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The Iron Manufacture of the North of England.

DISTRICTS OF CLEVELAND, DURHAM, AND CUMBERLAND.

BY MM. GRUNER AND LAN.

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IMPORTANCE OF THE REGION : THE NORTHERN COAL FIELD.

THE coal-formation of the north of England is divided into two east and west branches, like that of the centre ; but these two branches are very unequal. On the eastern side is the great basin of Newcastle, and on the western the narrow coal zone of Cumberland, skirting the sea, between Whitehaven and Maryport. Between these two rise up the waste table lands of Allenhead, composed of Millstone Grit and Carboniferous Limestone, containing lead veins.

*Divisions of the Northern Field.*—These two basins supply the iron works of the North of England, which may be classed into the three following districts :—

Cleveland (or Middlesboro'),  
Durham (or Newcastle), and  
Cumberland or North Lancashire.

The iron industry of the northern field differs in many respects from that of Staffordshire, of Wales, and of Scotland. While the Coal-measure ores abound in the three latter districts, forming the basis in the manufacture of pig-iron, they are almost entirely absent from the northern basin. In Cleveland the ore used is the Oolitic ironstone of the Lias, in Cumberland the red ore of the Carboniferous Limestone, and in Durham a mixture of these two ores with the Coal-measure ores or the spathic ore or brown hematite of the lead veins. Instead of raw coal, coke is exclusively employed.

The northern works produce specially forge-pig. The hematite

pig-metal of Cumberland, and especially that of Weardale, in Durham, made from the more or less decomposed spathic ores, is reputed to be of superior quality. The Cleveland pig-metal, although grey like that of Staffordshire, is much less tenacious and more impure. It is quoted at 1*l.* less than the ordinary metal of the central district, from 2*l.* 8*s.* to 2*l.* 10*s.*, instead of from 3*l.* 8*s.* to 3*l.* 15*s.* Cleveland also sells superior numbers as foundry-pig, but they are in much less demand than those of Scotland.

*Number of Works.*—The northern field comprises from thirty-five to forty works, with a hundred and twenty blast-furnaces. Its production of pig-iron amounts at present to from 700,000 to 800,000 tons, of which three-quarters are furnished by the Cleveland works.

*Coal Formation of the North of England.*—Before passing to the description of the iron districts, we shall say a few words on the coal-formation which supplies them with fuel. It is divided, as we have just said, into two unequal parts—the Newcastle and the Cumberland basins; the former annually producing from sixteen to seventeen millions of tons, and the latter one million. The details which follow relate principally to the Newcastle basin, but everything relative to the cost-price and to the nature of the coal applies equally to that of Cumberland.

The Newcastle basin extends, from south to north, from the valley of the Tees to that of Coquet. Its length is 50 miles, and its average breadth from 15 to 20. Its apparent area, not including the Millstone Grit, is 780 square miles. But to the east, between the Tyne and the Tees, the coal-formation dips under the Permian grits and limestones, and doubtless extends very far in this direction, for the workings of several mines have long been developed under these overlying deposits.

*Number of Coal-Seams.*—Forty coal-seams have been distinguished, of which eighteen are said to be workable; but these seams are far from being continuous, and never all exist through the entire extent of the coal-basin. In general, in the richest portions, there are rarely more than four or five seams of from 2 to 5 feet in thickness, and Mr. Buddle estimates that, on an average, taking the basin as a whole, not more than 12 feet of workable thickness can be calculated on. It will be seen therefore that the quantity of coal is not so enormous as is generally supposed; it is very much less than in Wales, where, over a much greater area, the workable thickness is almost double.

*Production of the Basin.*—As regards mere production, the northern basin is exceeded by that of the centre, but surpasses those of Wales and Scotland, as will be seen by the following figures:—

The central basin furnishes from 29 to 30 millions;  
 The Newcastle basin, from 16 to 17 millions;  
 The Scotch basin, 9 millions;  
 The Welsh basin, from 7 to 8 millions.

As to the specific production per mine, none can compare with the Newcastle basin. While the average per mine in all the United Kingdom is 22,000 tons; the average of the Newcastle basin reaches 55,000 tons.

*Exports of the Newcastle Basin.*—This basin also surpasses all the others in the quantity exported, which exceeds half the total exports of the kingdom. In 1858 it amounted to:—

Coal	..	..	..	..	3,542,922 tons.
Coke	..	..	..	..	207,103 „

*Nature of the Coals.*—The Newcastle coals occupy, from their nature, an intermediate position between those of Wales and Staffordshire. They are caking coals with a long flame, furnishing a silvery-white coke. These coals are equivalent with the caking coals of the basin of the Loire. To the south, in Durham, they are very soft and caking; while to the north, in Northumberland, they become harder and drier, and are more suitable for gas-works. Until within the last six or seven years the very small, obtained from screening, was at Newcastle, as in the central district, for the most part left on the waste heaps, or burnt in the open air as being of no value. At present, owing to the washing machine of M. Bérard, this small is cleaned and replaces in part the ordinary coal in the making of coke. The result has been a rise in the price of small, and a fall in that of large. In 1850, when the first iron-works were established at Middlesboro', the small was only worth at the pits from 3*d.* to 6*d.*, and now it ranges from 2*s.* to 2*s.* 9*d.*; while the ordinary large has fallen from 6*s.* 6*d.* to 5*s.* 6*d.*

