in 1879 was owing to the Durham miners' strike, and bad trade, and this year (1880) it will probably be 500,000 tons. The total production of the blast furnaces of the North of England district will probably reach the enormous total of 2,490,000 tons."

Mr. W. Richards gives some interesting details showing the efficiency of the metallurgical operations at the Consett Ironworks in Durham, and says: "A blast furnace practice, in the manufacture of Bessemer pig-iron, worthy of imitation, is that of Mr. William Jenkins, of Consett, who, at my request, furnished me with the following information, and the results show what I believe to be the best blast furnace in England. The figures are for eight consecutive weeks in hematite pig-iron:—Iron produced, 6,454 tons 13 cwts.; average per week, 806 tons 17 cwts.; 53 per cent. of the make being No. 1 quality. Coke used per ton of iron made, 19·21 cwts. The furnace is 55 feet high, 20 feet diameter at the bosh; 8 feet hearth; 7 tuyeres; 4-inch muzzles; blast, 4¼ lbs. pressure per square inch. There are four Whitwell stoves, 22 feet diameter, 28 feet 6 inches high, each stove having a heating surface of 8,200 feet; temperature of the blast averages 1,200 deg. Fahr. Mr. Jenkins attributes these good results to the better distribution of the blast, large hearth, better lines of furnace, and good heat." According to Mr. W. Richards, the average yield of the furnaces of the Cleveland district has been as follows during the ten years ending 1879; output per annum per furnace—

Year.	Tons.	Year.	Tons.
1870	14,491	1875	17,653
1871	15,196	1876	18,693
1872	15,146	1877	20,045
1873	15,148	1878	20,645
1874	16,009	1879	20,016

It only remains to append the following list of works and owners, with the number of furnaces built and in blast in the year 1880:—

No.	Name of Works.	Owners.	FURNACES.	
			Built.	In Blast.
1	Acklam, Middlesbro'	Stevenson, Jaques & Co.	4	4
2	Ayresome, Middlesbro'-on-Tees	Gjers, Mills & Co.	4	4
3	Cargo Fleet, ,, ,,	Cargo Fleet Iron Co.	5	4
4	Clay Lane, Eston Junction	Owners of Clay Lane Ironworks	6	3
5	Coatham, Middlesbro'	Downey & Co.	2	2
6	Middlesbro'	Bolckow, Vaughan & Co., Lim.	3	3
7	Eston (Iron and Steel)		11	11
8	Glaisdale (Yarm)	South Cleveland Ironworks Co. Limited	3	..
9	Grosmont, Whitby	Chas. and Thos. Bagnall, jun.	3	2
10	Lackenby, Middlesbro'	Downey & Co.	3	3
11	Linthorpe ,,	Edward Williams	6	3
12	Skinningrove	The Skinningrove Iron Co., Lim.	2	2
13	Newport, Middlesbro'	B. Samuelson & Co.	8	8
14	Normanby, ,,	Jones, Dunning & Co.	3	3
15	Ormesby, ,,	Cochrane & Co.	4	4
16	Redcar	Walker, Maynard & Co.	4	4
17	South Bank, Middlesbro'	Bolckow, Vaughan & Co., Lim.	8	8
18	Tees, Middlesbro'	Wilson, Pease & Co.	5	5
19	Tees Side, ,,	Tees Side Iron & Engine Works Co.	4	4
20	Thornaby, Stockton	William Whitwell & Co.	3	3
		Total of North Riding	91	80

Distribution of Cleveland Pig-Iron.—The pig-iron is widely distributed at home and abroad, and is increasing yearly. The total quantities shipped to foreign countries, and to other parts of the United Kingdom, from the port of Middlesborough during the four years ending 1880, were as follows:— *

Year.	Foreign.	Coastwise.	Total.
	Tons.	Tons.	Tons.
1877	321,946	460,390	782,336
1878	337,559	422,480	760,339
1879	395,658	419,905	815,563
1880	495,638	464,943	960,581

The foreign countries receiving the shipments in each of the same years appear in the annexed statement:—

* Cleveland Iron Masters' Association Returns, 5 Jan., 1881.

Countries.	1880.	1879.	1878.	1877.
	Tons.	Tons.	Tons.	Tons.
Germany	110,611	106,681	96,801	90,368
Holland	69,684	68,732	72,930	67,660
France	68,085	53,809	61,297	68,946
Belgium	73,144	44,565	50,270	41,620
Sweden	12,487	8,776	10,162	11,290
Norway	5,385	7,758	6,763	12,763
Spain	18,695	23,223	12,311	9,377
Portugal	6,328	10,250	11,592	4,901
Russia	33,454	22,060	9,000	7,199
Denmark	4,243	3,162	1,883	3,720
Italy	1,645	2,967	3,495	3,987
Jersey	...	75	80	...
India	250	...	270	125
Japan	900	...	550	...
China	300	...	...	...
Austria	140	600	...	...
B. N. America	...	1,000	205	...
U. S. America	90,087	42,000	...	...
Egypt	200	...	...	...
Total	495,638	395,658	337,559	321,946

