ART. XXXIII.—*On the General Metallurgical method of Messrs. Whelpley and Storer ; by T. STERRY HUNT, F.R.S.*

THE processes having reference to the working of metallic ores, designed and introduced by Dr. James D. Whelpley and Col. Jacob J. Storer of Boston, offer numerous points of interest both mechanical and chemical, which it is proposed to notice briefly in the present paper.

1. The first step in the treatment of ores is their sub-division, which is effected by two novel and ingenious machines, called respectively the breaker and pulverizer. The first of these consists of a horizontal circular table of heavy iron, forty-two inches in diameter, revolving about one thousand times in a minute, having bolted to its upper surface four or more radial bars or blocks of chilled iron, and surrounded by a fixed upright perforated screen. The ore in fragments not more than six inches in diameter, falling into this aperture, is broken by the revolving bars into dust and small grains which are ejected through the perforated screen or curb, from which the larger particles are thrown back to complete the breaking. Such a machine with fifteen horse-power will break to the size of sand and coarse gravel eighteen or twenty tons of quartz or hard ore per hour.

The pulverizer is properly designated as an air-mill, and consists of a horizontal shaft, furnished with arms or paddles, which are made to revolve from one to three thousand times a minute, within an inch of the inner surface of a steel-lined cylinder varying from eighteen to forty inches in diameter. The previously crushed ore is introduced through an opening in the center of a plate, which covers one end of the cylinder, and is perforated with numerous small holes. The other end is connected through a diaphragm having an axial opening, with an ordinary fan-blower generally attached to the same shaft that carries the paddles. The mutual attrition of the particles of ore at the rapid rate of revolution communicated to them in the peripheral space of the mill, reduces them to fine dust, which as soon as formed is removed from the cylinder by the current of air drawn

by the fan through the perforated end, and blown into large chambers, where it is deposited. While the interaction of their particles in the mill rapidly pulverizes brittle bodies, malleable metals, in the same conditions, are soon beaten into rounded pellets. It is proposed to apply this principle to the treatment of the native copper of Lake Superior, which may then be readily separated from its earthy gangue reduced to dust by the pulverizer. This air-mill has been employed for the pulverization of various drugs, of coal, for use as a combustible in the manner about to be described, and even for the grinding of cereals, for all of which purposes it may be adapted. It has also been employed, on a large scale, to pulverize bones for use as a fertilizer. One of these air-mills forty-two inches in diameter, and moved by fifteen horse-power will reduce from 2,000 to 3,000 pounds per hour of quartz, or hard ores, to a powder many times finer than can be obtained by the use of stamps.

2. The calcination of the pulverized ores is effected in what Messrs. Whelpley and Storer call the Water-furnace. This consists of a fire-tower, from twenty to thirty feet high, built of brick, with double walls, and somewhat conical in form, being from three to four feet in diameter at the top, and from four to six at the bottom. Around its upper part are built four fire-boxes, opening into the tower near its summit, which is closed and connected with a large fan-blower. By means of this, besides an abundant supply of air, more or less heated by passing between the two walls of the tower, ore and fuel, in the state of dust, are carried downward into the furnace. The effects obtained by the combustion of charcoal or other fuel pulverized and borne in a current of hot air, are very surprising. The finely divided combustible, being kindled by the flame drawn from the fire-boxes, burns in the descending current with great energy, and from the comparatively large surface exposed to the action of the air, generates a great amount of heat, and, with an excess of fuel, an intense light. The great fiery blast, nearly filling the tower, can at pleasure be made oxydizing or reducing in its action, by regulating the supplies of fuel and of air. I have seen it, at twelve feet from the top, so potent as to heat rapidly to whiteness two feet of a wrought iron bar an inch in diameter, and cause it, though supported at both ends, to bend like wax beneath its own weight in thirty seconds after it was placed in the blast. The powerful heating effects which may be obtained by this use of pulverized fuel are readily understood when we consider that a cubic inch of coal, reduced to particles one five-hundredth of an inch in diameter, will present to the action of the atmospheric oxygen a surface equal to not less than twenty-one square feet. This application of fuel promises to have important results for heating reverberatory, muffle

and glass furnaces, for the working of iron, and even for the generation of steam. Solid combustibles are by this method practically volatilized, and broken and refuse fuel is made available.

