UNITED STATES PATENT OFFICE.

WILLIAM CROOKES, OF LONDON, ENGLAND.

AMALGAMATING AND EXTRACTING GOLD FROM REFRACTORY OR OTHER ORES.

SPECIFICATION forming part of Letters Patent No. 462,535, dated November 3, 1891.

Application filed January 10, 1891. Serial No. 377,361. (No model.) Patented in Cape of Good Hope May 28, 1890, No. 607; in Natal May 28, 1890; in Transvaal May 28, 1890, No. 187, and in Queensland September 17, 1890, No. 1,039.

To all whom it may concern:

Be it known that I, WILLIAM CROOKES, a subject of the Queen of Great Britain, residing at 7 Kensington Park Gardens, London, England, have invented an Improvement in Amalgamating and Extracting Gold from Refractory or other Ores, (for which I have obtained Letters Patent in Natal under date of May 28, 1890; in the Transvaal under date of May 28, 1890, No. 187; in Queensland under date of September 17, 1890, No. 1,039, and in the Cape of Good Hope under date of May 28, 1890, No. 607,) of which the following is a specification.

The present method of extracting gold from refractory ores—such as sulphides, tellurides, arsenio-sulphides, &c., of zinc, copper, iron, bismuth, antimony, &c.—by direct amalgamation with mercury is very imperfect, as the sulphides, arsenio-sulphides, and other minerals in the ore have a deleterious action on the mercury, causing it to "flour" and "sicken," so that its fluidity is destroyed, and it becomes either a tenacious mass or assumes a powdery character. In either case its amalgamating action is almost entirely destroyed, with the result that from thirty to eighty or more per cent. of gold escapes the action of the mercury, being lost in the tailings, while large quantities of mercury are also carried off in the washings. The "flouring" of the mercury is due to a film or tarnish from some of the sulphides, arsenio-sulphides, &c., coating the mercury and preventing the separate globules from uniting when once divided by trituration or grinding. The trituration in the machines therefore constantly subdivides the mercury more and more until it becomes a black slimy mass, which will not settle in water for a long time, and is carried off in the washings and lost, the separation of this metallic slime from the heavier portions of the ore being almost impossible.

The "sickening" of the mercury is not quite so serious as its flouring. Sick mercury has taken up some of the constituents of the minerals present and has lost its fluidity and will not flow with a bright surface; neither will it touch gold except with great difficulty. Sick mercury can generally be restored by distillation, in which case not much is lost, the chief drawback being that sick mercury will not take up gold from the ore; but floured mercury is not only lost of itself, but it carries away with it all the gold which it may already have taken up. Again, supposing the mercury neither flours nor sickens, there is another serious loss when working with ores containing sulphides, tellurides, arsenio-sulphides, &c. Even when the mercury retains its bright metallic condition and is in its usual active state it will seldom take up more than half or two-thirds of the gold present in the ore, owing to the coat of tarnish which is almost always on the surface of the gold—a coating which can only be removed by chemical or mechanical means, the long grinding required to remove the coating mechanically then tending to flour the mercury.

Another method of extracting gold from the above-named ores is by roasting till free or almost free from sulphur and then treating with a solvent for gold. The precious metal is then precipitated from its solution by appropriate means. Chlorine is usually employed for this purpose; but it is expensive. In some cases cyanide of potassium or a soluble cyanide is used instead of chlorine to dissolve the gold. This reagent has, however, a very feeble solvent action on gold, and I can imagine few cases in which a sufficient amount of gold would be dissolved to repay for the expense of the solvent. It has been proposed to remove the tarnish or film (supposed to be sulphide of gold) by the action of weak nitric acid, nitrate of mercury being present in the bath for the purpose of amalgamating with the particles of gold as they are cleansed from the film or tarnish. The drawback to such a process is that even though the nitric-acid solution be a weak one it will tend to decompose the more easily acted on metallic sulphides present, such as lead, iron, zinc, and the like sulphides, and thus liberate sulphureted hydrogen, which in turn will recoat the particles of gold with a sulphide coating. It has also been proposed to use solutions of cyanide of potassium and other soluble salts both with and without a fur-

ther treatment by the electric current; but so far as I am aware it has always been proposed to use such substances as a solvent for the gold, which is subsequently recovered from its solution by a further process. Various proposals have also been made with regard to the use of an electric current, both for the purpose of assisting the amalgamating and for preventing the flouring or sickening of the mercury.

The object of my invention is to obviate the disadvantages inherent in the above processes; and to this end it consists in submitting the refractory or other ore to the action of a solution, preferably of cyanide of mercury, either in the commercially pure state or prepared at the time by double decomposition between a soluble salt of mercury, such as the sulphate, and the soluble cyanide or ferro-cyanide. The process is so conducted that the mercurial cyanide shall decompose the film or tarnish on the gold, the cleansed particles of which become amalgamated with the mercury as distinguished from becoming dissolved in the solution, the cyanide of mercury not being a solvent for pure gold. In lieu of the cyanide the sulphate of mercury can be employed. In many cases I also propose to use in conjunction with the solution of any mercurial salt the current from any alternating dynamo-machine.

