introduced, which removes the lighter material, while the heavier iron ore sinks and is conveyed from the jig as it is separated. It is in this way that at Lyon Mountain, N.Y., the Chateaugay Ore and Iron Company treats the lean magnetite taken from the mines, and a similar method is followed at Iron Mountain, Mo., for the separation of the leaner red hematites.

Magnetic separators have been in use for forty years, but it is only lately that this system has attracted much attention. Although the forms of magnetic separators vary, they may be classed under three general heads:

(1) Altering the trajectory of falling material by introducing the attraction of a magnet, to draw the magnetic portion away from the non-magnetic. Six of this class of machines are now used.

(2) Feeding the ore to a revolving drum or drums, in which is a magnet core, the shells of the drum being either of alternate magnetic and non-magnetic strips, or entirely of magnetic or non-magnetic material. In some of these drums the magnet core is wound so as to exert a constant polarity, in others a series of magnets in alternate polarity compose the core, and in some opposite drums are of opposite polarity. When two drums are used, they are placed so as to revolve toward each other, the ore passing between them, or they are arranged tandem, the drums revolving in the same direction, but sometimes at different speeds and with different degrees of magnetic force, so that the ore fed from one drum to the other receives successive treatment. Machines are also arranged with more than two drums. About thirty of this class are in use.

(3) Belt machines in which the ore is fed to a belt or series of belts passing under or over magnets or magnetic drums, the machines working sometimes in water and sometimes dry. In some of the machines the polarity is maintained continuously by means of pole pieces, in others the material is constantly submitted to magnets of alternate polarity, the belts being placed so as to run either vertically, horizontally, or on an incline, according as the conditions require. There are between twenty-five and thirty of this class now at work.

These separators are used either at the mines to enrich the ore, at steel works and rolling mills to remove the magnetic particles from slag and dirt, to separate iron ore from pottery clay or from emery—and in one instance iron ore occuring as a hematite with zinc ore is treated in a roasting furnace after being comminuted, and becoming magnetic, can be thus separated.

There is apparently a present field for magnetic separation in the States of New York, New Jersey, Pennsylvania, Virginia, North Carolina and Michigan, where there are large deposits of lean magnetic ores. The prejudice against the use of concentrated ore by some blast furnace managers has been largely overcome by practice, which has proven that properly concentrated ore contributes to the good working of the furnace, and in the future this class of ore may be used largely in place of some of the higher-priced ore brought to eastern blast furnaces. This class of ore has also been used in most of the direct processes, and any development of these will encourage a corresponding demand for concentrates.

During the year 1891 there were produced 16,802 long tons of hand-picked or cobbed ore, 98,546 long tons of magnetically separated ore, and 110,777 long tons of jigged ore.

Conclusion.—In presenting for your consideration the subject of this evening I have relied mainly upon the eye believing that in this way it would be possible to convey more information concerning typical features in an attractive manner than to weary you with theories and detailed statistics. Most of the time has been devoted to iron ore, because nearly all that we use or import is smelted to produce pig iron, and but a portion of the coal mined or limestone quarried enters into the production of iron. But the small attention given the fuel and flux must not be considered as a gauge of their importance. The mining and quarrying, the preparation, the handling of the raw materials entering into the manufacture of pig iron supplies work for an army of laborers, miners, mechanics, railroad men, sailors, clerks, engineers, superintendents and managers, and demands the investment of many millions of capital.

The Luhrig Process of Washing and Treating Coal.

By Mr. James I. Anson, Darlington, (Read Before the Cleveland Institution of Engineers.

