

UNITED STATES PATENT OFFICE.

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EXTRACTING METALS.

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To all whom it may concern:

Be it known that I, JOHN JAMES HOOD, chemist, a subject of the Queen of Great Britain, residing at 1 Fenchurch Avenue, in the city of London, England, have invented certain new and useful Improvements in Extracting Metals and New Solvent Materials Therefor, of which the following is a specification.

10 The improvements described herein relate to metallurgical processes for the extraction of valuable metals from their ores, and have for their object not primarily the precipitation of a more valuable metal from its solution at the expense of a less valuable metal, but the solution or dissolving of a more valuable metal by the precipitation of a less valuable one. Such improvements have regard more particularly to the precious metals gold and silver, which, as is well known, occur frequently in their ores in a metallic state. I employ for the extraction of such metals a solution of a salt or compound of a baser metal, which on being brought into the presence of the precious metal (whether in a metallic state or otherwise) causes it to pass into solution by reason of its displacing the baser metal in the solution. The extraction of the precious metals is effected by washing the ground ores with such a solution. Taking gold as an example, I will now describe several such solutions of metallic salts as will dissolve gold while the baser metal is precipitated and will set forth how the solutions are prepared and worked and the method of recovering the gold from the solutions. If metallic gold or natural auriferous ores be treated with certain solutions of salts of mercury or lead or other base metals, the gold is dissolved with great ease, the base metal being precipitated. The metal I prefer to employ is mercury; but lead does well, and several other metals—such as copper, arsenic, and antimony—will do, though less conveniently. This preference is because the base metals like lead tend to form a hard covering upon the particles of gold and so to render the further solution of the precious metal slow, whereas in the case of mercury as it is precipitated on the particles of gold it remains fluid and hardly, if at all, retards the solvent action of the solution employed. To

prepare such an active solution in one way I take the cyanide, sulphate, chloride, or oxide of mercury or other compound of mercury soluble in an alkaline cyanide and dissolve it in a solution of a suitable alkaline cyanide, preferably soda or potash cyanide or mixtures of these. Alkali, either as caustic or carbonate, (by preference caustic soda,) is in practice also added. If the material is being prepared for export, any insoluble matters are allowed to settle out and the clear solution is evaporated to dryness. This can readily be done, for the presence of the metallic salt prevents loss of cyanide during the evaporation. A mixture that answers well consists of two parts, by weight, of cyanide of potassium, (or its equivalent of cyanide of sodium,) one part of mercuric chloride or its equivalent of sulphate or other mercury salt, and from one-half to two parts of caustic soda. If a small quantity of this solution be placed upon gold, mercury is quickly deposited and gold goes into solution.

Estimating the amount of gold dissolved for a given amount of mercuric chloride, the reaction appears to be in its first stage represented by $2\text{Au} + 3\text{HgCl}_2 = 3\text{Hg} + \text{Au}_2\text{Cl}_6$, or, roughly, two parts, by weight, of mercuric chloride employed on a quantity of auriferous quartz with an alkaline cyanide solution will dissolve one part of gold.

If pure gold be treated with the above solution and kept warm, a secondary reaction probably takes place, resulting in the amount of gold dissolved being greater as compared with the mercuric chloride than the above proportion. This may possibly be explained by the solvent action of the auric salt acting on the metallic gold to form an aurous salt in the presence of alkaline cyanide, just as a ferric salt will dissolve metallic iron to form a ferrous salt, and substantially when a mercuric salt (*e. g.*, the chloride) is employed, the complete reaction appears to be $\text{HgCl}_2 + 2\text{Au} = \text{Hg} + 2\text{AuCl}$; in other words, the mercuric chloride dissolves 1.45 parts of gold. Doubtless, also, secondary reactions take place between the aurous chloride and the potassic cyanide to form the double cyanide of gold and potassium.

To prepare another base metal for dissolving gold—for instance, lead—I take one of its

compounds, such as ordinary litharge, boil it with caustic alkali to dissolve as much as possible, and mix this alkaline lead solution with the alkaline cyanide and employ the mixed solution, as in the case of mercury. Such a solution poured upon metallic gold soon gives a black deposit of metallic lead, and gold goes into solution. These gold solvents may be converted into solid masses and packed for export, or they may be prepared as required at the mines from the constituents.

