

but even when used after, it is usually followed again by the ordinary solution; it should be used directly it is made as it begins to decompose immediately, especially if made hot, on this account it is usual to use a perforated box which is placed over the leaching vat—the bluestone is placed in this box and the stock solution runs through it taking up its quantity of the sulphate in its passage. In passing through the charge the cuprous hyposulphite is decomposed at the same time as the silver salts and the copper passes into the solution from which it is recovered with the silver in the precipitating vat.

A solution of carbonate of soda is used to precipitate any lead that may be in the ore, as a carbonate, as by this means it is entirely separated from the silver. It is prepared by dissolving purified carbonate of soda in stock solution in preference to water, as, by so doing, the stock solution is not diluted when the carbonate solution is added. When impure carbonate of soda is used, silver will be precipitated with the lead, but, if the carbonate is pure, the separation is practically perfect.

The sodium sulphide solution is used to precipitate the silver and copper from the stock extra and solutions in which they are dissolved, and is prepared by boiling caustic soda in a cast iron tank with soda, and diluting to the required volume with stock solution.

The mode of working in the mill by this process is briefly as follows:—The ore on being brought from the mine is passed through a rock-breaker, and broken to about road-metal size; it is then conveyed to the drying floors and dried by heated plates, or by being passed through a drying cylinder, and from there is taken to the crushing plant and crushed to the necessary degree of fineness. Rolls are now considered the best form of crushing machine for any crushing or for concentrating works, as they produce a more even grade of mineral, and a smaller quantity of slimes or dust. From the rolls the ore is conveyed to the roasting furnace, usually for this

process of the Stetefeldt type, where after being first mixed with a proportion of salt, from 2 to 15 per cent, according to the nature of the ore, it is roasted, and then allowed to cool slowly in heaps to effect a better chlorodising, when cool it is charged into vats or tanks which vary in size, according to the capacity of the mill. It may be as well to observe, however, that the greater the capacity of the tank the better the work is done. The surface of the ore being now levelled, water is introduced and the charge is washed, in which operation, such of the "live" metals as have formed soluble salts are removed, and prevented from going into the solution, taking the silver, and lowering the value of the product. This wash water is passed over scrap iron to precipitate any small amount of silver it may contain, and is then allowed to run away.

When this washing is completed, the extra solution is turned and circulated by means of a pump for a given time and then conducted to a vat below the well of the leaching vat. Then the stock or ordinary leaching is turned on, and allowed to filter through the charge until the silver is dissolved out. From the tank it is conducted into the same vat as the extra solution. The charge is then washed again with water, and the residue assayed to find its content in silver, and if poor enough—as is usually the case after the first leaching—is thrown away.

To the liquor drawn off is now added the sodium carbonate solution to precipitate the lead, which quickly settles to the bottom of the vat. The liquor is syphoned off from this into another and lower vat, and sodium sulphide solution added to precipitate the silver and any copper that it may contain as sulphides. In this conversion of the silver and copper into sulphides, the sodium sulphide is also converted into sodium hyposulphite, thus explaining any loss the stock solution might suffer. When the precipitate has settled—which in this case does not take place so quickly—the liquor is again drawn off and pumped back into the stock solution tanks to be used over

again, The sulphides are removed, drained, and dried in the filter press, packed into boxes and sent to the refinery for treatment, or sold as sulphides, which is often the more convenient method.

There can be no comparison made between these two methods of treating silver ores as to the relative value of each, as, in a general way, the one process is suitable where the other is unsuitable. As a rule, ores containing a high percentage of silica and a low percentage of copper or lead, are unsuitable for smelting, but are the most suitable for leaching, and *vice versa*. But an ore of this kind may also be unsuitable for leaching, if, on account of the clayey or slimy nature of the matrix, great mechanical difficulties are presented in the filtering of the solutions through the charge; and it is in many cases necessary to separate the mineral from the matrix mechanically before treating it by either process. This is done by crushing and concentration.

#### CONCENTRATION OF ORES.

This is a very important branch in the treatment of some ores, as by means of it many that would otherwise be too poor to work profitably can be made to yield good returns; but it must always be remembered that many poor ores are not suitable for concentration, and many failures have resulted from overlooking this important point.

The principle of concentration is the separation of the different constituents in an ore by means of their different specific gravities, and it is usually performed in a stream of water, although many attempts have been made to use a current of air in place of this, with varying success. The separation is performed, after crushing and sizing of the mineral, on jigs, buddles, and sundry special machines. There still exists considerable difference of opinion regarding the relative merits of these apparatus for treating different kinds of material, and practice, therefore, presents analogous divergences.

A few words on each type of machine, and of their action, may serve to give a general idea of the process.

The general law upon which all concentration is based, is, that upon particles of minerals of the same size, but of different specific gravities being introduced into a current of water, the lighter particles will be the first and more easily moved than the heavier ones.