In this paper it was pointed out how the coal owners of Saxony had been driven by the development of their trade, thei ncreasing demands of which the better seams soon became inadequate to supply, to seek for a method of treatment which would enable them to put the produce of their inferior seams upon the market in such a state as would satisfy the requirements of the iron manufacturer and other users of fuel, with whom coal of a considerable degree of purity became from year to year more and more of a desideratum. The earlier and rougher methods of coal-washing could only accomplish very imperfectly the purification of small coal for cokemaking. But Mr. Luhrig solved the problem with signal success so far as the elimination of mechanically separable dirt was concerned. Certain modifications and improvements have since been introduced, but every plant is specially designed to meet the requirements of the particular place, so that practically no two are precisely alike. When Mr. Rathbone wrote, he stated that the system was very generally adopted in Germany, and was fast making its way into France and Belgium, while it would not be long before it was largely adopted in England, but as regarded the last named such had not been the case. But the same causes which led the German coal owners to face the problem of the adequate cleaning of fuel—viz., the working out of the better seams, on the one hand, and the demand for a purer product, on the other, were now forcing the problem upon the attention of the English coal owners. Messrs. Merry and Cuninghame were the first to adopt the Luhrig process in Great Britain, and the success which had attended the working at the Motherwell and other collieries belonging the firm led to the formation of the Luhrig Coal and Ore Dressing Appliances Company, of which Mr. A. Cuninghame is managing director. On the Continent, about two hundred Luhrig plants were in successful operation, and a considerable number in Scotland and Yorkshire, while others were in course of construction. At Maryport the system had been successfully applied to coal for coke-making. In Northumberland and Durham the system was, so far, unrepresented, but before long a complete plant for dealing with 1,000 tons a day will be in operation at the new Randolph pit of the North Bitchburn Coal Company. On the vital importance of a clean fuel in manufacturing operations, whether for direct metallurgical process or for the raising of steam, it was not necessary to dwell. Every blast furnace manager was fully alive to the necessity of using a coke as low as possible in ash and sulphur, and the frequent analysis to which coke was now usually subjected, both to ensure accuracy of results, and as a check upon the coke manufacturer, bore testimony to the fact that the question was most important. It was one thing, however, to stipulate for the supply of fuel containing a specified maximum of impurity, and another thing to get it with unquestioned regularity. Mr. Hawdon, in his presidential address to that institution in November, had remarked that as often as not 9 to 10 per cent. of ash was contained in the coke supplied nowadays as good blast furnace coke. The days were fast passing away of 5 per cent. ash in Durham coke. But if pure fuel was required in the blast furnace, it was equally important to have it in the puddling furnace, the heating furnace, and under the boilers. Yet, where did the iron and steel maker keep such careful watch upon the percentage of impurities in the coal supplied as the blast furnaceman kept upon his coke. The one was as important as the other. It had been estimated that the extra amount of coke containing 15 per cent of ash required, as compared with one containing only five per cent., amounted to about 17 per cent., to say nothing of the extra limestone needed in the blast furnace to flux the added 10 per cent. of ash. The comparative efficiency of coal containing 2 per cent. of ash as against one containing 14 per cent., was equivalent to a money value of 1s. 6d. per ton on the basis of a coal costing 7s. per ton. It might perhaps be said that the treatment of coal in such a way as to raise its purity to the desired point might be a costly process, and would so far increase the cost per ton that it might after all be better to use an inferior fuel at a lower price. By the adoption of a well considered scheme of handling, screening, washing, and loading coal as it came to bank, the whole of these operations could be achieved at an almost nominal cost per ton. At Motherwell, by the Luhrig process, the labor in handling, screening, handpicking, washing, and loading, did not exceed a half-penny per ton, whilst the saving in waste was an important factor. The Luhrig Company guaranteed under penalty that there should not be more than 2 per cent. of coal left in the final refuse, and it was found at Denaby Main that in daily practice this did not exceed one-half per cent. The author then considered the first principles on which the operation of every system of coal washing more or less depended, and showed that in order to effect a separation by washing, the bodies must be either of different specific gravities if of equal sizes, or of different sizes if of equal specific gravities. In the case of coal it was desired to separate the heavier dirt from the lighter coal. That could only be efficiently done when the mixed material was reduced to an approximately uniform size before washing, a principle which was rigorously carried out in the Luhrig system. This system of treating coal at the pit mouth was not one for washing only, but for the whole treatment of the coal, automatically and continuously, from the point at which it was delivered from the tubs to that at which it was delivered into trucks, storage hoppers, &c., including screening, hand picking of large coal, washing of nuts and small in as many sizes as might be reqnired, and automatic loading. In many cases only the washing plant with its attendant appliances was required. The plant in operation at Motherwell was a type of a complete arrangement for dealing with about 1,500 tons a day, including the whole of the processes involved in both dry and wet separation, automatic handling and loading. The plant treated the whole output of three pits, which was brought to one spot by endless rope haulage.