Although I have mentioned certain salts of baser metals in the preparation of my solution, I do not restrict myself to these salts. I mention them because they are merely convenient and cheap salts to use in the preparation of my solution, which when prepared consists, essentially, of the cyanide of an alkali with some salt of a baser metal in solution; and in all these cases the precious metal when being dissolved is acted upon by a solution which contains a baser metal or some salt of a baser metal in solution in the presence of an alkaline cyanide, and all the solutions act upon the precious metals in the same way—that is to say, by the precious metal displacing the baser metal in that solution. Instead of preparing this metallic compound in the manner above indicated, in which caustic alkali is employed, I may omit the caustic at this stage and proceed by reacting upon a soluble cyanide with a compound of mercury soluble therein and, if desired, crystallizing it. The material thus obtained is employed in conjunction with caustic alkali, or, what yields better results, with a solution of alkaline cyanide.

If the process be performed at the mines without the assistance of the compound previously prepared, the solutions may be formed in the vat itself and in the presence of the ore. Thus, if to an ore lying in a solution of alkaline cyanide a mercury or lead salt soluble in such solution be added the gold will pass into solution, displacing the baser metal, or the material may be made directly at the mines by dissolving a mercury or lead compound in alkaline cyanide just as required, employing about two ounces or more of the mercury salt for each ounce of gold.

To employ any of the above-described solvent solutions, the ore is ground in the usual fashion and placed inside tanks of wood, or if the tanks be of metal the inside and all the metallic connections are coated with paint or varnish or otherwise protected, so as to prevent the mercury salt acting upon them, and the mass of ore is washed to free it from acid bodies, which would precipitate the mercury, or the washing may be done simultaneously with the grinding. The alkaline solvent solution is poured over the ore and allowed to run through. It is again poured over the ore and allowed to rest for several hours, and it is essential that the solution should still be alkaline as it runs from the ore. The ore is next washed and the solutions and washings

are treated in either of the following methods: The auriferous solution is acidified with sulphuric or other acid and run over iron filings or finely-divided iron, which precipitates the gold, or without acidifying I employ the highly active galvanic couple devised by the chemists Gladstone and Tribe, known as the "copper-zinc couple," which may be prepared, according to the methods described by them, either as a wet or dry couple. The latter I prefer, as it is more suitable for export and is made by agitating and gently heating a mixture of finely-divided copper with zinc. This highly reducing agent plays a double office when brought into contact with the auriferous solution, as it not only reduces the gold to the metallic state, but also any excess of mercury that may be in the solution. The zinc-copper couple acts well even in an acid solution.

In the practical working of the process two rules are to be observed: first, the solution is to be alkaline until the gold has displaced the baser metal and the solution has been run off the ore, and, secondly, the alkalinity during the precipitation by the zinc-copper couple must not be so great as to prevent the precipitations taking place freely. The alkalinity may be regulated in the ordinary way by the addition of a sufficient quantity of an alkali, such as caustic soda, or by partially neutralizing by acid.

The above process is applicable to ores where the gold is in a metallic state as well as to those in which it is in chemical composition with other substances. Here I would remark that by the terms "base metal" and "baser metal" I mean to denote mercury, lead, and such other metals as are displaced by metallic gold from their solutions in alkaline cyanide. If and so far as the gold is in the form of a sulphide in the ore, the use of the metallic salt is not required, as the sulphide of gold will pass into solution in an alkaline cyanide without any other metallic salt being present. I do not, therefore, claim the above method as applied to the purpose of the extraction of gold when in the form of a sulphide of gold, which may be extracted or got rid of in any way desired, but only so far as the gold is in the shape of metallic gold or compound other than the sulphide; but, subject to the above limitations, I would have it understood that

What I claim is—

1. The solvent herein described, for the extraction of precious metals from their ores, comprising a solution of an alkaline cyanide and a salt or compound of a baser metal in the proportion of at least one part of the cyanide to two of the baser metal.

2. The method, substantially as hereinbefore set forth, for the extraction of precious metals from their ores, by the action of a solution containing alkali metal cyanide and a salt or compound of a baser metal in the proportion of one part at least of the former to

two parts of the latter, such treatment causing the precious metal to displace the baser metal and thereby pass into solution.

3. The method, substantially as hereinbefore set forth, for the extraction of precious metals from their ores, which consists in treating the ore with a solution containing both a cyanide of potassium or sodium and a salt or compound of a baser metal in the proportion of one part at least of the former to two parts of the latter; the metallic base of the solution being displaced by the precious metal, the former being precipitated.

4. The method, substantially as hereinbefore

set forth, for the extraction of precious metals from their ores, which consists in treating the ore with a salt or compound of mercury contained in a solution of an alkaline cyanide in the proportion of one part at least of the former to two parts of the latter, producing a precipitation of the mercury and the displacement thereof by the precious metal, which latter metal thus passes into the solution.

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Witnesses:

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