ON THE IRON INDUSTRY OF FRODINGHAM.

 BY MR. GEORGE DOVE, OF FRODINGHAM.

The writer has been requested to compile a few facts and figures bearing upon the present position of the Iron Industry of North Lincolnshire, in view of the excursion to Frodingham which is arranged for the concluding day of the present week's meeting. A former paper prepared by him with a similar object for the Iron and Steel Institute in 1876 (Journal, page 318) brought the history of the district down to that year. Since then the total number of blast furnaces has not been increased, the list being now as follows:—

Name of Works.	In blast.	Out of blast.	Total.
Trent Iron Works	4	2	6
Frodingham Iron Works . .	2	2	4
North Lincolnshire Iron Works .	2	2	4
Redbourn Hill Iron Works . .	2	2	4
Appleby Iron Works	3	0	3
	<hr/>	<hr/>	<hr/>
	13	8	21
	<hr/>	<hr/>	<hr/>

The plan shown in Fig. 1, Plate 55, indicates the connection of the Frodingham district with the railway system; and that in Fig. 2, Plate 56, shows the position of the several works and mines. In Fig. 3, Plate 57, are shown the sections of the various furnaces. These are mainly of the Cleveland type, with the difference that all, excepting two of those of the Redbourn Hill Co., are open-topped. The stone being charged in "raw," as it comes from the mines, it is probable that any more furnaces which may be built will also be of the open-topped class. The tendency as regards size appears to be in the direction of increase in height.

The sections of furnaces in Fig. 3, Plate 57, are arranged in order of date, beginning with the two Trent furnaces T, erected in

The annexed Table of analyses (page 417) may be taken as fairly representing the composition of the bed. From this it will be readily understood that great care is required in selecting the stone, in order to obtain the best results in the blast furnace. With careful selection it can be smelted alone, without any admixture of other stone; but in practice it is found desirable to use a portion of Northamptonshire or other silicious ore, which assists in the working of the furnace and acts as a safeguard against any accidental excess of lime in the charge.

The following are analyses of samples of the iron made:—

	No. 1.	Grey Forge.	White.
Iron	90·280	91·990	94·220
Combined Carbon	0·585	0·348	2·300
Graphitic Carbon	3·767	2·264	0·690
Phosphorus	0·965	1·119	1·170
Sulphur	0·006	0·019	0·102
Silicon	2·710	2·291	0·629
Manganese	2·255	1·799	0·888

The bulk of the make is “forge” iron; but there is an increasing demand for better qualities of “foundry” iron, for use as mixtures with other irons.

Considerable development has taken place during the past ten years in the working of the Frodingham ironstone for consumption in other districts, where its calcareous character adapts it for use as a mixture with more silicious ores. During the year 1884, 293,052 tons of stone were sent out from Frodingham; and the quantity consumed in the local furnaces having been 848,249 tons, the total quantity raised during the year was 1,141,301 tons. This represents in round numbers 326,086 tons of iron made from Frodingham ironstone in 1884.

The fuel used in the furnaces is entirely coke, which is obtained from Durham and South Yorkshire. The latter is the natural field from which all the supplies should be obtained; and that more attention is being paid to the manufacture is shown by the marked

increase in the output, which in 1884 was 412,000 tons as against 291,000 tons in 1880. But the quality of the material manufactured in this nearer district is generally so inferior that the ironmakers are of necessity compelled to draw a portion of their consumption from the more distant coalfield. It is demonstrated that it is possible from the Barnsley bed of coal to make a coke equal in chemical composition to the average Durham brands, though perhaps wanting somewhat of their splendid mechanical condition. But the fact remains that the bulk of the coke manufactured in South Yorkshire is at present of a very inferior description; and until a material improvement is effected, the Durham coke will continue to be introduced into what should be the natural outlet for South Yorkshire coke. In his former paper the writer ventured to point out two factors which would materially influence the future of the Frodingham ironfield:—namely, the proper selection of the stone, and the fuel supply. The selection of the stone may be said now to be practically carried out; and there remains but a much needed improvement in the quality of the fuel from the adjacent coalfield. During the long continued depression in the iron trade, Lincolnshire may be said to have fairly held its own; but with the second condition fulfilled, it will have a great future.

Analyses of a section of Ironstone Bed in the Frodingham Mines.

