THE BARROW HEMATITE STEEL WORKS.

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The Works of the above Company being of considerable extent, the present Paper, which is intended more particularly as a guide to Members when visiting the Works, Fig. 1, Plate 134, must necessarily be of a somewhat cursory character.

The Company was established in 1861 with the object of developing on a large scale the vast and wealthy deposits of hematite iron ore of the district, and of manufacturing pig-iron and all descriptions of Bessemer and Siemens-Martin qualities of steel. The special suitability of hematite iron ore for steel manufacture—either by the Bessemer or the Siemens-Martin process—has been most strikingly shown, and the rapid growth of the Furness district and of its industries is a proof, if one were needed, of the value of this metal, especially now that steel is so largely [used for all purposes where previously the best qualities of iron only were employed. The iron mines owned and worked by the Company are situated within 5 miles of the blast-furnaces.

Blast Furnaces.—The blast-furnaces, Fig. 2, are twelve in number, ten of which are 61 feet high and 18 feet 6 inches diameter at the boshes, and two are 70 feet high and 18 feet 6 inches diameter at the boshes. The number of tuyeres used varies at each furnace from seven to eight, each having 5-inch nozzles.

There are twenty-nine hot-blast stoves of various designs, four being Massicks and Crooks', two Whitwell's, nine Ford and Muncur's, and the remainder Cowper's, Plate 135. The newest stoves are of Cowper's design and are 70 feet high and 28 feet diameter, and heat the blast to a temperature of 1,500° Fahr. The blast is obtained from condensing beam-engines giving an average pressure of blast of 5 lbs. per square inch. Each furnace produces 750 tons per week of Bessemer iron. The whole of the iron made during the week is taken direct to a mixer, Plate 136, for use at the steel works, but the iron made at the end of the week is cast into pig-iron.

The materials, after being filled into iron barrows, are conveyed to the tops of the furnaces by an inclined tramway, and charged by hand on to the bell, which is afterwards lowered by the usual counterbalanced beam controlled by a rack and pinion arrangement. The ores smelted consist of both local and best foreign hematite, usually containing 50 per cent. of metallic iron. The coke used is principally obtained from Durham and Lancashire, and from the company's own collieries at Barnsley. The limestone is procured from the company's quarries situated 3 miles from the furnaces.

The blast-furnace slag is run into self-tipping bogies, Plate 137, and taken by narrow-gauge locomotives to the tip situated about half a mile from the furnaces.

The gases from the furnaces are utilised for heating the stoves and boilers.

Breaker.—This mechanical device for breaking pig-iron has just been introduced, Plate 138. It is placed upon a massive concrete foundation 13 feet 6 inches high, and is actuated by electric motors. The pig-iron is cast upon the pig beds in the customary manner, and when cool is picked up by means of a steam travelling-crane and placed upon wagons. These wagons are all taken to the machine where an electric travelling-crane lifts the comb of iron on to the breaker-girders, between which the feed table reciprocates. The machine is then put in motion, the table rises and the comb is carried forward under breaking rams, worked

from an eccentric shaft, which bring sufficient force upon the pigs to break them, the broken pieces falling into a receiving wagon placed under a shoot on the other side of the machine.

Mixer.—The mixer, Plate 136, was the first receptacle for this purpose erected in this country having mechanical movement. It has a capacity of 120 tons of molten iron, nearly 6,000 tons passing through it weekly. The iron is conveyed by a locomotive from the mixer to the Bessemer shop in ladles of 18 tons capacity.

Bessemer Shop.—This is one of the most modern of European Bessemer shops, and contains four converters, each of 20 tons capacity, arranged in one row, and facing what is generally known as the pit. The converters are elevated sufficiently to allow the ladle, standing on a crane below, to receive the contents of steel, and also to allow a bogie on a road beneath the converter to receive the slag. Each converter is actuated by means of a powerful pair of vertical hydraulic rams having a rack-and-pinion acting in opposite directions. In front of the converters is a platform, supported by iron columns, to which access is obtained by an inclined roadway, along which the molten iron is brought from the mixer in ladles, Plate 139. The locomotive places the ladle of iron in front of the mouth of the converter, a hook engages itself on to a pin fastened on the ladle and lifts it up gradually until the whole of its contents are poured into the converter. When the ladle is emptied, it is again lowered on to the carriage and returned to the mixer to be re-filled.

Spiegeleisen is charged into the converter in a similar manner, the cupola being at the one end of the platform, and on the same level as the converter.

