Iron Ore Concentration in Minnesota.

Editorial Correspondence.

The production of merchantable iron ore, by means of wet concentration, from material which is too low-grade for profitable reduction in the blast furnace, is one phase of the great iron and steel industry which is in its infancy. That it has been successfully done on a large scale, leads to the belief that it is an important step toward the genuine conservation of our iron resources, and one that will be followed by others which, in time, will make available much ore now without commercial value. This means not only the utilization of low-grade deposits, but the conservation of the best ore for special purposes, or for raising the average grade and quality of a large tonnage of less desirable ore.

Special systems of concentration have had to be devised to meet the requirements of iron-ore production. The intrinsic value of a ton of iron ore is not great enough to warrant too elaborate a system of treatment, while smelting conditions demand an ore with as much lump and as little fine as possible. Tonnage and physical condition of the product, therefore, become important factors in this business. The former is equally important in the treatment of other low-grade ores, such as gold or copper. In these cases, however, it becomes necessary to resort to elaborate systems of grinding and fine concentration, which, fortunately, can be dispensed with in the concentration of iron ore.

In point of tonnage capacity of a single plant, there are no other ore-dressing mills in the United States which approach the magnitude of the largest iron concentrator. The great copper concentrating mills of Utah and Arizona, having individual capacities ranging from 3000 to 12,000 tons in 24 hours, are still small compared with the Trout Lake mill of the Oliver Iron Mining Company, with its capacity of 35,000 tons in 20 hours. And yet, owing to the more complex flow-sheet of the former, and consequently the larger number of machines used and greater acreage covered, they make an impression more nearly in keeping with their magnitude than does the iron concentrator.

Trout Lake Mill, Oliver Iron Mining Company

The first and larger of the two iron concentrating mills in Minnesota, was built by the Oliver Iron Mining Company, on Trout Lake, near the western end of the Missabe range, where the ore is lower-grade than it is farther East. Here, also, the company has built the model town of Coleraine, beautifully situated on the north shore of the lake, and made attractive by substantial buildings, good schools, broad streets, cement curbing and sidewalks, and a system of artistic street lighting.

An exterior view of the mill is given in Fig. 1 and a flow sheet in plan and elevation in Fig. 2. The railway approach to the mill is over a long fill of earth and rock removed in stripping the iron deposits. This approach ends in a steel trestle, shown in the figure, reaching a height of 110 ft. above the ground, and giving the necessary elevation for a gravity flow of ore through the mill.

Unit Construction.

The flow-sheet, Fig. 2, represents one of the five units, each under independent control. The capacity of each unit is 350 tons per hour, and as the mill is operated during two shifts of 10 hours each, or 20 hours per day, the capacity of the whole mill is 35,000 tons per day. The crude-ore bin for each unit will hold 500 tons of ore, or about 1½ hour-supply for the unit. The views shown in Figs. 4 and 5, although taken in another plant, represent similar construction in a unit of the Trout Lake mill.

As shown in the flow-sheet, the concentrating machines of a unit are one conical screen (2-in. openings), two 25-ft. log-washers, two 18-ft. turbo-washers, and twenty Overstrom con-

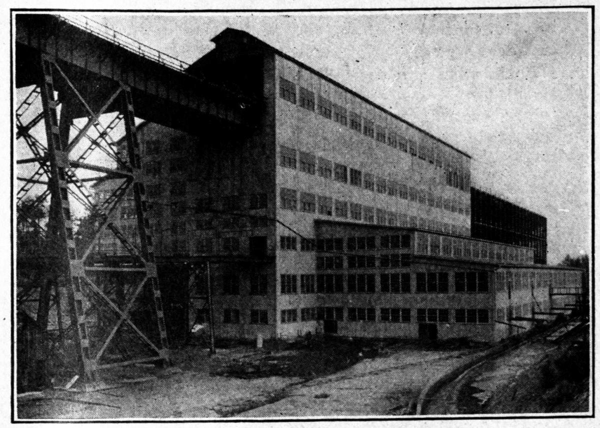

FIG. 1.—IRON-ORE CONCENTRATOR, OLIVER IRON MINING COMPANY.