The shipment coastwise, and the respective ports receiving the same, were as follows in each of the same years :—

Ports.	1880.	1879.	1878.	1877.
	Tons.	Tons.	Tons.	Tons.
Scotland	283,463	285,846	330,554	317,249
Wales	89,204	70,267	58,740	60,339
Newcastle	52,332	35,492	30,716	48,478
Other ports	39,944	28,300	32,470	34,324
Total	464,943	419,905	422,480	460,390

Average Price of Cleveland Pig-Iron.—Following the pages of those journals devoted to the progress of the iron trade, evidence is afforded of the very low prices of pig-iron in recent years. In 1873 the highest price that Cleveland pig attained in the market was reached, namely, £5 9*s*. 2*d*., since which date it has receded, till in July, 1879, it was sold (No. 3) at 32*s*. per ton. An improvement appears in 1880, when the average of the year's quotations shows an increase of nearly 10*s*. per ton. The variations in previous years were as follows :—

Year.	Average.			Highest.			Lowest.		
	£	s.	d.	£	s.	d.	£	s.	d.
1868	2	3	2	2	9	6	2	3	0
1869	2	5	9	2	10	0	2	3	0
1870	2	10	3	2	13	0	2	7	6
1871	2	9	8	3	5	0	2	6	6
1872	4	17	1	5	15	0	3	5	0
1873	5	9	2	6	5	0	4	7	6
1874	3	10	11	4	7	6	3	0	0
1875	2	14	6	2	19	0	2	9	0
1876	2	7	10	2	13	6	2	5	0
1877	2	2	1	2	6	0	2	5	0
1878	1	18	2	2	1	0	1	14	6
1879	2	1	2	2	15	0	1	16	6
1880	2	10	6	3	9	0	2	2	0

The lowest price previous to 1878 was in 1868, when the average was but £2 3*s*. 2*d.*; and it is only necessary to add that the average price in 1879 increased, owing to the sudden impulse imparted to the iron trade in the last quarter of the year, when prices rose from 33*s*. to 55*s*. per ton.

Coal and Ironstone used in Manufacture.—Mr. Windsor Richards, who has carefully consided the question of fuel used in manufacture, and who has followed its economy, says, that "the improvements most conspicuous in recent blast furnace practice are to be found in the better means adopted for heating the blast in the Cowper and Whitwell firebrick stoves. It is difficult," he adds, "to ascertain the amount of coke consumed to make a ton of Cleveland iron, as blast furnace managers are very reticent on this point, but there is little doubt that the consumption of coke has of late years increased and is increasing, and the matter is so important to us as a district in the severe competition we have to contend with, that the following details, describing the alterations recently made in these stoves, to render them efficient and economical, will be interesting":—

"The Cowper stove is made much higher than formerly, so giving largely-increased heating surface, which reduces the temperature of the escaping gases at the chimney valve to about 400 degrees Fah., after having been on gas for three hours, thus utilising to the fullest practicable extent the waste gases of the former. The stoves are now made up to 25 feet diameter and 54 feet high, and have the enormous heating surface of 75,000 feet. With two such stoves to a large furnace the heat may be kept on for four hours, with a loss of heat not exceeding 150 degrees. The combustion chamber, or flame flue, has been moved from the centre to the side of the stove, whereby the whole surface of the brickwork is rendered effective for absorbing and giving up heat. The gas is admitted at the bottom of this combustion chamber, and is split up into three parts so as to attain a more complete mixture of air and gas, which, in the increased diameter of the chamber, enables more gas to be consumed, giving a better flame to the centre of the flue. The simple means adopted of clearing the dust from the stove during tapping time (the man-hole floors are hinged, and can, by the aid of a long lever, be readily opened and closed) and the sudden letting out of the compressed air through these openings clears away some of the dust. Any dust which may be lodged in the stove can be got down by light charges of gunpowder fired through the 'sight-holes.' If these simple expedients are regularly attended to the stove can be kept continuously at work for many months together. There is also a specially constructed down-comer for the gas, with a contrivance for trapping some of the dust, and so prevent it from entering the stove. The bricks used in the regenerator are made larger than formerly, the size now preferred being 2 inches by 5 inches by 12 inches. There are also tiles placed over the very many passages to distribute the products of combustion equally over the whole regenerator. By these means the blast may be readily heated up to 1,500 degrees Fah. The hot-air valve, which used to be very troublesome in these stoves when they were first designed, now works very well, and without any water for keeping it cool."