The converters are attended below by two transfer cranes, Plate 140, on which are placed the ladles for receiving the steel. These cranes transfer the ladles to a centre or casting crane from which the "heat" is cast into moulds. In addition to the ladle cranes, there are two smaller ones which serve for changing the ladles or any other pit work. All these cranes, although of different sizes, are of the same

principle, namely, the top supported pillar having a wheel actuated by a ram and rack for the turning movement. This is a very simple arrangement, and is found to work admirably. The cranes are worked from an ordinary distributing box, from which the converter and lifts are also worked.

All the moulds are placed on bogies, each bogie carrying two moulds. They move forward under the nozzle of the ladle as required, the centre crane remaining stationary. The bogies are moved along by means of a finger fixed on a ram, which is situated on the floor level. Each mould is made to hold two tons of steel, and in order that the arrangement of casting should work well, about a hundred bogies are always in use, the consequence being that there is a constant stream of bogies and moulds in circulation, and by keeping them running in proper order, the moulds become cool by the time they are required without recourse to water cooling.

When the ingots have remained in the moulds ten minutes the bogies are drawn forward to the ingot stripper. This is a very useful machine, which, with a minimum of labour, strips the moulds from the ingots and places them on to an empty bogie that they may return to the yard to cool before being used again. The ingots still on the bogie, but stripped of their moulds, are taken to two gas-heated pits by a small locomotive. These gas-fired pits take the form of a long passage or channel 5 feet 6 inches wide and 6 feet 6 inches deep, at either end of which is a set of regenerators. There are five lids to each pit, and they hold twenty ingots, that is four ingots under each lid or door. The doors or lids are of cast-iron lined with bricks, and are supported by girders on which the four wheels of each lid run during the opening and closing. These doors are moved by a rack-and-pinion, actuated by a small hydraulic ram, and there is a clutch for each door. Each pit is served by a small crane similar to the serving cranes in the Bessemer shop, but with the addition of a racking-in motion.

When the ingots are of the proper heat, they are taken out of these pits by the same hydraulic cranes, and are placed upon a train of live rollers, which convey them to the cogging mill.

Cogging Mill.—This mill, Fig. 9, Plate 141, is a 36-inch train, driven by a pair of high-pressure horizontal reversing-engines, having cylinders 42 inches by 48 inches and geared 2 to 1. The rolls have five grooves, and the screws are fitted with a rack-and-pinion movement actuated by a ram, which lowers the rolls 2 inches so that the bloom receives a draught of 2 inches in passing through and returning. When the bloom has passed through the last groove of the cogging mill it runs on roller gearing to a shears where the rough ends are cut off. This prevents collars and other troubles arising during subsequent rolling.

Roughing Mill.—After shearing it passes in a straight line to the roughing mill. This mill consists of a 30-inch train, and is driven by a pair of high-pressure horizontal reversing-engines with cylinders 50 inches by 54 inches and working direct. In usual work a bloom makes five passes in this mill and then proceeds to the finishing mill.

Finishing Mill.—This mill, Fig. 10, Plate 141, is a 28-inch train, and the engines are similar to those at the roughing mill, except that the cylinders are 48 inches by 54 inches. There are five grooves here, after passing through which the bar proceeds on live rollers to the saw where it is cut into the requisite lengths. After sawing, each rail is placed on the hot bank by means of skids, of which there are four pairs, one pair for each bank. When the rails are cold they pass on roller gearing to the finishing bank where they are straightened, drilled, and finished in the customary way. The mill is capable of easily producing 5,000 tons per week.

Siemens Melting-Shop.—There are four Siemens furnaces of 50 tons capacity, Plates 142 and 143, one of 40 tons and three of 25 tons capacity. They are of the ordinary design producing about 1,500 tons of steel weekly. The gas for the Siemens furnaces is generated from a range of thirty-six ordinary Siemens gas-producers. There are three coal-fired horizontal heating furnaces for the slabbing mill arranged in semi-circular order, the curve being struck from a centre

on which revolves a hydraulic charger and drawer. This charger receives the ingots from the pit-side crane, and with very little manual labour attends to the charging and drawing of the furnaces.

Slabbing Mill.—The heated ingots are then conveyed by a small locomotive to the slabbing mill, where they are rolled to any desired size, and cut (by means of a mechanical shears) into the necessary lengths to suit the order specified, and conveyed to the plate mills. The mill is driven by a pair of high-pressure horizontal reversing-engines having cylinders 36 inches by 42 inches, and is geared 3 to 1. The train is 36 inches with a lift of top roll of 16 inches balanced by hydraulic rams. The screws are driven by a pair of small engines.