centrating tables, with the necessary complement of settling tanks, pumps and bins. The ore is sluiced from the bin onto a grizzly (6-in. openings), where large pieces of waste rock are

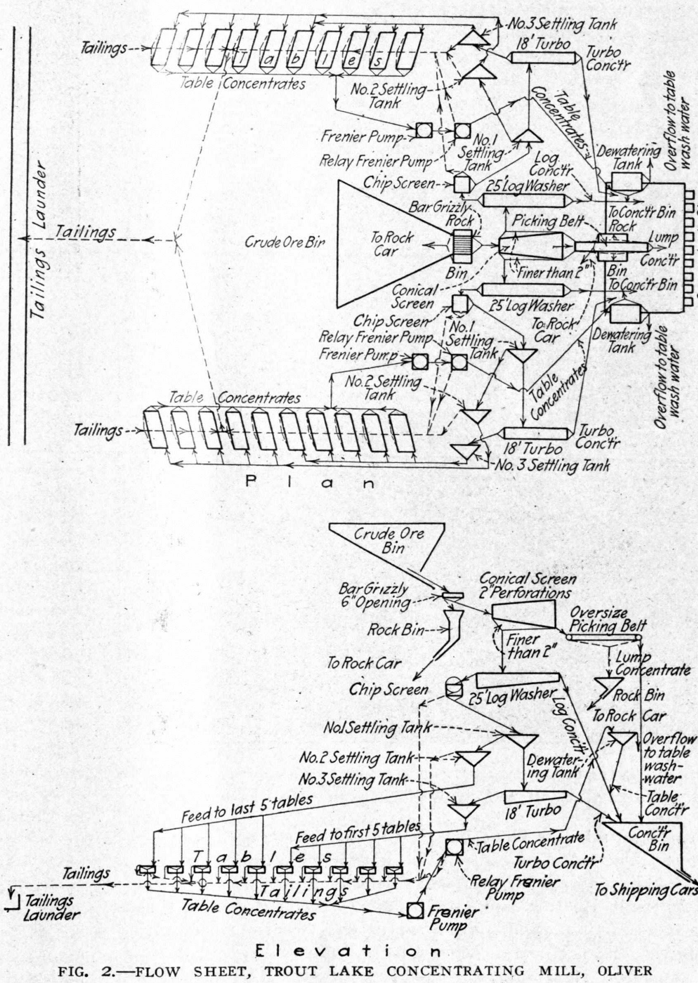

FIG. 2.—FLOW SHEET, TROUT LAKE CONCENTRATING MILL, OLIVER IRON MINING COMPANY, COLERAINE, MINN.

sorted out, and large pieces of ore broken to pass on to the conical screen. The oversize of the latter passes onto a picking-belt (Fig. 5), the rock being picked out and discarded, while the lump concentrate passes on to the bin.

The 2-in. undersize of the screen flows to the log-washers on either side (Fig. 4). These machines produce a coarse concentrate which passes to the bin, the overflow being thickened and

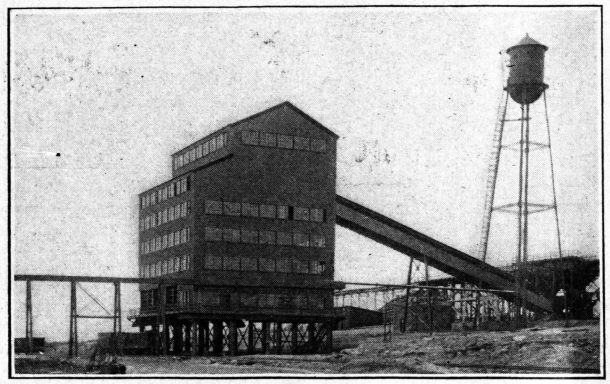

FIG. 3.—IRON ORE CONCENTRATOR OF WISCONSIN STEEL COMPANY, NASHWAUK, WIS.

