*Lixiviation,—*Ores suited for amalgamation can, as a rule, be successfully leached. In leaching, the silver ore is subjected to the action of solvents, which dissolve the silver; from the solution the silver is precipitated and converted into a marketable product.

The leading solvents are aqueous solutions of thiosulphates, un­systematically but generally termed hyposulphites. Sodium chloride, characteristic of the Augustin process in which the ores, after a chloridizing roast, were extracted with brine, and the silver pre­cipitated by copper, has almost wholly fallen into disuse; and potassium cyanide, which has become a very important solvent for finely divided gold, is rarely used in leaching silver ores. The use of sodium hyposulphite as solvent, and sodium sulphide as precipitant, was proposed in 1846 by Hauch and in 1850 by Percy, and put into practice in 1858 by Patera (*Patera* process); calcium hyposulphite with calcium polysulphide was first used by Kiss in i860 *{Kiss* process, now obsolete); sodium hyposulphite with calcium poly­sulphide was adopted about 1880 by O. Hofmann *{Hofmann* process) ; finally, sodium hyposulphite with cuprous hyposulphite was first applied by Russell in 1884, who included in his process the acidula­tion of the first wash-water (to neutralize any harmful alkaline reaction), and the separation of lead with sodium carbonate from the silver solution previous to precipitating with sodium sulphide (see C. A. Stetefeldt, *The Lixiviation of Silver Ores with Hyposulphite Solutions,* &c., New York, 1888).

In all processes the silver ore is finely crushed, usually by rolls, as, because making few fines, they leave the ore in the best condition for leaching. As a rule the ore is subjected to a preliminary chloridizing roast, though occasionally it may be leached raw. The vats in common use are circular wooden tanks, 16-20 ft. in diameter and 8-9 ft. deep if the leached ore is to be removed by sluicing, 5 ft. if by shovelling. They have a false bottom, with cloth or gravel filters.

The basis of the following outline is the Patera process. The ore, supposed to have been salt-roasted, is charged loosely into the leaching vat and treated with water (to which sulphuric acid or copper sulphate may have been added), to remove soluble salts, which might later on be precipitated with the silver (base-metal chlorides), or overcharge the solution (sodium chloride and sulphate), or interfere with the solvent power (sodium sulphate). The vat is filled with water from above or below, in- and out-flow are then so regulated as to keep the ore covered with water. Any silver dissolved by the first wash-water is recovered by a separate treatment. After the wash­water has been drained off, the ore is ready for the silver solvent. This is a solution containing up to 2% of sodium hyposulphite, of which one part dissolves 0∙485 part silver chloride, equivalent to 0∙365 part metallic silver, to form double hyposulphites. Silver arsenate and antimoniate are also readily soluble, metallic silver slightly so, silver sulphide not at all. (In the Russell-process double salts: 4Na2S2O3∙3Cu2S2O3, and 8Na2S2O3∙3Cu3S2O3 the metallic silver and silver sulphide are readily soluble; thus it supplements that of Patera.)

After the silver has been dissolved by percolation, the last of the solvent still in contact with the ore is replaced by a second wash­water. The silver solution, collected in a circular precipitating vat (10 ft. in diameter and 10 ft. deep), is treated with sodium sulphide (or calcium polysulphide), unless sodium carbonate was first added to throw down any lead, present in the ore as sulphate, that had gone into solution. Silver sulphide falls out as a black mud, with about 50% silver, and the solvent will be regenerated.

If the sodium cuprous hyposulphite was used as a solvent in addition to the simple sodium hyposulphite, cuprous sulphide will be precipitated with the silver sulphide, and the precipitate will be of lower grade. At some works the silver is precipitated with sodium sulphide, and the liquor, after having been separated from the silver sulphide, is treated with calcium polysulphide, that by the precipi­tation of calcium sulphate the accumulation of sodium sulphate may be prevented. The precipitated silver (copper) sulphide is filtered, dried, and usually shipped to silver-lead works to be refined; some­times it is converted into metallic silver at the works. The solution, freed from silver, is used again as solvent. Lixiviation has many advantages over amalgamation. It permits coarser crushing of the ore, the cost of plant is lower, the power required is nominal, the cost of chemicals is lower than that of quicksilver, less water is necessary, and the extraction is often higher, as silver arsenate and antimoniate are readily soluble, while they are not decomposed in amalgamation. On the other hand, silver and silver sulphide are readily amalga­mated ; and while they are not dissolved in the Patera process, they arc in the Russell process.

Mention may be made of the *Ziervogel* process, introduced at Hettstadt in 1841 for the purpose of extracting silver from copper mattes. In principle it consists in oxidizing silver sulphide to the sulphate which is soluble in water, the silver being then precipitable by metallic copper. This process when carefully carried out, especi­ally as to the details of the roasting process whereby the silver sulphide is oxidized, yields 92% of the silver originally present.