The calcination of sulphuretted ores, however, requires but a comparatively low temperature, and an abundant supply of oxygen. The fire-tower of the water-furnace, being heated to redness, the ore, with or without addition of pulverized fuel, is driven by a small fan into the great current of air down the tower; the sulphur and the base metals are rapidly oxydized and the calcined material falls into the water-tank beneath, while the current of air passes through successive chambers, built over this tank, and open to it beneath. This movement is aided by a large fan-wheel placed at the end of the series, which being furnished with paddles dipping into the water, produces in the final chamber a great amount of spray, serving alike to precipitate the suspended dust, and promote the absorption of the sulphurous acid gas. The escape of the excess of this into the air, provided it is not required for farther use, is prevented by a second spray-wheel beyond, supplied with milk of lime or some other absorbent.

In the case of sulphuretted ores of copper, the water tank is filled with a solution of the chlorids of sodium and calcium, by which, with the aid of the spray-wheel, the sulphurous acid is absorbed, and the oxyd of copper converted into dichlorid. This beautiful process, devised by Messrs. Whelpley and Storer, I have submitted to examination, and have found that the reaction taking place may be represented as involving one equivalent of chlorid of calcium, one of sulphurous acid, and two of cupric oxyd, and giving rise to one equivalent of sulphate of lime, and one of dichlorid of copper,

A solution of chlorid of calcium holding oxyd of copper in suspension, rapidly absorbs sulphurous acid gas, and if sufficiently concentrated, is converted into a white crystalline magma of gypsum and dichlorid of copper. This latter salt I find to be soluble in a boiling hot solution of chlorid of calcium, which, however, again deposits it on cooling, a reaction which may probably be found available on a large scale in separating copper from some other metals. In ordinary cases, however, the precipitation of the dichlorid of copper in the furnace-tank is prevented by the presence in the bath of chlorid of sodium, in which, as is well known, the cuprous chlorid is readily soluble.

The calcined and oxydized ore falling into the tank which extends sixty feet or more beneath the furnace and its chambers, is carried forward, with constant agitation, by means of a sub-

merged rotating helix, and at length falls into a well at the extremity, from which it is withdrawn, freed from oxyd of copper, but generally containing a small residuum of unoxydized sulphid, which, if of sufficient importance, is separated by a repetition of the process with the Water-furnace, or by a rapid calcination in a reverberatory, of the mass impregnated with chlorids, by which means the residual copper left by imperfect burning becomes readily soluble in the sulphurous chlorid bath of the water-tank.

A small but variable proportion of protochlorid of iron generally accompanies the chlorid of copper, and may be separated from the cuprous solution by a simple reaction which I also studied. Three equivalents of cupric oxyd, and two of ferrous chlorid, yield by their reaction one equivalent each of cuprous and cupric chlorids, and one of sesquioxid of iron,

The addition to the heated solution, separated from gypsum and insoluble matters, of a portion of cupric oxyd therefore suffices to precipitate the whole of the dissolved iron, and the dinoxid of copper in the presence of air rapidly produces a similar result. The addition of milk of lime now throws down, from the solution of cuprous chlorid, the whole of the copper as pure hydrous dinoxid, whose subsequent reduction to the metallic state is a very simple operation. Meanwhile the chlorid of calcium is regenerated, and the bath restored to its original condition may thus be used an indefinite number of times, the only reagent consumed in the process, in addition to the elements of the ore, and the oxygen of the air, being the equivalent of lime used to precipitate cuprous oxyd.

It will be seen that for sulphuretted ores containing gold, the treatment in the fire-tower, with the aid of a bath of water only, affords a simple mode of desulphurization, and leaves the gold particles in a state most favorable for amalgamation, while in the case of auriferous ores containing copper, a similar result may be obtained, and the copper, which is lost in the ordinary method of working such ores, recovered by means of the chlorid bath.

It is claimed by the designers of this series of processes, that copper can in this way be produced, at about one-third the cost of the ordinary method. The small consumption of fuel, and the mechanical facilities afforded for handling great masses of material, are such, that the new method will probably be found especially advantageous, in the treatment of low grade ores, in regions where transportation is difficult, and fuel scarce. The patentees have a small experimental furnace eighteen feet high, at East Boston, but are now erecting at the Harvey Hill mine,

near Quebec, a furnace thirty feet high, which, it is expected, will enable them to treat fifty tons of seven per cent ore in twenty-four hours.

The application of the Water-furnace to the treatment of the sulphuretted ores of other metals, presents many points of interest, whose consideration is reserved for another time.

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