Mr. W. Richards further remarks, in reference to the Whitwell stoves, that at several works which he lately visited—Cockeril, in Belgium; Denain, in France, and Millom—he noticed that the Whitwell stoves are being increased in height. Mr. Massicks, of Millom, has raised a set of stoves for one furnace from 28 feet to 40 feet, and finds that the temperature of the escaping gases from the 40 feet stoves, taken at the chimney valve, is 360 degrees Fah., and that of the 28 feet stove, taken under exactly similar circumstances, is 495 degrees Fah. Both of these were taken after having been on gas for three hours. This alteration, by increasing the heating surface, gives greater regularity of work in the blast furnace. These stoves are now being built

15 feet, 18 feet, and 22 feet diameter, by 40 feet, 50 feet, and 60 feet high, according to circumstances; and in America Whitwell's stoves are being constructed 21 feet in diameter and 70 feet high, each stove having 30,900 feet of heating surface. The advantages of these high stoves are increased heating surfaces, more perfect combustion, and reduced number of stoves, consequently reduced space and cost per furnace. The gases enter the large combustion chamber, where they are mixed with hot air, drawn by a new arrangement through the bottom brick-work of the stove. The flame rises to the top of the combustion chamber, then descends three smaller chambers at the same time, where it is mixed with more warm air; it again ascends through two or three chambers at a time, and finally descends the three or four remaining chambers, having been mixed with air at each ascent and descent. It then escapes at the chimney valve at a very low temperature, say from 300° to 400° Fahr. Doors allow access for the scrapers for removing the dust from the walls of the chambers, and other doors, six in number, allow of the dust which has fallen from the walls being readily removed from the bottom of the stove. This scraping and cleaning of the stove need not occupy more than six hours every three or four months, and there is no necessity for cooling down the stove for cleaning, for directly the blast is shut off the operation of cleaning can be immediately commenced. There is a disadvantage in having several firebrick stoves working into one large main flue leading to a single chimney, as it necessitates the stoppage of the whole of the blast furnaces during the time the main flue is being cleaned. Perhaps a better arrangement would be to erect a wrought-iron chimney for each stove, just high enough to convey the waste gases over the heads of the men charging the blast furnaces. The chimney could be secured to the stove itself, and the waste heat is so low that no damage would result to the plates of the chimney.

The united improvements of these hot-air stoves in recent years, and the adjustment of the blast furnace to the largest capacity, consistent with economy, for smelting the ore of Cleveland, have mainly contributed to economy in the use of fuel. In 1860 the consumption of fuel was an average of 38 cwts. of coke, or 63 cwts. of coal per ton of iron, the coal yielding 60 per cent. of coke. As a matter of general practice, Mr. I. Lowthian Bell * says "that a capacity of 12,500 cubic feet, with air at 1,000° Fahr., is regarded as effecting all that can be hoped for in reducing the coke required for the blast furnace. Other considerations connected with labour, &c., have led many ironmasters to think that a furnace 80 feet high, with a diameter of 25 feet, and containing therefore 25,000 cubic feet, when supplied with air at 1,000 degrees Fahr., is as economical a form as can be devised for smelting the ironstone of Cleveland. The weekly make of a furnace of the above dimensions is said to be 400 tons."

Following the consumption of fuel in the manufacture of pig-iron, the annexed statement gives, for the nine years ending 1880, the pig-iron made and the coal and ironstone used in its manufacture :—

Year.	Pig-Iron Made.	Coal Used.	Ore Used.
	Tons.	Tons.	Tons.
1872	1,122,114	2,533,781	3,493,000
1873	1,156,431	2,643,997	3,489,383
1874	1,158,471	2,896,177	3,504,660
1875	1,240,243	2,875,357	3,740,300
1876	1,261,013	2,923,870	3,807,800
1877	1,374,582	3,220,616	4,339,907
1878	1,358,442	2,934,634	4,234,017
1879	1,210,091	2,589,660	3,699,108
1880	1,666,156	3,611,543	5,044,420

An analysis of these figures shows that in 1872 and 1873 each ton of pig-iron consumed 46 cwts. of coal; in 1876 and 1877 it was slightly above this average, while in 1878 and 1879 the average was about 41¾ and 42¾ cwts. of coal respectively to each ton of pig-iron made. In 1872 the average of the kingdom was 51 cwts. of coal to each ton of iron made, compared with 44 cwts. in the year 1880, showing economy to the extent of 7 cwts. of coal to each ton of iron made, equivalent to a saving of nearly 14 per cent. in a period of nine years.

The average amount of metallic iron in the ores of Cleveland is about 30 per cent., and where the ore alone is employed 70 cwts. of raw stone is required to each ton of pig-iron. The ironstone is previously calcined in suitable kilns—the mineral

* "Notes on the Progress of the Iron Trade."—*The Iron and Coal Trade Review* June 7th, 1878.

being thus concentrated, 100 tons of raw stone yielding on calcination from 70 to 75 per cent. of metal, and even more. In the calcination of the ironstone, in Gjer's calcining kilns, largely employed in the district, having a capacity of 5,500 cubic feet, about one ton of coal slack is required for each 20 tons of ironstone, while in kilns of larger capacity the consumption of fuel is reduced to one ton per 25 tons of ironstone.