In carrying out my combined process I proceed as follows: I take the gold ore, tailings, sulphurets, &c., reduced to powder in the usual manner, and mix with them a solution of sulphate, nitrate, chloride, cyanide, or any soluble salt of mercury, and then pass a rapidly-alternating current of electricity through the mass, either when in a state of rest or when agitated or stirred in any convenient manner. The bulk of the mass is not a very good conductor of electricity, while the fine particles of gold sparsely disseminated through the mass are, as is well known, excellent conductors. Iron, carbon, or other convenient conductors may be used as the poles. Each pole is alternately cathode and anode. If water is decomposed by such a current, the gases being able to escape do so, and a mixture of hydrogen and oxygen comes from each pole. If, however, the results of the decomposition are fixed, such as acid and metal, the decomposition by the current in one direction is reversed by the following current in the opposite direction and practically little or no decomposition results. Assume that sulphate of mercury is the mercurial salt chosen. Then when the pole with which it is in contact becomes positive sulphuric acid is there liberated, while mercury is liberated at the opposite pole; but in a fraction of a second the poles are reversed, the opposite decomposition is effected, and the sulphuric acid just liberated finds itself in presence of nascent mercury, with which it immediately combines. At the other pole the mercury liberated by the first current finds a molecule of sulphuric acid ready to reunite with it, and so at each pole the mercurial salt is decomposed only to be immediately reunited. Every particle of gold in the wet mass through which the alternating current is passing is a much better conductor of electricity than the surrounding mass, and the equipotential lines of force will converge toward them, with the result that more of the electric current passes through them than through the rest of the mass, and the two sides of each particle of gold act alternately as anode and cathode. On one side (the anode for the time being) sulphuric acid is liberated, and on the other side (the cathode for the time being) mercury is liberated; but the affinity of gold for mercury is so great that the two metals instantly unite and the gold becomes amalgamated. At the next alternation the side of the gold particle which had the sulphuric acid liberated on it now has the mercury precipitated on it. The affinity of gold for mercury here again comes into play, and instead of reuniting with the sulphuric acid the mercury prefers to attack the gold. Thus each alternation precipitates mercury on alternate faces of the particles of gold in the mass of ore without requiring the gold to be in metallic communication with either pole of the dynamo, as the extra conductivity of the gold draws to it the lines of force. The size of the particles is not essential, as the finest flour and "float" gold will be amalgamated, and consequently weighted, as easily as the largest pieces. Neither does it matter to what degree of coarseness the ore is crushed so long as the solution of the mercurial salt penetrates to one part of the piece of gold locked up in the ore, for the action will then take place and the metal will become amalgamated and in the subsequent amalgamating operation dissolved in the mass of mercury.

A further advantage incidental to the use of an alternating current is that the sudden and violent decompositions and recompositions alternating with great rapidity cause the mass to become hot, thereby greatly facilitating the amalgamation.

Any ordinary alternating current from an alternating dynamo or other source of electricity will produce the desired effect; but the most efficient action is dependent on the right adjustment of several variable factors, such as, first, current density; second, area of electrodes; third, rate of alternation per second; fourth, electric conductivity of the wet mixture of crushed ore and liquid. The latter varying with every different kind of ore, it is evident that the others will have to be adjusted in each separate case in order to get the maximum effect, and that therefore no general directions can be here given which will meet all cases.

When it is impracticable to use an electric current, I propose to employ a solution of cyanide of mercury or a sulphate of mercury, either

of which solutions will remove the film or tarnish and superficially amalgamate the particles of gold. The process will not, however, be so rapid as it is when the alternating electric current is used, although it may be hastened somewhat by heating the mass. When carrying out the process in this manner I propose to use a solution composed of two or three pounds of cyanide of mercury or of sulphate of mercury dissolved in eighty to one hundred gallons of water for each ton of ore; but special circumstances may render it advisable to vary these quantities. When the action is complete, the mercury solution may be drained or drawn off or removed in any other convenient way and the ore treated in amalgamating pans or machinery or in other appropriate manner.

In some cases I find it an advantage to add to the mercury used for the subsequent amalgamation process a little amalgam of sodium, as described in my British specification No. 391 of 1865, or some of the modified amalgams described by me in my British specification No. 2,229 of 1865.

It will be evident that the mercurial salt, either alone or in conjunction with the amalgams just referred to and with or without the use of the alternating electric current, may be employed in the grinding and amalgamating apparatus, and in this case the cleansing of the gold from the tarnish or film and the collection and amalgamating of the cleansed particles may go on simultaneously. When this is desired, fresh mercury should be added to the mass and thoroughly mixed or incorporated therewith. The solution of mercurial salt and an alternating current may also be advantageously employed in concentrating and vanning machines, such use causing the gold particles to unite more readily with the mercury.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is—

1. The improvement in the process of amalgamating and extracting gold hereinbefore set forth, which consists in submitting the ore to the combined action of a solution of a mercurial salt and an alternating electric current, substantially as described.

2. The improvement in the process of amalgamating and extracting gold hereinbefore set forth, which consists in submitting the material in the final amalgamating process to the combined action of a solution of a mercurial salt and an alternating electric current, substantially as described.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

WILLIAM CROOKES.

Witnesses:
ALLEN P. JONES,
JAMES BOLES.