*Royalties.*—In Durham, between the Tyne and the Tees, the coal royalties belong for the most part to the bishoprick of Durham. On an average a royalty of 6*d.* per ton is paid; but it varies, according to the situation and quality of the coal, from 4*d.* to 8*d.*; here and there it amounts even to 1*s.*, and some mines in the neighbourhood of Newcastle pay as much as 1*s.* 3*d.* In the southern part of Durham, which furnishes all the coal for the Cleveland works, almost all the mines are in the hands of one proprietor, Mr. Joseph Pease, of Darlington. He alone raises 1,200,000 tons per year. Still some of the principal ironmasters of the district—Messrs. Bolckow and Vaughan, of Middlesboro', the Derwent and Consett companies and that of Ferryhill and Tudhoe—have their own mines and raise the coal, either for their own use or for export.

*Cost Price.*—The cost-price of the coal, in the south and west of Durham, is extremely low at most of the mines. Owing to the soft-

Nature of the Coal.	Price at the Pits or at the neighbouring Works.		Price at the Works at Middlesboro'.	
	<i>s.</i>	<i>d.</i>	<i>s.</i>	<i>d.</i>
Unscreened .. ..	3	6 to 4	4	9 to 5
Unwashed small.. ..	2	3 „ 2	3	6 „ 4
Nuts .. ..	3	0 „ 4	5	0 „ 5
Ordinary lumps.. ..	5	2 „ 5	6	6 „ 7
Superior lumps .. ..	6	9 —	8	0 —

The average distance from the mines to the works or to the port of export is 30 miles, and the carriage is ½*d.* per ton per mile, or 1*s.* 3*d.* for the entire distance.

ness of the coal it rarely exceeds from 2*s.* 9*d.* to 3*s.* per ton.\* The foregoing table shows the present selling price.

Durham is traversed by numerous railways. Besides the North-Eastern, the north and south trunk lines from London to Edinburgh, by Darlington and Newcastle, various branch lines, connecting the mines with the nearest ports, have been constructed for the carriage of the coal: thus in the valley of the Tees is the oldest English railway, from Darlington to Stockton and Middlesboro'. More to the north, various lines connect Stanhope, Weardale, Auckland, and the town of Durham with the ports of Hartlepool, Sunderland, and Shields; next, in the valley of the Tyne, is the east and west trunk line from Carlisle to Newcastle, extended as far as the ports of Tyne-mouth and North Shields. On the other hand there are few canals in this district; but vessels of light draught can at high water go up the Tees as far as Stockton, and up the Tyne as far as Newcastle.

*Price of the Coke.*—The coke is manufactured on the mines, either from the ordinary coal or from the washed small. The operation is generally conducted in ordinary round ovens like bakers' ovens. The coal yields on an average 55 per cent., and the coke is sold, according to quality, for from 8*s.* to 9*s.* The cost-price is made up as follows:—

	<i>s.</i>	<i>d.</i>
1 ton 16 cwts. of coal at 3 <i>s.</i> 9 <i>d.</i> .. .. .	6	9
Cost of make .. .. .	1	3
Cost-price on the mine per ton .. .. .	8	0
Cost of carriage from the mines to the works at Middlesboro', a distance of 30 miles .. .. .	2	0
Cost-price per ton at the Cleveland blast-furnaces .. .. .	10	0
Or for superior qualities .. .. .	11	0

The best coke, for cupolas or locomotives, is quoted f. o. b. at from 12*s.* 6*d.* to 14*s.*

*Coal-Measure Ore.*—The northern coal-basin contains, as we have said, very little ironstone. It is found, however, here and there towards the base of the formation, but the nodules are too scattered to be workable, unless occurring immediately at the roof of the coal seams. It is thus that in working the coal, there is procured from the Durham and Northumberland mines about 20,000 tons of carbonate of iron, which is smelted by the Derwent company in their blast-furnaces. It costs 8*s.* per ton, but this would be greatly increased if it were necessary to open special workings for its extraction.

#### THE CLEVELAND DISTRICT (MIDDLESBORO').

Of the three northern districts that of Cleveland, although the most modern, is by far the most important. The works are grouped on the opposite banks of the river Tees, within a radius of five or six miles from its mouth. The greater number are situated on the right

\* Throughout the Cleveland and Newcastle districts the legal ton of 20 cwts. is exclusively used. In the mines where the coal is soft a hewer breaks in a day from 6 to 7 tons. In the north of the basin the coal is harder, and consequently the cost-price amounts to 5*s.*

bank, between Stockton and Redcar, near the small town of Middlesboro'.