treated in the turbo-washers, which are practically smaller log-washers in which the feed is kept well agitated by numerous jets of water rising from the bottom of the casing. Between the logs and turbos are so-called "chip" screens or trommels, to separate and remove "chips" of rock which are carried in the overflow of the log-washers. The turbo-washers produce a smaller size concentrate, and their overflow is thickened, and

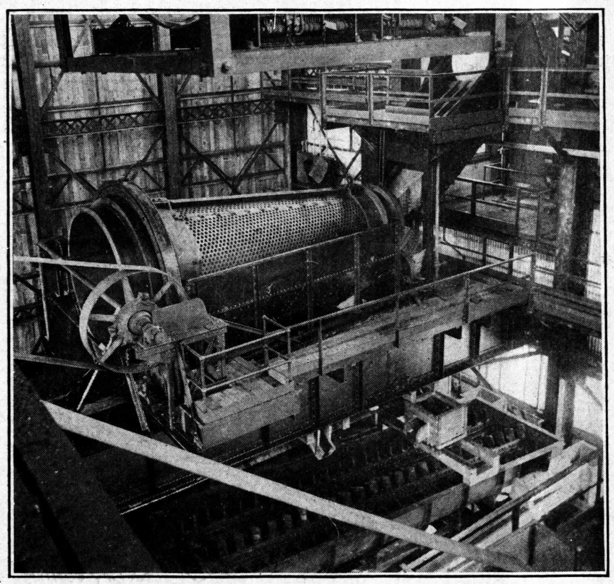

FIG. 4.—INTERIOR OF CONCENTRATOR OF WISCONSIN STEEL COMPANY, NASHWAUK, MINN., SHOWING SCREEN AND LOG WASHER.

treated on tables. The table feed is clearly shown in the flow-sheet. The table concentrate is elevated by Frenier pumps, in two stages, dewatered and sent to the bin.

A 100-hp motor drives the conical screen, log and turbo-washers, and a 15-hp motor serves the twenty concentrating tables. The perforated plates of the conical screen are ½ in. high-carbon steel, and last about 100 days. The chilled-iron paddles on the logs last from five to six months. The decks of the Overstrom tables have been remodeled to suit the conditions, by removing the riffles and substituting a corrugated wood surface. This change resulted in increasing the efficiency of this department nearly 50 per cent.

The grade of the crude ore as it comes from the pits ranges from 35 to 42 per cent iron. The concentrate averages 57 per cent iron, and represents about 67 per cent by weight of the crude ore treated. The phosphorus content of the concentrate is slightly greater than that of the crude ore. All tailings are combined and sent to the Lake through a concrete flume, seen at the right in Fig. 1.

The pump and power station is situated on the shore of the lake, about 1¼ miles below the mill. The power plant, consisting of boilers, engine and 1250-kw generator, is capable of supplying twice the amount of power required in the mill, but the capacity of the pump is not much greater than the steady mill demand of 8000 gal. per minute. Water is raised a total height of 255 ft. above the lake, being delivered through a 30-

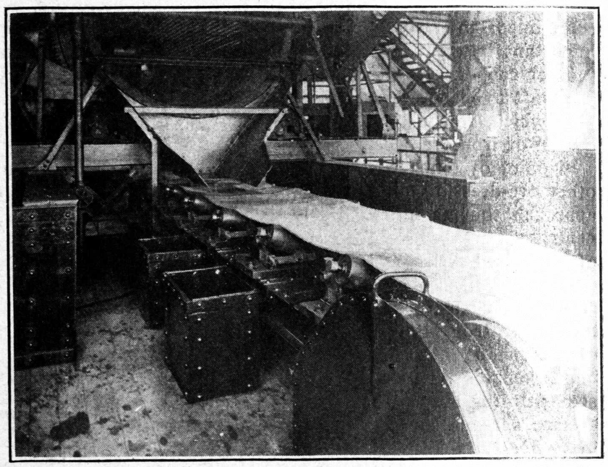

FIG. 5.—PICKING BELT BELOW SCREEN, NASHWAUK PLANT, WISCONSIN STEEL COMPANY.

in. pipe-line to a 110,000-gal. tank erected on a steel structure near the mill. The tank is in no sense a storage reservoir as it holds only about 15-minutes supply, but simply provides the necessary head of water for the mill.