Stratum in Bed. <i>See page 414, and Fig. 4, Plate 57.</i>	B	C	D	E	F	G	H	I	Average of worked beds C-H
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Peroxide of iron	23·290	41·170	32·430	44·350	20·240	46·720	35·841	18·970	39·527
Protoxide of iron	trace	trace	nil	nil	23·440	nil	nil	9·024	1·465
Silica	45·637	5·070	3·099	5·920	7·811	8·101	3·409	2·212	5·383
Lime	1·710	14·450	24·102	13·550	5·801	8·380	20·071	34·420	14·589
Manganous Oxide.....	0·689	1·379	2·347	2·500	2·523	3·501	5·870	1·513	2·258
Sulphuric Acid.....	0·036	trace	0·002	trace	0·370	0·103	trace	2·096	0·036
Phosphoric Acid	0·256	0·678	0·991	0·547	0·687	2·680	0·603	2·291	0·947
Alumina.....	4·755	0·711	2·904	2·569	4·115	1·753	2·763	1·006	1·689
Carbonic Acid	nil	12·890	15·145	6·065	16·800	4·570	14·500	21·710	11·624
Magnesia	0·411	0·375	0·191	0·463	2·520	0·205	trace	0·440	0·475
Alkalies	0·472	0·296	0·458	0·490	0·610	0·842	0·530	0·532	0·443
Organic matter.....	0·169	trace	—	—	—	—	—	—	—
Water at 212° F.	16·179	17·572	12·824	15·124	9·254	13·874	11·750	4·088	15·327
Water combined	6·571	5·303	5·166	8·216	5·846	9·150	4·715	1·512	6·128
Total.....	100·175	99·894	99·659	99·792	100·017	99·878	100·050	99·814	99·889
Total insoluble matter	46·052	5·521	3·434	6·651	9·163	8·775	4·162	3·038	5·953
Loss on calcination ...	22·919	35·765	33·135	29·505	30·900	27·594	30·965	27·300	33·028
Iron in dry stone	21·10	37·56	26·79	38·31	36·97	41·80	29·22	21·41	36·029
Iron in wet stone	16·30	28·82	22·79	31·04	32·40	32·76	25·08	20·30	28·815

Discussion.

Mr. CHARLES COCHRANE considered the members were very much indebted to the author for supplying by this descriptive paper the means of understanding more readily what they would see in the excursion to Frodingham. In reference to the capacity of the blast-furnaces, and the gradual development which had taken place from the very small and almost insignificant furnaces of 40 feet height and 14 feet diameter up to 75 feet height and $20\frac{3}{4}$ feet diameter, it was evident that Lincolnshire had found the importance of largely increasing the size of the furnaces. But what had surprised him was that the charging bell had not been more generally adopted for taking off the gases and economising fuel at the boilers and at the stoves; and he hoped the author would give some explanation as to why the bell had not been adopted, with such an important economy in store for those who did adopt it. Was the progress of the district in that respect interfered with in consequence of the large quantity of moisture, which the iron ore contained, preventing the gas from being used with efficiency? It was remarkable that only at one furnace was the author able to record the application of the highly superheated blast obtained from fire-brick stoves; he did not know whether it had been attended with any disappointing results in the one case in which it had been applied; but if so he should be glad to be informed of the circumstances.

With reference to the quantity of coke consumed per ton of iron in the best furnaces in the district, he enquired whether this had been brought down to anything like 19 or 20 cwts. of coke per ton of iron: so as to get some idea of what improvement the furnaces were still capable of. If they still used from 22 to 25 cwts. of coke, no matter whether it came from Yorkshire or from Durham, there was still an improvement in store, unless it were limited by the size of the stone itself. In that respect he was pleased to see that the furnaces had been able to reach such a height as 75 feet. When on a visit to Lincolnshire many years ago he remembered that the smallness of the stone, coupled perhaps with the accident of bad

selection from the bed itself, was such as to prevent the blast from passing up freely through the furnace; and so the furnaces were debarred at that time from improvements which he hoped were now rendered possible by the better selection of the stone, in recognition of the fact that it must be selected in order to get the best results in the blast-furnaces.