*Number of Blast-Furnaces.*—In 1860, the period of our visit, they amounted to:—

32	blast-furnaces south of the Tees.
16	,, north ,,
—	
Total 48	forming 12 distinct establishments.

With these blast-furnaces are associated only two forges, that of Middlesboro' and that of Teeside, both near Middlesboro'. The forges are more numerous in Durham, near the collieries, while the blast-furnaces have rather been erected in the neighbourhood of the iron mines.

*Special conditions of the Cleveland District.*—The Cleveland mines are of very recent origin, the oldest dating back scarcely ten or twelve years, the period of the discovery of the Lias ore; but, owing to the abundance of this ore, the district has, in a few years, attained a very great importance. Everything has indeed combined to favour this rapid development. The ore crops out, in thick beds, in the eminences which border the sea, and is worked without shafts open-cast, or by simple levels. The Durham basin, of which we have just spoken, furnishes the fuel; and for forty years the oldest railway in the United Kingdom has carried its coal to Middlesboro', a distance of 30 miles, for the small sum of 1s. 3d. per ton for coal, and 2s. per ton for coke. Thus the blast-furnaces, constructed at the foot of the iron mines, found themselves already connected with the collieries, and in a position to export directly by sea their manufactured products. This exceptional situation threatened the other districts of the United Kingdom with ruin. Fortunately for them these favourable conditions are in part counterbalanced by the special nature of the ore. Much less reducible and less fusible than the Coal-measure carbonate, it is besides more phosphorised and quite as sulphurised, without, like it, containing as a corrective a large proportion of oxide of manganese. From these causes the Cleveland foundry-pig is less soft than that of Glasgow, without being more tenacious; and the forge-pig, although grey, is not suitable for the making of rails, or for irons or plates of ordinary quality. It cannot therefore in any case replace the forge-pig of the central district.

### 1. *Raw Materials.*

The Cleveland works procure their fuel and refractory clay from the Durham mines, of which we have just spoken, especially from those which surround West Auckland and the higher valley of the Wear. The ore comes from the Cleveland hills, at the foot of which are erected the blast-furnaces; the limestone from the calcareous table-lands of Stanhope and Allendale which separate the Newcastle basin from that of Cumberland: of all the raw materials used, the latter has to bear the most carriage, about 40 miles. We shall not refer again to the fuel of which we have already stated the source, the price, and the nature. There is nothing to say of the refractory clay,

the price and quality of which are about the same in all the basins. The following are the details respecting the ores—

*Liassic ore.*—This ore was discovered ten or a dozen years ago by the principal ironmasters of the district, Messrs. Bolckow and Vaughan, who had some years before established a forge at Middlesboro', for the treatment of scrap iron and the refining of pig-metal derived from various sources.

From the mouth of the Tees to Whitby, the sea is skirted by a series of flat hills, ranging east and west, with an average height of from 300 to 350 feet. At the base the Lias appears, towards the top the Lower Oolite, and halfway up, in the Middle Lias, a ferruginous seam 14 feet thick crops out. This is the Cleveland ore, formed of an intimate mixture of grey carbonate and of greenish hydrosilicate of protoxide of iron.\* The seam, striking east and west, inclines at the outcrop 7 in 100 south, becomes horizontal under the centre of the hills, and then rises in an inverse sense and crops out again at a distance of 6 or 7 miles in the valley of Guisborough, which ranges east and west like the hills themselves. It is along these outcrops that the ore is wrought. The most important and oldest mine was opened by Messrs. Bolckow and Vaughan on the northern outcrop, near Eston, between Redcar and Middlesboro'. At the western extremity of the same outcrop is the mine of Bell, brothers, the proprietors of the five blast-furnaces of Clarence works, situated opposite Middlesboro', on the left bank of the Tees. Lastly, in the valley of Guisborough, are the mines of Mr. Joseph Pease, the rich colliery proprietor of Darlington. Besides these, many less important mines have been opened to the east and west of them.

*Quantity of Ore raised.*—The whole of these workings furnish annually from 1,400,000 to 1,500,000 tons, of which half comes from Eston only, belonging to Messrs. Bolckow and Vaughan. We shall give a few details respecting this mine, the extent of which is about 2 miles following the direction of the seam, and 2½ miles following its dip.