As previously stated, 70 cwts. of raw Cleveland stone is required for each ton of pig-iron made; considerable quantities of richer ores are, however, employed; these are the hematites of the west coast, and of Spain, containing from 50 to 60 per cent., and even more, of metallic iron, which, when used in admixture with the Cleveland stone, greatly diminishes the quantity of ore employed in making each ton of iron, which does not exceed from 60 to 62 cwts.

Referring to the question of fuel and ore used in the Cleveland furnaces, it only remains to add that the coke employed is obtained from the Durham coal-field, the iron ore employed, as already stated, being derived from various localities; the great bulk being obtained in the district.

Of the iron ore thus employed, the statement below, prepared from numerous sources, will show approximately the quantities used, and from whence derived, in each year since 1872:—

Year.	Cleveland Ironstone.	Cumberland Ore.	Lancashire Ore.	Foreign Ore.	Other Ores.	Total Iron Ore used.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1872	2,955,000	32,498	17,502	58,000	430,000	3,493,000
1873	2,920,000	32,629	30,250	64,280	442,224	3,489,383
1874	2,980,500	57,668	11,210	49,379	404,903	3,504,660
1875	3,296,824	32,438	10,000	27,523	373,515	3,740,300
1876	3,524,962	38,736	21,600	94,269	108,233	3,807,800
1877	3,980,770	40,087	25,945	133,562	159,543	4,339,907
1878	3,850,045	37,578	25,430	178,982	135,982	4,234,017
1879	3,380,015	37,896	31,694	112,247	137,256	3,699,108
1880	4,463,229	35,298	22,646	430,212	93,035	5,044,420

The quantities in the column "other ores" include ores from various localities, Cornwall, Devonshire, &c.; also forge and mill cinder from the malleable-iron works and "purple ore."

Malleable Ironworks and Steelworks.—The Middlesborough Bar Ironworks were projected by the Messrs. Bolckow & Vaughan about the year 1840, and twenty years later consisted of

70 puddling furnaces and 6 rolling mills. In the year 1852 these works turned out no less than 56,000 tons of plate, rails, and other kinds of finished iron, including angle-iron of all sizes. In 1860 the works and their resources were as follows, giving an aggregate of 116 puddling furnaces and 16 rolling mills :—

Name of Works.	Name of Firm.	Number of Puddling Furnaces.	Number of Rolling Mills.
Middlesbro'	Bolckow & Vaughan	70	6
Tees	Gilkes, Wilson, Pease & Co.	5	6
Tees Side	Hopkins & Co.	41	4
	Total	116	16

Recently, in the pages of the *Colliery Guardian*,* appeared an interesting account of the finished iron trade of Cleveland, from which many of the following facts and figures are drawn. The puddling furnace and the rolling mill inevitably followed in the train of the blast furnace, and as the number of the latter multiplied so also did the former increase. During the decade 1860—1870 the height and economy of the blast furnace was the all-absorbing question in the district, and after came that of mechanical puddling. In 1870 there were 20 works in Durham and 11 in Cleveland, with a total of 1,582 puddling furnaces and 97 rolling mills, of which 529 puddling furnaces and 30 rolling mills were in Cleveland, the remainder being in Durham, giving an average of 51 puddling furnaces and 3 rolling mills to each concern.

The works and firms in operation in 1870 were as follows :—

Name of Works.	Name of Firm.	Situate.	Puddling Furnaces.	Rolling Mills.
			Nos.	Nos.
North Yorkshire	North Yorkshire Iron Co., Lim.	Middlesbro'	58	1
Cleveland	Bolckow & Vaughan	"		
Middlesbro'	" "	"	175	8
Witton Park	" "	"		
Tees Side	Hopkins, Gilkes & Co., Limited	"	102	5
Newport	Fox, Head & Co.	Stockton	54	2
Stockton	Stockton Malleable Iron Co.	"	56	5
Thornaby	William Whitwell & Co.	"	31	3
Yorkshire	Richardson, Dack & Co.	"	9	2
Westbourne	John Holdsworth & Co.	"	21	1
West Stockton	West Stockton Iron Co.	"	23	3
	Total of District		529	30

* 17th December, 1880, p. 971.

About this time, and until 1873, trade was in a buoyant state, but the resources for manufacture also increased, several new works being projected; however, towards the close of the last-named year prices began to decline, and this told heavily upon the department of trade in the district; indeed, no other department and no other district felt it so heavily. Towards the close of 1879 only one-half of the works for the manufacture of finished iron were in operation. Of the works in this district and Durham 22 were standing in 1879, representing a total of 1,328 puddling furnaces, and in October, 1879, Mr. Wm. Whitwell gave the following as the condition of these furnaces:—

	FURNACES.
Failed and not since restarted	821
Pulled down for steelworks	67
Standing possibly temporarily	432
Working	830
Total furnaces	2,150

The depression in the finished iron trade was decisively shown in 1876, when there was a great falling off in the production. In 1877 this was made manifest by a decrease in the number of works employed in that department of the trade. Not the least remarkable feature of the trade is the fact that the production of finished iron decreased while that of pig-iron increased.