*Electrolytic Methods.—*Crude silver generally contains small amounts of copper, gold, bismuth, lead and other metals. To eliminate these impurities, electrolytic methods have been devised; of these that of Moebius is the most important and will be described in detail.

Under his earlier patent of 1884, cast crude silver anode plates, about ¼ in. thick, and thin rolled silver cathodes, were suspended in a ½%, slightly acid, solution of silver nitrate contained in tarred wooden tanks. The deposit from this solution even with low current­densities is pulverulent and non-coherent, and therefore during electrolysis wooden scrapers are automatically and intermittently passed over the surface of the cathode to detach the loose silver, which falls into cloth trays at the bottom of the tanks. These trays are removed at intervals, and the silver washed and cast into bars, which should contain over 99∙9% of pure metal. The relatively electro-negative character of silver ensures that with moderate current densities no metal (other than precious metals) will be deposited with it; hence, while the solution is pure a current-density of 30 amperes per sq. ft. of cathode may be used, but as copper accumulates in it, the current-density must be diminished to (say) 15 to 20 amperes per sq. ft., and a little extra nitric acid must be added, in order to prevent the co-deposition of copper. A pressure of 1·5 volt usually suffices when the space between the electrodes is 2 in. The tanks were arranged in groups of seven on the multiple system.

Of the metals present in the anode, practically all, except gold, pass into solution, but, under the right conditions, only silver should deposit. The whole of the gold is recovered as anode slime in cloth bags surrounding the anodes. Practical results with a large plant indicate an expenditure of 1∙23 electrical horse-power hours per 100 oz. (Troy) of refined silver. In later installations, under the 1895 patent, the anodes are placed horizontally on a porous tray resting within the solution above an endless silver band revolving, also horizontally, over rollers placed near the ends of a long shallow tank. The revolving band forms the cathode, and at one end makes a rubbing contact with a travelling belt placed at an angle so that the crystals of silver detached thereby from the cathode are con­veyed by it from the solution and deposited outside.

Alloy scrap containing chiefly copper with, say 5 or 6% of gold, and other metals, and up to 40 or 50% of silver, is often treated electrolytically. Obviously, with modifications, the Moebius process could be applied. Other systems have been devised. Borchers uses the alloy, granulated, in an anode chamber separated from the cathode cell by a porous partition through which the current, but. not electrolyte, can pass freely. The anode residue is collected in the angular bottom of the tank, the electrolyte passes from the anode chamber to a series of tanks in which the more electro-negative­constituents (silver, &c.) arc chemically separated, and thence to the cathode chamber, where the copper is deposited electrolytically, thence it passes again to the anode chamber and so completes the cycle. In one form of the apparatus a rotating cathode is used. Dietzel has described *{Zeitschrift für Etektrochem.,* 1899, vol. vi. p. 81) the working of his, somewhat similar, process at Pforzheim, where about 130 lb of the alloy was being treated by it daily in 1899. The alloy is cast into anode plates about 1/6 in. thick, and placed in the anode chamber beneath the cathode cell, and separated from it by linen cloth. In the upper compartment are two large revolving horizontal cathode cylinders. Acidified copper nitrate solution is. run into this cell, copper is deposited, and the more or less spent solution then passes through the linen partition, and, taking up metal from the anodes by electrolytic solution, is run out of the trough through a series of vessels filled with copper by which the silver is precipitated by simple exchange; after acidification the resulting silver-free copper solution is returned to the cathode cell for the deposition of the copper, the solution being employed again and again until too impure for use.

*Chemically Pure Silver.—*Even the best “ fine" silver of commerce contains a few thousandth-parts of copper or other base metal. To produce perfectly pure metal the usual method is to first prepare pure chloride and then to reduce the chloride to metal. This may be effected by mixing the dry chloride with one-fifth of its weight of pure quicklime or one-third of its weight of dry sodium carbonate, and fusing the mixture in a fire-clay crucible at a bright red heat. In either case we obtain a regulus of silver lying under a fused slag of chloride. The fused metal is best granulated by pouring it into a mass of cold water. A convenient wet method for small quantities is to boil the recently precipitated chloride (which must have been produced and washed in the *cold)* with caustic soda and just enough sugar to reduce the silver oxide (Ag2O) transitorily produced. The silver in this case is obtained as a yellowish grey heavy powder, which is easily washed by decantation; but it tends to retain unreduced chloride, which can be removed only by fusion with carbonate of soda.

Stas in his stoichiometric determinations employed the following process as yielding a metal which comes nearer ideal purity. Slightly cupriferous silver is made into dry nitrate and the latter fused to