*Mode of Working.*—In the first place the outcrop was worked open-cast, to an extent of more than a mile. At that period the ore only cost 2s.; but soon, owing to the steepness of the hill, it became necessary to lay open the seam by levels and headings. At present, besides a cross-cut drainage level, three large tramway-headings traverse the mine starting from the outcrop; each of which is provided with a fixed horizontal steam-engine of about 15-H. P., placed underground at a few yards below the surface. Each puts in motion an endless wire rope, guided by sheaves and pulleys, to which the waggons are attached. These headings, which are about 1,000 yards long, are not perfectly straight, and dip with an inclination of at most 2 or 3 in 100: they are lighted with gas all the way. These trains are composed of twenty-five full waggons coming up, and of as many empty ones returning; but it is said that this number might be increased to forty. Their rate of travelling reaches

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\* At 80 or 100 feet above the principal seam there is a second one, much thinner, containing nodules of a richer ironstone. It is being worked at points, and particularly for some time in the neighbourhood of Whitby.

from 8' to 10' per second. The waggons are of iron and rectangular in form; they hold about 1½ tons of ore, and weigh empty about 18 cwts. From the mouth of each of these three headings there is a self-acting inclined plane at the surface, from 500 to 700 yards long, which takes the ore to the bottom of the hill. Here it is emptied from the mine waggons into the railway waggons, on the branch line running into the Stockton and Darlington railway, whose various branches between Middlesboro' and Redcar directly serve to connect all the blast-furnaces on the right bank of the Tees. There is another branch in the Guisborough valley, for the purpose of connecting the blast-furnaces with the mines of the southern outcrop worked by Mr. Joseph Pease.

The method of working adopted at the Eston mine is very simple. The seam is cut out into blocks 30 yards by 10, by headings 3 yards wide, the length of the blocks being taken along the line of dip. The headings are in the first place driven 3 yards high following the wall; above which a yard of ore is left provisionally, inasmuch as it forms a better roof than the shales. The blocks are afterwards taken away, starting from the outcrop, by being again divided up by a series of workings at right angles to each other, very small pillars being left as supports. This method is economical but it entails a loss of a quarter of the ore.

This mine employs about four hundred miners and three hundred other workmen. The miners work two and two, and are paid 10*d.* per ton, out of which they pay for powder and candles, but not for the repair of tools. Each miner breaks about 5 or 6 tons, and gets from 3*s.* 6*d.* to 5*s.* per day. Per ton of ore broken one-fifth of a pound of powder is consumed. The timber used for propping, which is pine, is derived in part from the Department of Les Landes, by Bordeaux or Bayonne, and costs delivered at the mine 14*d.* or 15*d.* per foot.

*Cost-price of the Ore.*—The iron ore, loaded in the railway waggons, costs, including interest of capital, from 3*s.* 3*d.* to 3*s.* 6*d.* per ton, as follows:—

	<i>s.</i> <i>d.</i>
Breaking .. .. .	0 10
Tramming and accessories .. .. .	0 9
Wood and other materials .. .. .	0 6
Royalty .. .. .	0 8
Office expenses and interest of capital .. .. .	0 5 to 6 <i>d.</i>
Cost-price per ton .. .. .	3 2 ,, 3 <i>s.</i> 3 <i>d.</i>

The weekly production was 14,000 tons at the time of our visit. The greater portion is smelted in the sixteen blast-furnaces which belong to the proprietors of the mine. The rest is sold to the neighbouring works at 4*s.* 6*d.* per ton loaded in waggons. The nearest works are at a distance of 2 miles, and the furthest, 5 or 6 miles; the cost of carriage is 1*d.* per ton and mile. At Guisborough the cost-price does not reach 3*s.*, but the distance to the works is 10 or 12 miles. For this reason it is found preferable to calcine the ore on the spot, and to sell it in that state: the operation is conducted in kilns. The calcined ore is sold, delivered at Middlesboro', at 6*s.* 6*d.*

*Nature of the Ore.*—The Cleveland ore contains in a raw state from 29 to 30 per cent., and after calcining 40 per cent., the calcination causing it to lose 25 per cent. of its weight. The most striking characteristic of this ore is the great proportion of alumina which is as high as that of silica (from 8 to 10 per cent.), while in the Coal-measure ores it is generally comprised between 30 and 50 of the percentage of silica. This circumstance, added to the small proportion of manganese, explains the refractory nature of this ore.\* It also contains iron pyrites which is found here and there in small irregular veins. But its most injurious constituent is phosphoric acid, the proportion of which varies between 1.5 and 2 per cent.; that is double or triple the amount contained in the Coal-measure ores. Towards the base of the seam the ore is particularly full of fossils which seem to increase the proportion of phosphorus. After this it is not surprising that the Cleveland iron should be all cold short.

*Red Ores.*—The Cleveland blast-furnaces in general only smelt the Liassic ores, of which we have just spoken; still some ironmasters, in order to improve their pig-metal, mix with them the red hematite of Lancashire and Cumberland. But as it costs 20s. per ton at the works it is very little used. According to Mr. Hunt's statistics the Cleveland district in 1858 only imported 11 or 12,000 tons; a tenth of the ore smelted.

*Forge-Cinders.*—Some ironmasters also charge forge-cinders; but in all cases only those from the heating furnaces, and always in very small proportion.

*Limestone.*—The Jurassic formation of Cleveland does not contain any calcareous deposits which are not argillaceous. The limestone for the blast-furnaces is derived from the Carboniferous Limestone, forming the table-lands of Stanhope and Allenhead, 40 miles from Middlesboro.' For this reason it costs 4s. per ton delivered at the furnaces.