In jigging, which may be described as the sorting of particles by an intermittent rising current of water forced through a bed of the mineral to be sorted, from the bottom, the lighter particles having less inertia than the heavier, are moved first, and carried upwards at every stroke, while the heavier ones are gradually left at the bottom, from which they are discharged.

The original hand-jig, from which all others have grown, was simply a sieve with two handles, into which the ore was put and shaken up and down in a tub of water. This motion was soon given to the sieve by mechanical means, and the sieves were then made larger. The incessant shaking of the heavily-loaded sieve was productive of much wear and tear, and to overcome this, the sieves were made stationary, and a piston forced up and down in a vessel, communicating with the jig-box, which in its descent forced the water up through the bed of ore, and on its return allowed it to resume its level again. This form is now the one almost universally employed.

In a continuous horizontal stream of water, as in buddles and tables, the lighter particles are carried down with the stream, while the heavier ones are deposited on the table at a point nearer to that at which the ore was fed on to the machine.

Buddles are of various kinds, the most common being that of a circular pit about 22ft. in diameter, from 1 to 1½ feet deep at the circumference, with a raised centre 10ft. diameter, and a sloping floor falling towards the outer circle. The mineral is brought to the centre of the buddle in launders, and dis-

tributed upon the raised centre from a revolving pan, carrying a number of spouts so as to spread the stream uniformly in a thin film, which flows gradually outwards over the whole of the sloping floor to the circumference. The mineral held in suspension in the stream is in its passage down gradually deposited, according to its specific gravity, the heaviest particles being deposited first. The outlet is regulated by a wooden partition, having holes bored at different heights, which can be plugged up as the mineral is deposited in greater quantity. To prevent channels forming in the bed of mineral as it is deposited, revolving arens carrying brushes are attached and kept continually sweeping round the buddle. When full the mineral is shovelled out in three concentric portions, that nearest to the centre being the richest and ready for treatment, and the other two being done over again. There are many other forms of buddles, but the principle involved in each being the same, there is no need to describe them.

Tables are practically continuous. Buddles are made of all shapes and sizes. The class principally used in Europe is the stationary round table, with revolving launders, while that used in America is of the Frue Vanner type. The German shaking table was a contrivance to prevent the ore from packing, by keeping it continually agitated, while the stream of water separated the particles. This was the first use of the principles now used in Frue Vanners, the Embry, and similar machines. The percussion table sought to accelerate the separation by a series of taps or blows, either on the end or on the side of the table, and was, to a certain extent, successful. The Brunton Belt was a continuous travelling-inclined belt, on which the ore was fed at the higher end, and as the mineral to be saved was deposited, it was carried over the end of the machine and removed. It was found, in this machine, that the mineral packed hard on the belt, so that a good separation could not be effected. The earliest table of all was the old stationary slime-table, which was simply an

inclined plane, on to which the ore was fed, and the mineral to be saved was removed periodically as it was deposited. The combination of Brunton's Belt with the shaking table is now seen in the Frue Vanner and kindred machines. By using the shaking motion, the objection arising from the ore packing is overcome, and at the same time a continuous working is effected. This class of machine is very suitable for saving pyrites from quartz and as a slime-dresser to follow jigs; but it is always better wherever possible to do as much work by the jigs as can be done, as the ore brings in larger particles for jigging less is carried away with the stream of water.

Before attempting to concentrate, the mineral should always be sized or classified, either by screening or by hydraulic classification, as it is impossible to do satisfactory work without this being done.

The crushing for concentrating work is best done by rolls, as these produce less slimes than any other class of crusher, and moreover can be used to crush to any degree of fineness or coarseness required. The ore, after passing through the rolls, is screened; and any that will not pass through the required mesh is returned for re-crushing.

The sizing is done by means of trommels or revolving screens placed in an inclined position, and following one after another in different sizes as required.

Hydraulic classification is effected by means of the pointed box, through which a continuous rising stream of water is flowing from the bottom; the heavier particles fall through this stream, while the lighter ones are carried over the outlet into another box to be treated in the same way, a series of from 4 to 10, or even more, of these boxes, being often used.

It will be seen from the foregoing, that for an ore to be concentrated successfully it must fulfil the following conditions, viz. :—

1. The mineral to be saved must differ in specific gravity from the material it is wished to separate it from sufficiently to allow of their separation, through the law previously mentioned.

2. The mineral to be saved must be in a form coarse enough to resist the tendency of the stream of water used in the process to wash it away.

3. It must exist in such a form that it can be separated from the matrix by crushing.

If it fails in either of these conditions, the attempt to concentrate must prove a failure.

Having now, in a very cursory and imperfect way, introduced this subject to your notice, as one which is of great importance to the whole country, and especially worthy of the attention of engineers as to what improvements can be made in the simplifying or rendering more efficient the various machines employed in the different processes, doubtless members who have directed their attention to any parts of these processes will be able to offer valuable suggestions as to how many of the difficulties which arise in carrying them out can be surmounted.