There is no means of ascertaining correctly the quantity of finished iron made annually, statistics not being collected in this branch of the iron trade. There is, however, one reliable source of information. Since the year 1872 the firms on the north-east coast, that are associated with the Board of Arbitration for the district under review, have given annual returns of their production. It is believed that between the years 1872 and 1877 the firms in association produced nine-tenths of the total finished iron in the district, but since 1877, owing to some large firms having withdrawn from that board, the statistics issued under its auspices are said now to represent only three-fourths of the total production.

From the returns of the Board of Arbitration, in each of the following years, will be seen the proportion of the several varieties of finished iron, and the fluctuations to which each of these branches of the trade has been subject:—

Year.	Rails.	Plates.	Bars.	Angles.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.
1872	330,000	194,857	82,653	63,967	671,477
1873	356,884	182,151	87,368	48,843	675,246
1874	291,520	196,099	100,157	54,450	642,226
1875	270,828	190,757	111,800	45,369	618,754
1876	118,615	189,611	97,133	57,930	463,289
1877	40,425	236,195	84,844	73,738	435,202
1878	25,973	280,754	93,937	105,178	505,842
1879	8,460	217,121	76,848	61,114	363,543
1880	27,414	316,720	71,377	92,897	508,434

The branch of the finished iron trade that has shown the greatest diminution is the manufacture of iron rails, and Mr. Edw. Williams, President of the Iron and Steel Institute, explained the cause of the decay of the industry clearly in a recent address, when he said: "That for rail making the puddling forge has disappeared, and it is highly improbable that it will return. The place of it has been entirely taken by the Bessemer pit, which, in principle, general arrangement, and the most minute details, remains as it came from the hands of the inventor, and seems scarcely to admit of much improvement.

"If it be true that iron rails are doomed to ultimate disuse, it is no less true that the present year has witnessed the beginning, in Cleveland, of the manufacture of steel rails from its own native iron, the cheapest in the world. The basis of a new industry has been laid in this department of the trade under the most favourable auspices. The firm of Messrs. Bolckow & Vaughan, who were the pioneers of the Cleveland iron trade, and who now produce one-third of the total quantity of the iron produced in the district, have also taken the lead in the establishment of steel works. In the year 1877 they opened the Eston Steelworks, which had been about eighteen months in course of construction. They were started especially for the manufacture of steel rails, and for that purpose Spanish hematite was imported in considerable quantities. Since then the discovery of the basic process of dephosphorisation last year, and its successful application more recently at the above-named works, will probably prove the commencement of a new and more promising era in the history of the finished iron trade of Cleveland."

The successful issue of the experiments made in this direction are thus referred to by Mr. E. W. Richards, in his address to the Institution of Cleveland Engineers, in November, 1880.