Wisconsin Steel Company's Mill at Nashwauk.

The second iron-ore concentrator built in Minnesota was erected by the Wisconsin Steel Company, to treat ore from the Hawkins mine at Nashwauk. With the exception of some changes, which will be noted, it was modeled after the Trout Lake mill, in which a test run of 1000 tons of Hawkins ore was made, to see what results could be obtained. The two main points of difference are in the method of delivering the crude ore to the head of the mill, and in the extent to which fine concentration is carried. In the Nashwauk mill, Fig. 3, the ore is elevated from the railroad ore-pockets by means of a belt conveyor, passing then through a concentrating system similar to that at Trout Lake, except that no concentrating tables are used.

By reference to Fig. 3, it will be seen that ore is delivered by railroad to two ore-pockets of 250-tons capacity. Below the pockets are shaking launders arranged to deliver to a common point. In operation they discharge alternately onto a 3-ft. rubber-belt conveyor set at an inclination of 19 deg. The conveyor is about 150 ft. long and discharges ore onto a 6-in. grizzly at the head of the mill at a point corresponding to the mouth of the crude-ore bin in the Trout Lake mill. The head pulley of the conveyor is discernible in the upper part of Fig. 3.

The operation of the shaking launders is controlled by one man at the ore-pockets, and the movement of the belt conveyor is governed by the men at its upper end, whose duty it is to sort out waste rock and break large lumps of ore which will not pass the grizzly. Should it become necessary to stop the belt, the man at the feeders is signalled by an electric bell, and the feed is temporarily stopped.

The advantages claimed for this system are: First, that it avoids the construction of the long approach required to deliver carloads of ore to the head of the mill; and second, that a more regular feed is insured by eliminating the possibility of sudden rushes of great masses of ore, which sometimes occur in a large bin. Irregularity of feed, of course, subsequently affects the efficiency of the screen and the log-washers, as well as the quantity and grade of concentrate produced.

The decision to omit the concentrating tables in the Nashwauk mill was determined by the fact that only 3 per cent additional recovery could be made by their use; and the ore thus recovered, being fine, would be the least desirable of all the concentrates. When dry it would practically be dust, subject to loss in transportation as well as in the blast furnace, and altogether hardly worth the outlay of capital and operating expense for fifteen or twenty tables.

With the exceptions noted, the concentrating system at Nashwauk is practically the same as at Trout Lake. A minor difference is the use of small grizzlies instead of chip-screens to remove large particles of lean ore and rock from the overflow of the log-washers to the turbo-washers. The punched plates in the conical screen show about the same life as at Trout Lake. When the blades of the log-washers are worn thin, they are not removed, but are patched with pieces of white-iron bolted to the worn blades. The white-iron blades last from five to six weeks.

All concentrates are delivered to the same bin, and in order to mix the coarse and fine, a part of the stream of log-concentrate is diverted to the launder carrying turbo-concentrate before the latter enters the bin. The ailing flows out of the mill through an elevated launder which discharges onto an area of low land where the solid tailing accumulates, and the water drains back into the small lake near which the mill is built.

Concentration Results.

The ore treated at Nashwauk is higher grade than at Trout Lake, and the product is proportionately of better quality. The crude will average 40 to 45 per cent iron and 15 to 16 per cent silica. The mixed concentrate averages 60 to 62 per cent iron and 3 to 6 per cent silica. Phosphorus is about two points higher in the concentrate than in the crude ore. It has been found profitable for the purposes of this company to concentrate crude ore containing up to 56 per cent iron. Eighty per cent of the iron in the crude ore is recovered, and the concentrate represents about 62 per cent by weight of the crude ore. Of the total product, 10 per cent is lump concentrate from the conical screens and picking belt, 80 per cent coarse concentrate from the log-washers and 10 per cent fine concentrate from the turbos. Sampling is done twice daily, all the concentrates being temporarily diverted to a steel bin provided for this purpose.