## 2. *The Making of the Pig-Iron.*

*Situation and Arrangement of the Works.*—The Cleveland works are generally excellently although not luxuriously constructed, and are mostly on the same type. The blast-furnaces, exteriorly cylindrical, are enveloped in a mantle of iron plates. The most modern ones rest on columns; the others on four brick pillars, connected by conical arches.

The different furnaces of any ore works, generally ranged in a line, are connected two and two by iron bridges, but in other respects are entirely isolated.

Under the bridges are the hot-air apparatus, two for each furnace; and behind are the pneumatic lifts, one serving for two or three furnaces. On the right and left are the steam-boilers and blowing machines.

The gas is everywhere utilised, either for the boilers or for heating the air. Most of the throats are closed with the aid of a

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\* It is this same high proportion of alumina which renders the oolitic ore of Mondalazac, in Aveyron, and many of the ores of the department of Indre, so refractory.



movable distributor; at Teeside, however, a vertical cylinder fixed into the throat has been adopted.\*

The Cleveland furnaces have generally only three tuyers, the diameter of which is 4"; the pressure of the blast is from  $2\frac{3}{4}$  lbs. to  $3\frac{1}{4}$  lbs.; the temperature from 320° C. (600° Fahr.) to 350° C. (860° Fahr.). To heat the air the ordinary Calder apparatus with flattened syphons is used, or else, as at Clarence works, the apparatus with truncated syphons, with interior partitions. The blowing engines in most of the works are with upright cylinders and beams. The steam works at a high pressure and expansively. The blast-cylinders are of from 8' to 10' diameter and stroke, and the velocity of the pistons is  $6\frac{1}{2}$ '.

*Nature of the Pig-Metal.*—The normal product of the Cleveland works is, as in Staffordshire, grey pig, properly so called. Nos. 1 and 2 are for foundry, and Nos. 3 and 4 for forge use.

*Form of the Blast-Furnaces.*—In order to obtain this pig-metal from the aluminous ores of which we have just spoken, neither the Welsh form of furnace with enlarged hearths nor still less that of the Glasgow district without hearths properly so called can be used. The old traditional form has been adhered to, particularly in respect of the boshes and a true hearth. To obtain, however, a very large production the body has been enlarged. This is nearly cylindrical excepting a rather sharp contraction towards the throat, with the view of facilitating the collection of the gases. Owing to the hardness of the coke and of the ore the height of the body can, without inconvenience, be carried as far as 50' to 60'. The interior capacity measures from 200 to 230 cubic yards; some, like those at the Teeside works, go beyond 250 cubic yards. Such a blast-furnace, with all accessory apparatus, buildings, blowing engines, branch railways, &c., costs in Cleveland from 8,000*l.* to 10,000*l.*

The Cleveland ore calcined is less fusible but quite as reducible as the Coal-measure ore. With a given capacity of the body as great a production can be obtained as in Staffordshire, and in fact the ordinary furnaces of from 200 to 230 cubic yards produce from 20 to 26 tons, and those of 250 cubic yards a minimum of 30 tons, which corresponds to  $8\frac{1}{2}$  cubic yards per ton of pig in the twenty-four hours.

*Consumption of Coke.*—The infusibility of the aluminous gangue is shown by the weight of coke consumed, which is rather high for a calcined ore yielding 40 per cent. From 1 ton 10 cwts. to 1 ton 14 cwts. is consumed according as the metal is more or less grey; for the same reason the charge of limestone amounts to 14 cwts., and a dense blast and a high temperature are used. This powerful blast is however little favourable to the reduction of the silica, owing to the excess of alumina and lime. The Cleveland metal therefore is neither so siliceous nor so black as that of Glasgow; but on the other hand it is more phosphorised. As ordinary air would not in any degree remedy this latter inconvenience, the use of the cold blast has never been entertained: the pig-metal would be quite as impure with a much higher consumption.

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\* See *Mining and Smelting Magazine*, vol. i, Plate III, Fig. 7.

*Slags.*—The slags are entirely different from those of the other districts. They are always stony and short, and after cooling never present the enamelled tint, clear olive or apple green, of the maniferous slags.

*The Use of Forge-Cinders.*—Some ironmasters are beginning to charge forge-cinders. When their use is confined to the cinders from the heating furnaces, which are not much phosphoretted, and when the proportion does not exceed from 5 to 10 per cent., the deterioration of the iron is not more sensible than in Staffordshire. Some masters even maintain that there is rather an improvement, which indeed may not be impossible, considering the aluminous nature of the ore and the siliceous character of these cinders.