The Thomas-Gilchrist Process.—He said: "A short history and description of a process which has created so much interest in the metallurgical world during the last two years will no doubt be of interest to you. Messrs. Thomas and Gilchrist made numerous experiments on a small scale at the Blaenavon Iron-works, where they were assisted by the manager, Mr. Edward P. Martin, and they tried also a couple of casts in a large converter at Dowlais. They prepared a paper, giving very fully the results of their experiments, with analyses, which was intended to be read at the autumn meeting of the Iron and Steel Institute in Paris in 1878; but so little importance was attached to it, and so little was it believed in, that the paper was scarcely noticed, and it was left unread till the spring meeting in London in 1879. Mr. Sidney Thomas first drew my particular attention to the subject at Creusot, and we had a meeting a few days later in Paris to discuss it, when I resolved to take up the matter, provided I received the consent of my directors. The consent was given, and on the 2nd of October, 1878, accompanied by Mr. Stead, of Middlesborough, I went with Mr. Thomas to Blaenavon. Arrived there, Mr. Gilchrist and Mr. Martin showed me three casts in a miniature cupola, and I saw sufficient to convince me that iron could be dephosphorised at a high temperature. I visited the Dowlais Works, where Mr. Menelaus informed me that the experiments with the large converter had failed, owing to the lining being washed out. We very quickly erected a pair of 30 cwt. converters at Middlesborough, but were unable for a long time to try the process, owing to the difficulties experienced in making basic bricks for lining the converter and making the basic bottom. The difficulties arose principally from the enormous shrinkage of the magnesian limestone when being burnt in a kiln with an up-draught, and of the failure of the ordinary bricks of the kiln to withstand the very high temperature necessary for efficient burning. The difficulties were, however, one by one surmounted, and at last we lined up the converters with basic bricks, when, after much labour, many failures, disappointments, and discouragements, we were able to show some of the leading gentlemen of Middlesborough two successful operations on Friday, April 4th, 1879. The news of this success spread rapidly far and wide, and Middlesborough was soon besieged by the combined forces of Belgium, France, Prussia, Austria, and America. We then lined up one of the 6-ton converters at Eston, and had fair success. The next meeting of the Iron and Steel Institute in London, under the presidency of Mr. Edward Williams, was perhaps the most brilliant and interesting ever held by the Institute. Messrs. Thomas and Gilchrist's paper was read, and the explanations and discussions by other members of the Institute were listened to with marked attention. Directly the meeting was over, Middlesborough was again besieged by a large array of Continental metallurgists, and a few hundred-weights of samples of basic bricks, molten metal used, and steel produced were taken away for searching analysis at home. Our Continental friends were of an inquisitive turn of mind, and, like many other practical men who saw the process in operation, only believed in what they saw with their own eyes and felt with their own hands—and were not quite sure then, and some are not quite sure even now. We gave them samples of the metal out of the very nose of the converter. Our method of working at that time was to charge the additions of oxide of iron and lime at the same time into the converter, and pour the molten metal upon them. The quantity of additions varied from 15 to 25 per cent. on the metal charged, according to the amount of silicon in the pig-iron used. We soon found that the oxide of iron was unnecessary; besides, it cooled the bath of metal, and we afterwards used lime additions only. After about three minutes under blow, a sample of metal was taken from the converter, quickly flattened down under a steam hammer, and cooled in water. The fracture gave clear indications of the malleability of the iron. When the bath was sufficiently dephosphorised to give a soft ductile metal, the spiegel was added. Other firms have taken up the manufacture of steel on the basic system, notably the Hoerde Company, in Westphalia, and Messrs. Brown, Bayley & Dixon, of Sheffield. Very interesting papers on the subject have been read by Messrs. Pink and Messenez and Messrs. Holland and Cooper. On Monday, the 23rd of August last, I visited the Hoerde Works with a few friends, and saw two successful casts in a small converter. Imitating the good example set me, and having good friends in Messrs. Messenez and Pink, I took a sample of the re-melted pig as it was running from the cupola to the converter, and a sample of dephosphorised metal and of the steel. Mr. Cook's analysis is: Re-melted pig—Combined carbon, 2·75; manganese, ·50; silicon, ·9; sulphur, ·31; phosphorus, 1·51. This analysis agrees with that given by Mr. Messenez in his paper read before the Institute. The metal, after three minutes' after-blow, gave phosphorus, ·13, and a further 25 seconds gave phosphorus ·10; carbon, a trace; manganese, ·17; sulphur, ·12. At this stage of the operation a large quantity of slag was poured out of the converter, and then the spiegel was added. The steel contained carbon, ·19; manganese, ·57; sulphur, ·10; phosphorus, ·10. The steel worked well under the steam hammer. The slag was of the following composition:—Iron, 10·20; lime, 46·94; silica, 9·67; phosphoric acid, 9·70. On Thursday, the 20th August, I visited the Rhenish Steelworks with several members of the Iron and Steel Institute, and the samples brought home were analysed by Mr. Cook, who shows re-melted metal to contain—Combined carbon, 2·90; manganese, 1·10; silicon, ·46; sulphur, ·16; phosphorus, 2·03. The after-blow was very long, being nearly 4¼ minutes before the first sample was taken, and a further three-quarters of a minute before the second sample was taken—in all five minutes. The carbon lines appeared on the spectroscope in a few seconds after the converter was turned up. The steel contained:—Carbon, ·28; manganese, ·56; sulphur, ·08; phosphorus, ·08—the metal, before the addition of the spiegel, having P, ·07. In a second cast the steel gave—C, ·27; M, ·40; S, ·07; P, ·10. The slag here is not passed off before the spiegel is added. The sample of slag analysed by Mr. Cook is almost identically the same as that given above from the Hoerde Works. Another cast, made when about 150 members of the Institute were present, contained, I am informed, P, ·13. It was most difficult to get near the workmen who were testing the samples, so great was the crush and the desire to obtain a piece of metal, and the wonder was that the metal was so well blown and so low in phosphorus, considering the circumstances under which the operation was conducted. At the meetings of the Institution in December last I mentioned that Messrs. Bolckow, Vaughan & Co., Limited, were about to erect some large converters at the Cleveland Steelworks of a size and form which they expected would enable them to overcome some of the difficulties which they experienced when working with the old converters on the basic system."