The tubs were run into tumblers, or kick-ups of an improved type, and the contents discharged over vibrating screens pierced with 2 in. round holes. All the coal above 2 in. passed from these screens on to long picking belts, formed of links in the usual way, but in place of plates to carry the coal there were steel bars with spaces between, so that any small coal due to breakage might fall through on to a table below the return belt. Cross shoes of angle iron, with a plate about 8 in. high, were attached to this belt at intervals, and as these were reversed and travelled backwards towards the screens they acted as scrapers, which collected the small coal which had fallen through and delivered it into the same hopper as received all the coal which passed through the screens. In cases where it was desired to pass unscreened coal over the picking belts, plates were used in place of the open bars. As it was carried along by the belt the large coal was picked by hand in the usual way, and at the end furthest from the screens the belt was carried round a movable arm which could be lowered into the trucks, into which the large coal was gradually and automatically delivered, the cross shoes preventing its slipping down with a run, and thus saving breakage. Any pieces of shale or dirt with inter-grown coal were thrown into shoots, which carried them to a stone breaker, from which they were delivered to the main hopper under the screens and underwent the same subsequent treatment as the rest of the coal, a large amount of coal being recovered in this way which ordinarily went to waste. With regard to the coal which had passed through the 2 in. screens, this fell into a large hopper beneath them, of about 100 tons capacity. Into this hopper had also been delivered the small coal due to breakage recovered from the picking belt and the mixed coal and dirt which had been passed through the stone breaker. The contents of this hopper were taken by an elevator to the top of the washery building and delivered down a shoot into a large sizing drum or revolving screen having concentric shells of different meshes. Here it was sorted into treble nuts 2 in. to 1¼ in., double nuts 1¼ in. to ⅞ in., single nut ⅞ to $\frac{5}{16}$ in. peas, and small $\frac{5}{16}$ in. and downwards. From the sizing drum each size of nuts was conveyed down a shoot into its own washer—a wooden box with a vertical partition extending for a portion of its depth, dividing it into two compartments which communicated with each other below. In the back compartment was a large wooden piston, actuated by an eccentric on a line of shafting which ran above the back of the washers, by which the necessary impulse was given to the water, the stroke of the piston being proportioned in each case to the size of coal to be washed. In the front compartment was a sieve on to which the coal was delivered from the sizing drum, an opening being provided in the front and near the top of the washer for the washed coal to flow out with the washing water, whilst near the bottom of the space above the sieve was another opening, adjustable by means of a sliding shutter, out of which the refuse passed. Any small dirt which passed through the sieve fell to the bottom of the washer, from which it was let out from time to time by a valve which passed it into the channel through which the rest of the refuse was conveyed to the refuse pit. The dirt or shale, together with such coal as might be adherent to or integrous with it, was carried by a spiral conveyor to an elevator, by which it was taken to a pair of crushing rollers, whence it descended again through a shoot to one of the washers, in which it was treated for the recovery of the intergrown coal. As the washed nuts left the front of the washers, they were delivered over perforated draining shoots, to which a shaking motion was given similar to that of a shaking screen, into loading hoppers. The small coal, $\frac{5}{16}$ in. and downwards, as it came from the sizing drum, met the overflow waters from the nut-washers and was carried into a grading box consisting of a wooden trough, under which was a series of inverted pyramids, in which the small coal was successively deposited in constantly decreasing sizes, the largest coal coming to rest first, the smallest at the further end of the series. From the bottoms of these compartments the coal passed to the small coal washers, which were like the nut washers, but in each had a layer of felspar crystals resting upon the sieve or grating through which the upward current of water was propelled by the pulsation of pistons of very short stroke. The layer of felspar slightly lifted and opened out at each pulsation of the water, closing again with the downward current. In that way the fine dust was allowed to settle down through the layer of feldspar. By that device, the use of a very fine mesh which would quickly clog was avoided. The washed fine coal flowed with the washing water down a channel to a revolving drum made of copper sheets pierced with holes $\frac{1}{64}$ in. in diameter, in which it was separated from the finest sludge, which was carried with the water in which it was suspended into the sludge recovery tank. The sludge recovery was a special feature of the Luhrig process, and it obviated the use of settling ponds, with the attendant cost of labor in clearing these. The water employed was used over and over again. The guarantees of the company at Motherwell, taking that as a sample, were:—(1) Plant to be capable of treating 1,500 tons of coal per day of ten hours on basis of coal containing 23 per cent. of ash; (2) ash contained in washed coal $\frac{5}{16}$ in. to $\frac{1}{16}$ in. not to exceed 6 per cent., and for every 1 per cent. of ash left in the coal beyond that, the patentees to forfeit £100; (3) the rubbish or dirt washed out not to contain more than 2 per cent. of fine pure coal, and for every 1 per cent. above that, patentees forfeit £100; (4) cost of labor guaranteed not to exceed $\frac{8}{10}$d. per ton of coal handled, patentees to forfeit £150 for every 4-10ths exceeded, this to include labor in hand-picking, sorting, working and loading into trucks. However, the ash did not exceed 2½ per cent., the coal in the dirt 1 per cent., and the labor ½d. per ton. It had been proved practically that efficiency in results could be obtained at very small cost and with practically absolute regularity in working.

English mail to hand advises a better market for Canadian phosphate. Quotations for 80% having advanced to 10½d.

Messrs. Eugene Munsell & Co., of New York, report that the demand for Canadian amber mica for electrical purposes continues to steadily increase.