Mr. DOVE replied in regard to the charging bell that the first large blast-furnace built in Lincolnshire was erected by Mr. Adamson in 1865, 70 feet high and 20 feet diameter, and closed with a bell. After it had been working some little time under disadvantageous circumstances so far as the supply of ironstone was concerned, there was an unfortunate accident, and one half of the furnace was blown off. For some years afterwards, till 1872 or 1873, bells were not used in Lincolnshire at all. In 1874 at the Redbourn Hill Works two furnaces were built which were fitted with bells; and these two furnaces had been working with the bells ever since, with fairly satisfactory results. As to the question of coke consumption per ton of iron, he did not now think, though for years he had been of a different opinion, that there was any saving in the working of furnaces fitted with bells. The manufacture of iron could be carried on in open-topped furnaces with as low a consumption of fuel as in those fitted with the bell top. Moreover with a sufficient chimney draught there was no difficulty in drawing off gas enough from the open-topped furnaces for the stoves and boilers. In some of the open-topped furnaces a cylinder was fixed in the throat, of the full diameter of the throat and hanging down into the furnace to a depth of 6 to 10 feet, which materially assisted the chimney in drawing off the gas from the closed annular chamber so formed around the cylinder; but with a sufficient chimney draught there was no difficulty in drawing off gas enough from open-topped furnaces without any such cylinder in the throat. In Lincolnshire there were no coals used under any of the stoves or boilers. In favour of the open-topped furnaces there was of course the fact that the ironstone contained a large percentage of moisture, running up sometimes to 25 and even 30 per cent. in weight. With the bell the

(Mr. Dove.)

whole of that heavy percentage of moisture would be drawn off in the gas, and would pass under the stoves and boilers, which considerably militated against the heating efficiency of the gas. Besides this, there was the secondary advantage of the open-topped furnace, that its working was open to view. For with every attention to the working and every care in the selection of the ironstone, there sometimes occurred some little trouble from excess of lime, which occasionally led to scaffolding. This did not now happen so frequently as in former years; but some disorganisation had occurred now and then.

With respect to the coke employed, he regarded it as a matter of the utmost importance to North Lincolnshire that the whole of it should come from the South Yorkshire coalfield. There was no question but that in the course of time it would do so. Lincolnshire had passed in its early years through similar experience to that which Cleveland had gone through in starting. Whilst the Cleveland furnaces had an admirable ironstone, their success had been to a very great extent due to the quality of the fuel which could be obtained from the adjacent Durham coalfield; and he hoped that at some time or other the Lincolnshire furnaces would be able to obtain their entire supplies from their adjacent coalfield, of a quality equal to that of the north; and until this was so, Lincolnshire was not obtaining the full advantage of its geographical position. The consumption of coke per ton of iron varied considerably at the different furnaces; and the conditions under which they were working—some working with all South Yorkshire coke, and some with different proportions of Yorkshire and Durham—rendered the results so different that he was unable to give any figures which might be taken to represent an average of the consumption of fuel per ton of iron in the district.

The PRESIDENT mentioned that he had received a letter from Mr. Adamson—who had been referred to as having built the first large close-topped furnace at Frodingham, and who continued to take a great interest in the subject of this paper—expressing his regret that he was not able to be present.

As the paper was largely of a geographical and descriptive nature, much discussion upon it could scarcely be expected. It had been prepared in order to give additional interest to the excursion to Frodingham; and he was sure they were all very much obliged to the author for laying before them so clearly as he had done these interesting particulars, in the absence of which their visit to the district would have been somewhat bare and far less intelligible. He proposed that their best thanks be given to Mr. Dove for his paper.

FRODINGHAM IRON INDUSTRY.

Fig. 1.
Frodingham Iron District.

(Proceedings Inst. M. E. 1885.)

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FRODINGHAM IRON INDUSTRY.

Plate 56.

Fig. 2. *Iron Works and Mines at Frodingham.*

Scale $\frac{1}{700}^{\text{th}}$
Dimensions
in Feet.

FRODINGHAM IRON INDUSTRY.

Fig. 3. Sections of Blast Furnaces.

Names of Iron Works

T = Trent. F = Frodingham. N = North Lincolnshire.

R = Redbourn Hill. L = Lindsey. A = Appleby.

Dimensions in Feet.

(Proceedings Inst. M. E. 1885.)

Fig. 4. Section of Strata.
Scale $\frac{1}{40}^{\text{th}}$