*Cost-Price of the Pig-Iron.*—Of all the districts of the United Kingdom the economical situation of Cleveland is most favourable to the production of pig-iron. The cost-price per ton varies according to situation from 2*l.* 7*s.* to 2*l.* 10*s.*; but this price includes the interest of the capital employed, and often also a certain profit on the raw materials. If this profit and interest were deducted it would be seen that in reality the cost-price, calculated as in Wales, is not more than 2*l.* 3*s.* for forge-pig. In 1860, in one of the principal Cleveland works, we found the following details of cost:—

	Tons	Cwts.	s.	£	s.	d.
Calcined ore of 40 per cent. .. ..	2	10	at 6	0	15	0
Coke .. ..	1	12	„ 10	0	16	0
Limestone .. ..	0	14	„ 4	0	2	10
Coal for engine and hot air .. ..	0	10	„ 4	0	2	0
Labour (not including that for calcining and carbonisation) .. ..				0	5	6
Repairs, management, discount, &c. .. ..				0	4	0
Interest of capital .. ..				0	2	0
Cost-price per ton .. ..	2	7	4			

But these figures may be reduced, even irrespective of the charge for interest of capital and the profit realised on the raw materials. If from 5 to 10 per cent. of forge-cinders are added, and if besides the object is to produce chiefly Nos. 3 and 4 for forge use, the consumption of coke would only be from 1 ton 8 cwts. to 1 ton 10 cwts., instead of 1 ton 12 cwts. The saving would thus be nearly 1*s.* on the ore and 1*s.* 6*d.* on the coke, reducing the cost-price to 2*l.* 5*s.* per ton.

*Markets.*—The Cleveland pig-metal is less sought for foundry use than that of Scotland, and is generally quoted at 3*s.* or 4*s.* less. In June 1860 the quoted prices f. o. b. at Middlesboro' were:—

	£	s.	d.		£	s.	d.
No. 1 .. ..	2	10	0	No. 3 .. ..	2	8	6
No. 2 .. ..	2	9	6	No. 4 .. ..	2	7	6

Nos. 5 and 6 (mottled or white), 2*l.* 6*s.* to 2*l.* 6*s.* 6*d.*

Generally only the three superior numbers are sold; the others are refined, in the district itself, for rails and common bars.

Part of the pig-iron is exported. Of late years Germany, and still more Holland, have taken the greater portion, France coming

third. According to Mr. Hunt the following are the exports from the Middlesboro' district:—

	1856.	1857.	1858.
	Tons.	Tons.	Tons.
Germany .. .. .	21,159	20,034	8,331
Holland .. .. .	9,584	22,840	30,129
France.. .. .	12,598	15,815	8,585
Other countries .. .. .	6,466	11,211	8,948
<b>Total .. .. .</b>	<b>49,807</b>	<b>69,900</b>	<b>55,993</b>

The pig thus exported is partly refined. France will doubtless import increasing quantities, but, we repeat, the wrought iron made from it, will always be of very ordinary quality, principally cold short, although sufficiently good for the making of rails.

*Second-Fusion Pig.*—The superior numbers of the Middlesboro' raw pig are mostly converted, in the district itself, by second melting in a cupola, into railway chairs and pipes. One establishment alone, that of Messrs. Bolckow and Vaughan, makes as much as 100 tons of chairs per day. The consumption, for the second melting, is 10 per cent. of coke; and in 1860 the chairs were sold at 30s. more than the raw pig, or 4l. : the pipes for from 4l. 15s. to 5l. 15s., according to their dimensions and forms.

*Profits.*—The profits of the first Cleveland ironmasters were considerable from 1853 to 1857. Since then things have changed, and yet the conditions are now more favourable than otherwise, at least those of the principal works, whose proprietors also own coal and iron mines. So while the production has diminished in the other districts since 1857, in this one a continued increase is reported, excepting a slight falling off in 1858. The districts of Middlesboro' and Newcastle produced:—

	Tons.		Tons.
In 1857 .. .. .	527,600	In 1859 .. .. .	617,966
In 1858 .. .. .	499,800	In 1860 .. .. .	658,679

And this increase arises entirely from the Middlesboro' works. It is evident also that the production of these works is alone limited by the consumption; for there can be no falling off in either the ore or the coal for a long time to come.

### THE DURHAM DISTRICT (NEWCASTLE).

#### *General Conditions of the Newcastle District.*

The Durham district differs in many respects from that of Middlesboro'. It being supposed, *à priori*, that the carboniferous district of the north-east would prove as rich in iron ores as the other coal basins, some blast-furnaces were erected there, about the period when the iron works of Wales and Staffordshire commenced to develop themselves. But the clay carbonates being found wanting, almost all these furnaces remained idle, and their situation was not improved

until the discovery of the Lias ores of the Cleveland hills, and when, by means of railways, it became possible also to obtain the red ores of Cumberland and the brown hematites and spathic ores of the Carboniferous Limestone. From the fact of this situation the ore is dearer than at the Middlesboro' works, but, on the other hand, the coal is on the spot. Therefore, in fact, as regards the cost-price of the pig-iron, the difference is inconsiderable. But this iron must be wrought on the spot, for, taken for export in a raw state, it cannot compete with that of Middlesboro'.

The works of the Newcastle district are dispersed over the whole extent of the coal basin, and not, like those of Cleveland, concentrated round a centre.