Mr. Richards next directed attention to a new converter; continuing, he said: "This converter is concentric, whilst the old converters are eccentric. During the operation of blowing, the lime and the metal are lifted by the force of the blast, and when that force is somewhat expended the materials fall again on to the bottom in the new form, whilst in the old form some portions would cling to the nose. The 'concentric' form has also another advantage; it gives a much larger area of floor to work in, by enabling the metal to be poured into the converter when turned on its side with the nose pointing away from the converter ladle crane, just the contrary of the present practice. On the 18th October last this converter was set to work on the basic system, and was quite successful, answering the purpose well, and showing no more symptoms of gathering at the outlet than when making ordinary steel. Our plan of operation is exceedingly simple. The converter, as is usual, is first heated up with coke so as to prevent the chilling of the metal. Then a measured quantity of well-burnt lime, about 16 per cent. of the weight of molten metal, mixed with a small quantity of coal or coke, is charged into the converter, and blown till the lime is well heated. The molten metal is then poured on the lime additions, the blast of 25 lbs. pressure is turned on, and the carbon lines disappear in about ten minutes; then after about 2½ minutes over-blow the converter is turned down, and a small sample just made, which is quickly beaten into a thin sheet under a small steam hammer, cooled in water, broken in two pieces, and the fracture shows to the experienced eye whether the metal is sufficiently ductile. If it is not so, then the blowing is prolonged, after which the spiegel is added, and is now being poured into the ladle, not into the converter. For the basic process the initial bath should be low in silicon, because silicon fluxes and destroys the lining, and causes waste of metal; it should be low in sulphur, so that the metal may not be red short. Nearly one-half the sulphur is eliminated by the basic process. In order to work economically the metal should be taken direct from the blast furnace, so as to avoid, first, the cost of re-melting in a cupola; and, second, to avoid further contact of the metal with the sulphur and impurities of the coke. It is not an easy matter to accomplish, in a blast furnace, the manufacture of a metal low in silicon and at the same time low in sulphur. It would, no doubt, very much help to keep sulphur low if maganese was added in the blast furnace, but maganese is a costly metal. At present we have succeeded in making a mottled Cleveland iron with 1 per cent. of silicon and ·16 sulphur, and white iron with ·5 silicon and ·25 sulphur, which, taken direct from the blast furnace, have both made excellent steel. But we have another method of operating, which relieves us from the necessity of making a particular quality of Cleveland pig-iron. We call this second mode of working the transfer system, because we transfer the metal from the acid to the basic converter. The transfer system enables us to take any grey iron direct from the blast furnace to the converter without any consideration as to the per centage of sulphur, which is always low in grey iron. This grey metal is poured into a converter with a silicious lining, and desiliconised, when, after say twelve or fifteen minutes' blowing in the ordinary manner, it is poured out of the converter into the ladle, and poured again from the ladle into a converter lined with dolomite, taking care that the highly silicious slag is prevented from entering the basic-lined converter. Then in the second converter it is only necessary to add sufficient lime for the absorption of the phosphorus of the metal, and the blowing then need not occupy more time than is necessary for the elimination of the phosphorus, say about three minutes. This mode of operation will no doubt give the basic lining and bottom a much longer life, but we have not yet been long enough at work to obtain the necessary experience to determine which is the better system of working, but both are good and effective, and have given excellent results. I have thus summed up in ten minutes what has taken about two years of constant work, and the expenditure of large sums of money, to accomplish. I am now able to say that the basic process has been brought to a technical and commercial success at the Cleveland Steelworks of Messrs. Bolckow, Vaughan & Co. One feature in this new process seems to have been lost sight of by those who have written on the subject, namely, the possibility or otherwise of being able to eliminate phosphorus before the carbon flame drops so as to avoid the after-blow. Few give any hope of this being accomplished, but when we remember that few gave any hope of the basic process, or any other process, being successful in eliminating phosphorus at the high temperature of the Bessemer converter, we should not abandon research or relax efforts. It has been said, over and over again, that the basic process was a failure, and would never succeed. It is a grand trait in the character of our Englishmen, that of not knowing when they are beaten. If the after-blow could be avoided, the wear of the lining and bottoms would be very much reduced. We know already that the basic lining will not be anything like so enduring as the acid lining, so special means have been adopted to quickly change a converter. An overhead steam-travelling crane, capable of lifting sixty tons, is being erected, so that directly a converter lining has worn out the crane will remove the worn converter out of the way, and bring in a re-lined one dried and ready for working. A very ingenious plan for quickly changing the converter, without removing the trunnion, is that patented by Mr. Holley, the well-known American engineer and metallurgist. The converter, freed from the trunnion, is lowered to the floor by means of the hydraulic ram. Then a re-lined and dried converter is placed on a four-wheeled bogie, and ran from the repairing and drying shed into position on the top of the hydraulic ram, which is placed directly under the trunnion. The water is turned on, and the converter is raised into position, and is then fastened by a dozen cotters to the trunnion, and is thus got very quickly ready for work."