Steam-electric power is generated by a Parsons turbine and 500-kw generator, which gives power greatly in excess of the 125 kw required in the mill. The main unit is operated by a 100-hp motor, as at Trout Lake. The belt conveyor consumes about 30 hp and the shaking feeders about 10 hp. A Prescott steam pump of 2500 gal. per min. capacity supplies water to the mill, the consumption being only 1200 gal. per min. This is proportionately less than is used at Trout Lake, due largely to the omission of the tables.

Iron-Ore Concentration a Recent Development.

The mills described are in operation only six months in the year, corresponding to the regular shipping season on the lakes. The Trout Lake mill has finished its third season, and the Nashwauk mill its first. It is interesting to note that both mills far exceeded their rated capacities, practically by 100 per cent, and have given fully as good results as were anticipated. The Nashwauk mill was planned as a two-unit plnt, but the single unit has proved ample for present needs, and the second may not be installed. As much as 8000 tons of ore has been treated in this unit in one day of 20 hours.

At Coleraine, Mr. M. H. Godfrey is general superintendent for the Oliver Iron Mining Company. Mr. Wm. Nicholls, who is superintendent of the Trout Lake mill, was formerly engaged at some of the large Western copper concentrators. Mr. C. J. Mott is assistant superintendent. The Nashwauk mill is under the management of Capt. Sellwood, of Duluth. Mr. B. W. Batchelder, of Nashwauk, is superintendent.

Problems in the Manufacture of Chemically Pure Acids.*

By J. T. Baker.

The manufacture of chemically pure acids, hydrochloric, nitric, and sulphuric, is a subject concerning which very little if any literature is to be found. The reason for this is mainly that the manufacture of acids which will pass to-day as chemically pure is limited to comparatively recent years and the methods of manufacture have not yet found their way into chemical publications and textbooks.

Twenty-five or thirty years ago the yearly production of chemically pure acids probably did not exceed one month's production at the present time, and owing to the enlarged field

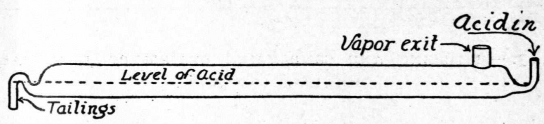

FIG. 1.—IDEAL STILL.

of analytical chemistry, the demand is constantly increasing. The manufacture has now reached a volume which entitles it to be classed as one of the large industries of the country and there are several manufacturing plants devoted in part, if not altogether, to this particular branch of chemical industry.

As a result of the growth of the business, manufacturers have been stimulated, if not obliged by reasons of competition, to devise improved methods of manufacture, in consequence of which the cost of production has been materially reduced and the market prices have fallen during the period mentioned from 50 to 85 per cent. In this connection it is interesting to note some of the improvements which have been made, and

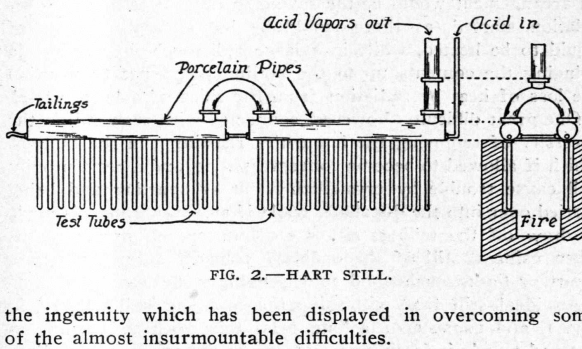

FIG. 2.—HART STILL.

the ingenuity which has been displayed in overcoming some of the almost insurmountable difficulties.

The improvements referred to and to be herein described relate only to the methods of purifying so-called commercial-

* A paper presented before The American Institute of Chemical Engineers. Slightly abstracted from vol. IV of The Transactions of the Institute.