

be obtained by one or two novel patented methods of which he has no personal experience.)

It seems to the writer most advantageous, therefore, to subject the entire mass of ore to lixiviation, rather than to complicate matters and increase expenditure by any preliminary concentration.

3. *Lixiviation of the Ore direct, with a Solution of Ferrous Chloride and Salt (old Hunt and Douglas Method).*—Considerable quantities of ore have been successfully worked by this process in the United States. The method depends upon the fact that oxide of copper is decomposed by ferrous chloride solutions, forming insoluble ferric oxide, while the copper goes into solution as cuprous and cupric chlorides. It is precipitated in a very pure metallic form by iron, the ferrous chloride solution being thus also regenerated, and requiring only the addition of a little salt to fit in for further use. The consumption of metallic iron in this method is very small, as much of the copper is in solution as cuprous chloride.

As the copper must be in an oxidized form, in order to go into solution quickly and thoroughly, the ore will require a preliminary roasting of sufficient thoroughness to convert most of the copper present into oxide or sulphate. This means that the ore must be crushed dry, though not to nearly so fine a state as would be required for its concentration. Therefore, instead of wet crushing followed by concentration, the writer would suggest dry crushing followed by roasting.

It is impossible to make a comparison of the costs of these two different plans of operation without being accurately acquainted with the physical and chemical character of the ore under consideration. By the use of modern high-speed rolls of great diameter and weight, and of the automatic reverberatory roasting furnaces so generally in use in the United States of America and elsewhere, the cost of dry crushing and roasting should not exceed the cost of wet crushing and concentration, while the condition of the pulp for lixiviation is incomparably better when produced by the former treatment. Apart from the advantage gained by the coarser condition of the pulp, and the much lesser proportion of very fine powder, the ore undergoes a physical change in roasting, which makes it much like sand and gravel, and enables the solutions to permeate it with a completeness and rapidity that are quite surprising. The advantages thus gained will only be fully appreciated by those members who have had experience in leaching the same ore both before and after roasting. There are so great that, in several instances in this country, tailings are roasted previous to lixiviation, solely for the purpose of improving their physical condition, and of increasing the thoroughness and rapidity of the latter operation.

The writer desires to emphasize this dry crushing and roasting as being, in his opinion, the most important step towards a successful leaching of these ores by the methods that he has called Nos. 3, 4 and 5.

4. *Lixiviation of the Ore direct, with Hydrochloric and Sulphuric Acids, which are regenerated in the Solution by the Precipitation of the Copper from a Chloride Solution by means of Sulphurous Acid (new*

*Hunt and Douglas Method).*—By this method, the copper is precipitated from its chloride solution, by means of sulphurous acid gas, which throws down the copper as a very heavy white cuprous chloride, that settles almost instantaneously. Sulphuric and hydrochloric acids are generated in the solution, which only requires the addition of salt to make it ready for further use.

One great advantage of this method is the rapid dissolving of the oxidized copper present by the strongly acid solution, which even attacks sulphides with considerable energy. Any lead and silver present remain undissolved. The ores require to be roasted, as in the previous process. A supply of pyrites is essential to the economical working of this method, and, of course, it is very advantageous if these pyritic ores contain some metal of value.

5. *Lixiviation of the Ore direct, with Sulphuric Acid.*—Mr. Muir has already considered this method in his paper, though he confined it to the treatment of the tailings after concentration.

The writer can only add that, if lixiviation is at all suited to the fine tailings and slimes from the concentration process, it is still more feasible and more economical, when employed upon the coarsely crushed roasted ore; and, that instead of taking 11 weeks for the extraction of the copper, it is probable that, with roasted ore, an equally perfect extraction would be accomplished within two or three days.

6. *The Rio Tinto Method of Gradual Lixiviation in Heaps.*—The writer agrees with Mr. Eissler in having a strong leaning towards this process of slow, but inexpensive, lixiviation, in cases where the climate is suitable, and where the chemical and physical condition of the ore favours the gradual and persistent formation of sulphates. From the description of the ore given by Mr. Muir the writer fears that, in the present instance, the percentage of sulphides might not be large enough to maintain the energetic and persistent chemical action necessary for the gradual decomposition of the chalcocopyrite, and the formation of soluble salts of copper.

There is another very serious objection to the Rio Tinto method that does not always weigh sufficiently with the metallurgist, who confines his attention too closely to the perfection of his technical results, namely:—The time and money required to demonstrate on a large and safe scale that any given ore will eventually yield up its copper to this slow and tedious process. There is also great difficulty in finding reliable deposits of sufficient size to yield the enormous quantities of ore of a nearly identical composition that are required for the profitable installment of this method, as well as in raising capital willing to wait so long for returns.

This completes the list of methods that seem to the writer worthy of consideration in connection with Mr. Muir's Australian ores. There are one or two recent British patented methods that bear on this same subject. No doubt they have been investigated by British engineers who are interested in the mechanical concentration of difficult copper ores, and the writer does not feel at liberty to discuss them in this place.