

caustic solution. Whenever the stock solution shows the presence of caustics it must be neutralised with sulphuric acid. The latter, Mr. Russell states, is not diluted, but added in concentrated form while stirring the solution. The consumption of sulphuric acid per ton may be from  $\frac{1}{4}$  lb. to  $\frac{3}{4}$  lb. It seems most convenient to add the sulphuric acid to a caustic stock solution in the silver precipitating-tanks immediately after the precipitation of the sulphides has been finished. The reaction of the solution on litmus-paper should be closely observed, so that not more acid is consumed than is absolutely necessary. Copper-sulphate also neutralises the caustic; hence an extra solution will have to assume a caustic reaction, and can be made from a caustic ordinary solution. In fact, ordinary solution having an acid reaction should not be used in the preparation of extra solution, because the latter is then more liable to decompose. On account of the greater cost of copper-sulphate, preference should be given to the use of sulphuric acid for neutralising a caustic stock solution.

"It is evident that the amount of stock solution kept in hand and in circulation should be reduced to a minimum. The quantity of stock solution required for works of given daily capacity depends upon the time of leaching with extra and ordinary solution, and upon the volume of the solution necessary to saturate a ton of ore. This will be made clear by example. Suppose the daily capacity is 80 tons—1 ton requires 9 cubic feet of solution for saturation; the time of leaching with extra solution is six hours. In that case 100 tons of ore are constantly under treatment, and this requires 900 cubic feet of solution for saturation. Besides, a certain quantity of the solution stands above the charge in the vats—say, 150 cubic feet—and one precipitating-tank is full and settling, and the second one is half filled—say, 750 cubic feet for both—then there is a certain accumulative solution in the sump for the pump and filter-press—say, 250 cubic feet. Finally, we must have sufficient solution in the storage-tanks to make a charge of extra solution of about 300 cubic feet; and, in addition to that, we should have not less than 300 cubic feet to supply the lixiviation-vats. This would give a total of 2,400 cubic feet. That works of large capacity require comparatively less stock solution than those of smaller capacity can easily be seen. In most cases the best results are obtained in lixiviating with an ordinary solution heated from 90° to 125° Fahrenheit.

"*Extra Solution.*—This is not kept in stock, but is made up in charges as needed, and is then immediately used. It decomposes much more quickly than ordinary solution, and is converted into the latter before leaving the precipitating-tanks. As a rule, the quantity of extra solution made and used is just sufficient to saturate the ore. The only exception to this rule occurs in the lixiviation of roasted ores containing caustic lime, as will be shown later on. The extra solution for raw ore is made as follows: The necessary amount of copper-sulphate put into a box with holes placed above the extra-solution tank is dissolved by ordinary solution turned on from the storage-tank. Before this is done, however, the tank below is filled with about two-thirds of the required amount of ordinary solution. In this way the strong copper solution meets at once a sufficient amount of sodium-hyposulphite to prevent the precipitation of a canary-yellow salt of cupreous-hyposulphite.

"As already stated above, it is not judicious to use an acid stock solution in preparing the extra solution, because cupreous-hyposulphite decomposes more quickly upon heating in the presence of an acid than if the solution is neutral. If the extra solution is to be used warm the ordinary solution is previously heated in the storage-tank, or in the extra tank itself. In case the stock solution needs strengthening a proper amount of sodium-hyposulphite is put into a box over the extra-solution tank and dissolved prior to the copper-sulphate. The introduction of fresh hyposulphite is most judicious at this stage of the process, by reason of the decomposition of sodium-hyposulphite with copper-sulphate, as already referred to, as the fourth cause of weakening the stock solution. It is evident that the extra solution, by passing the precipitating-tank, must produce an ordinary solution of less concentration than the stock solution possessed from which it was made, unless a fresh supply of hyposulphite has been added. Of course, a part of the hyposulphite lost in the manufacture of the extra solution is replaced by the hyposulphite entering with the sodium-sulphide in precipitating the copper and silver.

"The consumption of copper-sulphate for the extra solution is generally calculated for a ton of ore and varies between 2 $\frac{1}{4}$  lb. and 7 lb. As it takes from 7 to 10 cubic feet of solution to saturate 1 ton of ore, and not more than this quantity of extra solution is generally needed, its concentration in copper sulphate may vary between  $\frac{1}{10}$  and  $\frac{1}{15}$  per cent. Only, if caustic lime is present in roasted ore weaker but larger volumes of extra solution of  $\frac{1}{10}$  to  $\frac{1}{15}$  per cent. concentration are used. Since the effect of the extra solution depends, in a certain measure, more upon its concentration than its quantity it is apparent that the consumption of copper-sulphate per ton of ore is affected by the specific gravity of the ore, or by the quantity of solution necessary to saturate a ton of ore. Hence roasted ores, on an average, require more copper-sulphate than raw ores, although, in the latter case, the extra solution may have to perform more work than in the former.

"After the most advantageous quantity of copper-sulphate required per ton of ore has been determined by experience, another point should not be neglected in the preparation of the extra solution. It has been demonstrated that those extra solutions are the most effective in which the relation between the quantity of copper-sulphate and sodium-hyposulphite is as 1 to a fraction above 2—we will say, for the sake of safety, as 1 to 2 $\frac{1}{4}$ . An excess of copper causes the formation of an insoluble cupreous-hyposulphite salt, which will only dissolve upon more sodium-hyposulphite. An excess of sodium-hyposulphite in the extra solution, while it diminishes its efficiency upon metallic silver, silver-sulphide, and certain silver minerals, does not act as injuriously as an excess of copper. Especially if the extra solution is used on raw ores prior to the ordinary solution, and these ores carry a fair percentage of the silver in the form of chloride, an excess of sodium-hyposulphite is beneficial for the more rapid extraction of the silver-chloride. From this it follows that in making the extra solution the strength of the stock solution should be approximately known, and that if it is deficient in sodium-hyposulphite a proper amount of the latter should be added. To illustrate this: Suppose that ore is treated which requires 8 cubic feet of solution to saturate 1 ton;