1. *Works in Northumberland.*—There exist a certain number of works along the Tyne, near Newcastle itself, and further north in Northumberland; but these establishments are unimportant, being too distant from the iron mines to be successful. Thus out of eighteen furnaces, distributed among eight distinct works, six only were in blast in 1858, and their production did not exceed 45,000 tons.

2. *Of Durham.*—Between the Tyne and the Tees, in Durham itself, there are three principal establishments; which, taking them from north to south, are:—the works of the Derwent Iron Company, those of the Weardale Iron Company, and Witton Park, belonging to Messrs. Bolckow and Vaughan, the fortunate proprietors of the Eston iron mine.

3. *Of the Derwent Iron Company.*—The Derwent Iron Company possesses eighteen blast-furnaces, and a large forge of eighty-four puddling furnaces, for rails, large irons and common plates. The whole constitutes three distinct works near Shotley Bridge, Bradley, Crook Hall, and Consett.\* The oldest, that of Consett, was erected not far from the western border of the coal basin, in the hope of finding the clay ore at the base of the formation. As is known this attempt failed and the company was ruined; and it is entirely owing to the discovery of the Cleveland Lias ores that the three works are at present in activity; but their position has been precarious since 1858, on account of their distance from the sea. In 1860 out of eighteen furnaces only eleven were in blast. The company itself possesses coal mines containing nodules of clay carbonated iron, but these can only be worked when found immediately in the roof of the coal seams. The blast-furnaces are only supplied with 15,000 tons of it, out of a total of from 200 to 250,000 tons of different kinds of ores annually smelted. The Coal-measure carbonate thus broken with the coal costs 8s.

The Cumberland red ore costs 20s. delivered at the works; the cost of carriage is 8s. for a distance of 120 miles by rail. The Derwent works smelt annually at most from 25 to 30,000 tons, but will consume more for the future. For the sake of reference we may mention the brown hematite of the Carboniferous Limestone. It is used only in small quantities because it is poor, in proportion to its price of 11s. per ton. It thus appears that four-fifths at least of the

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\* Consett was built in 1841; the two other works, after the discovery of the Lias ore; Crook Hall, 1850; and Bradley, in 1854.

ores smelted in the blast-furnaces of the Derwent Iron Company are furnished by the Cleveland mines. The distance is from 45 to 50 miles; the carriage is 3*s.* 9*d.*; consequently the calcined ore costs 9*s.* per ton.

The form and working of the Derwent furnaces differ little from those of Middlesboro.' The production is generally grey metal. Some furnaces however are charged with a high proportion of forge cinders, and in that case, like the Welsh works, furnish white pig more or less granular. The normal production is 20 tons per furnace, when charged only with Cleveland ores; from 25 to 26 tons when a fourth or a third of red hematite is added; and upwards of 30 tons when the charge contains from 20 to 30 per cent. of forge cinders. It will be seen from this that the quality, like the cost-price of the iron, varies within rather wide limits.

*Cost-Price.*—When the Lias ore is smelted alone the cost-price is made up as follows:—

	Tons.	Cwts.	<i>s.</i>	<i>d.</i>	£	<i>s.</i>	<i>d.</i>	
Calcined ore .. .. .	2	10	at	9	0	1	2	6
Coke .. .. .	1	12	„	8	0	0	12	9
Limestone .. .. .	0	14	„	1	10	0	1	3
Coal for engine and hot air ..	0	10	„	2	0	0	1	0
Labour .. .. .	..	..	..	..	..	0	5	6
General expenses, including interest ..	..	..	..	..	..	0	5	0
Cost-price .. .. .	..	..	..	..	..	2	8	0

As thus appears the conditions are a little less favourable than at Middlesboro'; and as there is, besides, the cost of carriage to the sea (4*s.* 6*d.* per ton), it will be seen that exporting, in competition with Middlesboro', is almost impossible under present circumstances. The pig-iron must therefore either be worked up on the spot, or the cost lowered by the addition of cinders. Both systems have been adopted simultaneously; thus, in 1859, out of a production of from 80 to 90,000 tons of pig-iron 25,000 tons of rails were made, 13,000 tons of large plates, and 4,000 tons of iron in bars.

4. *Of the Weardale Iron Company.*—The Weardale Iron Company possesses four works, all very modern ones: five blast-furnaces at Towlaw near Weardale; one at Stanhope; and two at Ferry Hill, built in 1860. Lastly, a large forge of sixty-four puddling furnaces, built about 1853 at Tudhoe near Ferry Hill. The make at these works is quite special. The Weardale company treat in their furnaces at Towlaw the spathic ores and brown hematites of the Weardale, Allenhead, and Alston Moor table-lands, &c.\* They have the monopoly of all the ores furnished by the lands of the Bishop of Durham. These ores are very manganiferous, without phosphorus, and almost without sulphur, and contain less than 1 per cent. of alumina. They also smelt the red ores and some Cleveland ore, but only as an accessory. It will be seen from this that the Towlaw pig is specially adapted for manufacture into wrought iron. It is white, lamellar,

\* These ores are furnished by veins which, in the Carboniferous Limestone, occupy a zone of 20 miles in length by 4 or 5 in width. The average distance of the mines from the blast-furnaces is from 10 to 12 miles.

and easily refined. Its cost-price doubtless exceeds by about 20s. that of the ordinary Cleveland pig, but it can be refined for fine iron and thin plates, which are superior to the best irons of Staffordshire; and even in applying the Lowmoor method products are obtained in no respect inferior to those of that establishment. The Towlaw pig-metal is also puddled at Tudhoe for steel, and, at the time of our visit, a Bessemer apparatus was being erected, it having been proved at Sheffield itself, that it was capable of yielding by that method good cast-steel.