Plate Mills.—There are two plate mills; the first is driven by a pair of high-pressure horizontal non-condensing engines having cylinders 50 inches by 54 inches. The train is 28 inches, and consists of two pairs of rolls each 7 feet 6 inches long, and rolls plates from $\frac{1}{4}$ inch to 2 inches thick. The slabs are heated by four ordinary coal-heated furnaces served by a charging and drawing machine similar to that at the slabbing mill. There are live rollers on both sides of the rolls and a skid arrangement to convey the plates from the soft to the hard rolls. The plates when cool are conveyed to the shears by a steam travelling-crane having a span of 70 feet.

The second plate-mill is driven continuously by a vertical beam-engine of an old type. The soft rolls are three high, and the finishing are two high, the rolls in both cases being 6 feet long, and the train 26 inches. This mill receives slabs about 4 inches thick, and rolls all those received which are too thin for the large mill, namely, from $\frac{1}{8}$ inch to $\frac{1}{4}$ inch inclusive.

Merchant Mill.—This mill has an 18-inch train of rolls, and is driven by a pair of horizontal engines with cylinders 33 inches by 48 inches. It is used for the rolling of fish-plates, light rails, angles, bars, &c., from 4-inch billets.

Tram-Rail Mill.—This is driven by a pair of high-pressure horizontal reversing-engines with cylinders 42 inches by 48 inches having Corliss valves, and is geared 3 to 1. The mill consists of two pairs of rolls and is a 28-inch train. The mill is also used for the rolling of girders, angles, channels, sole-plates, &c.

Foundries.—The foundries, of which there are five, namely, three for the production of steel castings, one for making ingot moulds, and one where all the brass castings are made, are well equipped with stoves and powerful cranes, the latter serving to cast, and afterwards lift, the heaviest stern frames, rudder frames, rolls, and other large castings.

The small steel foundry, which is used for the production of small steel castings, possesses a 7-ton Siemens furnace having a Duff gas-producer alongside.

Roll-Turning Shop.—This shop has nine lathes, and is designed on the best known principle. It is provided with an overhead rope travelling-crane which runs the whole length of the shop.

Engineering Shops.—These are extensive and comprise the machine shops and subsidiary shops, namely, the boiler, smiths', wagon-building, saw-making, pattern-making shops, &c., and saw-mills, all containing fine tools of recent date. It is in these shops that the machining and finishing of the marine castings takes place, as well as the construction of all the firm's own new work, and repairs.

Electrical Installation.—This consists of two dynamos each giving 750 ampères at 220 volts, driven by two vertical non-condensing engines and one dynamo of 300 ampères at 120 volts, driven by a horizontal engine which also drives the shop machinery. These three dynamos supply the necessary electricity for 1,500 incandescent lamps, 130 arc lamps, and 12 motors.

General.—There are 60 steam boilers, Plate 144, in use at the iron works and 105 at the steel works, and 15 broad-gauge and 15 narrow-gauge locomotives employed.

The wire works is situated at a short distance from the steel works, and contains a rod mill and two hoop mills.

Other departments of the works are the general offices, laboratory, drawing office, testing house, stores, &c.

The total number of hands employed is about 3,500, exclusive of those at the coal and iron mines, which are extensive, and about 250 at the wire works. The area of the land occupied by the company's works, including railway sidings and reservoirs, is 245 acres.

The Paper is illustrated by Plates 134 to 144.

Fig. 1. *Bird's Eye View.*

Fig. 2. *Blast Furnaces.*

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Fig. 3. Cowper Stove, 28-feet diam.

The firebrick lining in bottom and sides is 13 inches thick,
in roof 9 inches, and in spout 3 inches

Fig. 4. *Metal Mixer.*
General arrangement.

Fig. 5. Slag Bogie.

Fig. 6.
Pig-Breaking Machine.

Fig. 7.

Side Tipping Ladle
for

New Bessemer Plant.

inches 12 0 1 2 3 4 5 Feet

BARROW STEEL WORKS.

Plate 140.

Fig. 8. Receiving Crane for Bessemer Shop.

Fig 9. Cogging Mill.

Fig. 10. Rail Mill.

BARROW STEEL WORKS.
50-ton Steel Melting Furnace.

Plate 142.

Fig. 11.
Section at EF,
Fig. 13.

Fig. 12.
Section at A B C D,
Fig. 11.

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Pl.
142.

50-ton Steel Melting Furnace.
Fig. 13. Section at g H I. Fig. 11.

Plate 143.

BARROW STEEL WORKS.

Plate 143.

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Fig. 14. Coal Furnace and Boiler.