The following is a list of the malleable-iron works in Cleveland in 1880, with the number of furnaces and mills in operation :—

No.	Name of Works.	Name of Firm.	Nearest Port or Railway Station.	No. of Puddling Furnaces.	No. of Rolling Mills.
1	Ayrton Rolling Mills .	Jones Bros. & Co., Lim. .	Stockton-on-Tees .	29	2
2	Bowesfield . . .	Bowesfield Iron Co. .	" . .	33	3
3	Britannia . . .	Dorman, Long & Co. . .	Middlesbro' . .	60	1
4	Erimus	Erimus Iron Co., Lim. .	" . .	..	..
5	Eston Grange . .	Eston Grange Iron Co. .	" . .	..	..
6	North Yorkshire . .	North Yorkshire Iron Co., Limited . .	Stockton-on-Tees .	..	..
7	Carlton . . .	The Carlton Iron Co., Lim.	" . .	..	..
8	Cleveland . . .	Bolckow & Vaughan . .	" . .	..	3
9	Middlesbro' . . .	" " .	" . .	..	1
10	Tees Side	Hopkins, Gilkes & Co., Limited. 11 Danks's	" . .	80	4
11	Newport . . .	Fox, Head & Co. . .	" . .	46	4
12	Yorkshire . . .	South Yorkshire Iron Co., Limited .	" . .	..	..
13	Westbourne . . .	John Holdsworth & Co. .	" . .	22	2
14	West Marsh . . .	Dorman, Long & Co. .	" . .	20	2
15	Hull	East Riding Malleable Ironworks . .	Hull	..	..
16	Imperial (South Bank)	Jackson, Gill & Co., Lim.	. . . . .	38	3
17	Star	Star Rolling Mills Co. .	Middlesbro' . .	..	..
	Total of District .	. . . .	. . . . .	328	25

Considering the consumption of fuel in these works, it was ascertained that in the year 1872 some 640,000 tons of coal were used, increased to 660,000 tons in the following year; since that date the fuel consumed annually in these works in Cleveland has fallen off considerably, and in the year 1879 did not exceed 405,000 tons. It has been observed that when the manufacture of iron rails in Cleveland saw its best days, that district produced, it is estimated, nearly one-third of the rails made in the United Kingdom. The success which has attended the process of dephosphorising Cleveland iron brings it within the bounds of possibility that that district may before long occupy as prominent a position in the manufacture of steel rails as of old it held in the iron rail trade. Already the leading firm is reported to be producing steel at the rate of 150,000 tons per annum, nearly double the total quantity produced last year in the whole district, and if that is mostly made into rails, the revival of that industry is as rapid as was the decline of the iron rail trade.

Prices of Malleable Iron and Puddlers' Wages.—These have been subject to great fluctuations; the average prices of rails, plates, bars, and angles, in 1879, were about one-half of the prices current in 1873, and wages showed a corresponding fluctuation. From the Board of Arbitration returns in each year since 1872 the average selling prices of iron, including rails, plates, angles, and bars, were as follows; and side by side appears the average puddlers' wages, in each of the same years:—

Year.	Average Selling Price.			Average Puddlers' Wages	
	£	*s.*	*d.*	*s.*	*d.*
1872	9	0	3	11	6
1873	11	9	1	13	0
1874	10	9	5	11	7
1875	8	1	0	9	4
1876	7	2	2	8	3
1877	6	15	3	8	3
1878	6	2	7	7	8
1879	5	8	6	7	0
1880	6	3	9	7	9

The highest price reached was in the year 1873, when puddlers' wages were 13*s.* 3*d.* during nine months of that year.

Prices fell in the following year, and wages increased somewhat. The rate of wages changed four times in 1874, and three times in 1875. During 1876 and 1877 it remained stationary, since which, in 1878 and 1879, the tendency was downwards. However, in the first half of 1880 the wages of puddlers gave an average of 8*s*. 3*d*., while the realised prices per ton fell to £5 5*s*. 6*d*.

Following the prices of each variety of iron since the year 1872, the annexed statement, based upon the returns of the Board of Arbitration, will indicate those of plates, bars, and angles, which were as follows:—

Year.	Plates. Average.	Bars. Average.	Angles. Average.
	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*
1872	10 6 1	9 16 4	9 1 11
1873	12 6 1	12 5 3	11 11 1
1874	11 6 4	10 15 7	10 11 10
1875	8 14 9	8 9 8	8 3 6
1876	7 9 9	7 1 8	7 0 4
1877	6 19 8	6 16 2	6 8 1
1878	6 6 9	6 4 6	5 13 2
1879	5 10 10	5 8 11	5 1 3
1880	6 9 5	6 7 9	5 14 9

From the annual Report of the British Iron Trade Association, for the year 1879, some very interesting facts are obtained, showing the average prices, in each of the above years, of iron rails, as compared with steel rails, the former being, in 1872, £9 6*s*. per ton, compared with £4 18*s*. 3*d*. in 1879; while steel rails were, in 1872, current at £13 17*s*. 6*d*. per ton against £5 2*s*. 6*d*. per ton in 1879. The average prices are as follows:—

Year.	Price of Iron Rails.	Price of Steel Rails.	Difference.
	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*
1872	9 6 0	13 17 6	4 11 6
1873	11 4 4	15 10 0	4 5 8
1874	8 9 0	9 17 6	1 8 6
1875	6 19 6	8 7 6	1 8 0
1876	6 0 10	7 2 6	1 1 6
1877	5 15 3	6 7 6	0 12 3
1878	5 2 1	5 12 6	0 9 11
1879	4 18 3	5 2 6	0 4 3
1880	6 3 4	7 7 6	1 4 2