The Weardale company sell but little iron in pig. Almost all that they produce is converted into wrought iron at their fine forge at Tudhoe, one of the best appointed that we saw in England. About 30,000 tons of wrought iron per year can be produced there, and of late years, besides fine irons, superior rails for Russia have been manufactured at 8*l.* 10*s.* per ton.

5. *Of Witton Park.*—The Witton Park works, in the valley of the Wear, above Bishop-Auckland, belong to Messrs. Bolckow and Vaughan. This establishment, erected since the discovery of the Cleveland ore, comprises four blast-furnaces and a large forge.\* Lias ore exclusively is smelted there. Being situated 34 miles from the iron mines, the ore costs about 1*s.* less there than at Consett, and as the coke is almost the same price, the ordinary grey metal does not cost more than 2*l.* 6*s.*; which is a little less than at Middlesboro' but the carriage to the port is 3*s.* It is necessary therefore to refine the pig on the spot, which, besides, can be more advantageously done than at Middlesboro', owing to the vicinity of the coal mines.

Besides the thirty blast-furnaces of the three companies of Derwent, Weardale and Witton Park, Durham includes five other works with ten furnaces, without counting the sixteen on the left bank of the Tees, which we have included in the Middlesboro' district. Out of from 6 to 700,000 tons of pig actually produced per year by the two districts of Newcastle and Middlesboro', about 200,000 tons are furnished by the former.

#### THE CUMBERLAND AND NORTH LANCASHIRE DISTRICT.

We shall only say a few words on this third district, which may be said to be yet in a nascent state. We have stated that its ore is the red hematite; and we have spoken of its coal basin, which borders the sea from Whitehaven to Maryport. Until of late years almost all the ore of this district was exported into other districts. In 1858 there were only four blast-furnaces in Lancashire, of which one was worked with wood, and nine in Cumberland. Of these thirteen furnaces seven only were then in blast, and their total production did not reach 30,000 tons. Since then a large establishment of six blast-furnaces has been erected near the port of Barrow, in North Lancashire, whence the red ore of the district is exported to

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\* The two forges belonging to Messrs. Bolckow and Vaughan, that of Middlesboro' and that of Witton Park, include together 150 puddling furnaces; they can turn out per year nearly 80,000 tons of wrought iron.

South Wales. In Cumberland the two old works of Cleator Moor and Workington have also been resuscitated.

The ore of this district contains neither sulphur nor phosphorus, and very little alumina. It is specially adapted therefore for the making of forge-pig, and it is it principally which is at present converted by the Bessemer process into common steel at Sheffield. It is with this cast steel that boiler plates and railway points are made. The metal is obtained with hot air and costs at present at the Barrow works less than 3*l.* per ton. Owing to the new method of refining steel, and above all owing to the purity of the pig-iron, the Cumberland district is certainly destined to be largely developed, if the small extent of the coal basin does not prove an obstacle. A considerable increase in the production of pig-iron has been already reported. According to Mr. Hunt:—

	In 1859.	In 1860.
Lancashire furnished .. .. .	Tons. 26,491	Tons. 81,250
Cumberland „ .. .. .	50,097	87,750
Total production of the district ..	76,588	169,000

## On the Manufacture of White Oxide of Zinc direct from the Ore.

BY GEORGE DARLINGTON.

THE manufacture of zinc-white direct from the ores of zinc is an industry which has hitherto failed to have an existence in England; and the attempts which have been made to produce this pigment have invariably had their basis upon an arrangement dependent upon the use of a close vessel or retort, where the ore or metal and the products of combustion do not mingle. Thus the manufacture has remained an expensive one, and when carried out on a large scale, as in the Vieille Montagne works, the metal has been the foundation of the oxide. Upon this arrangement much ingenuity and money has been expended; but no attempt has been made to meet the objection of expense by a direct production from the ore in an open furnace, and under circumstances where retorts, and that homeopathic arrangement so peculiar to the metallurgy of zinc, should be done away with completely.

Perhaps the only valuable contribution which the Americans have made to the science of metallurgy has been in this particular branch of manufacture; indeed as regards the production of white zinc it must be confessed that they have brought it to a very high degree of perfection—if by this word we understand the production of an excellent commercial article at such a price as to leave perhaps the largest relative profit found in any smelting operation. Under these