Cyanid Process of Working Gold, Silver, or Other Ores
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CYANID PROCESS OF WORKING GOLD, SILVER, OR OTHER ORES.


To all whom it may concern:

Be it known that we, ROBERT H. OFFICER, JAMES W. NEILL, JOACHIM H. BURFEIND, and FRANK H. OFFICER, citizens of the United States and residents of Salt Lake City, in the county of Salt Lake and State of Utah, have invented certain new and useful Improvements in Cyanid Processes of Working Gold, Silver, or other Ores, of which the following is a specification.

Our invention relates to metallurgical processes wherein a solution of cyanid salt—as, for instance, cyanid of potash—is used as a solvent for recovering gold, silver, or other precious metal from ores, tailings, slimes, or other material; and its object is, generally speaking, to cheapen the process by reducing the loss of valuable solvent, to lessen the time of the operation, to avoid danger to workmen, and to secure other advantages which will be obvious to those skilled in the art from the subjoined description of our process.

Our invention is designed principally for use in those processes wherein a charge containing the cyanid is agitated by air or other gas forced into or through the charge; but is also applicable to other processes wherein hydrocyanic-acid gas is freed or released during the process of treating the material contained in a suitable treating tank or vat.

Briefly stated, our invention consists in conveying the hydrocyanic-acid gas released in the treating-tank to a suitable regenerator-tank, where it is brought into contact with a suitable solution of caustic soda, caustic potash, or other salt suitable for producing a cyanid salt.

When our invention is carried out in connection with the process of agitating the material in the treating-tank by air, we not only are enabled to recover the hydrocyanic acid in a useful form, but by using the air over and over again we avoid the action of carbonic acid and oxygen upon the cyanid in the treating-tank.

Our invention consists also in other improvements hereinafter more particularly described and then specified in the claims.

Our invention is useful not only in the treatment of ores, tailings, or slimes for the purpose of recovering gold or silver by the cyanid process, but may be also applied to the treatment of the foul or spent cyanid solution, as will be more particularly hereinafter set forth.

In the accompanying drawing we have shown in general side elevation and partial vertical section a preferred form or arrangement of apparatus suitable for use in practicing our invention.

In the drawing, 10 indicates in outline a treating or dissolving vat or tank adapted to receive the charge which is to undergo treatment. The tank or vat may be of any desired form, but is preferably constructed to permit the charge to be readily agitated by a stream of air or other gas introduced into the charge under pressure in such a way as to circulate the same and to thereby bring all parts of the metal-bearing material into contact with the solvent. Preferably, therefore, we use a tank having a conical bottom, as shown, and provided with means for introducing air or gas under pressure in a stream directed downwardly or outwardly at the apex of the conical bottom, so as to produce a circulation of the pulp upward along the sides of the tank and then downward around the center.

11 indicates a suitable pipe whose outlet is located as described and which leads from any suitable receiver or source of air or gas under pressure, such as indicated at 12.

4 is a cock for controlling the flow of the gas or air through the pipe 11.

14 is a discharge-pipe connected with the bottom of the tank for conveying the pulp to any suitable filter-press, (indicated in outline at 15,) and 13 is a pipe connected with any suitable source of air or gas under pressure, preferably the receiver 12, and serving to introduce air or gas under pressure into the discharge-passage from the tank.

Suitable valves 1, 2, and 6 are located, as shown, to control the flow of the air or gas 95 and of the liquid. By opening valves 2 and 6 the pulp is permitted to flow to the filter-press, and at the same time by opening valve 1 gas may be directed into the discharge-pipe in any desired quantity to act as an injector to help to force the pulp through the outlet-pipe 14 to the filter-press or into any other
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So vessel. By closing valve 6 and causing the air passing through pipe 13 to be introduced forcibly upward into the bottom of the tank sediment collecting at that point may be removed and agitated. The process will be repeated after the sediment has been remobilized.

Tank 10 is closed at its top, but is provided with a suitable charge-hole at 3, that may be sealed in any proper manner, and with an air or gas outlet 16, controlled by a suitable valve 5. Another pipe 17 leads from any suitable tank containing a solution of the cyanid or other substance used in treating the ore, slimes, tailings, concentrates, or other metal-bearing material.

18 is a suitable regenerator-tank, which in carrying on our process is to be charged with a solution of caustic soda, caustic potash, caustic lime, or any other caustic alkali or alkaline earth adapted to unite with or absorb hydrocyanic acid, and thus produce the soluble simple cyanid adapted to act as a solvent for gold, silver, or other metal contained in the material which is to be treated in the tank or vat 10. The tank 18 is preferably located at a higher level than the tank 10, so that the solution of cyanid salt generated therein may flow by gravity through pipe 17 to the tank or vat where it is to be employed as a solvent.

30 as a solvent. A suitable valve 7 may be located in the passage or pipe 17 to control the flow of the solution from the tank 18. The tank 18 is closed at its top, but is provided with a suitable charge hole or opening for the caustic liquid employed in making the generating solution. It is also provided with an inlet-pipe 19, connected with the pipe 16 and adapted to introduce the air or gas collected at the top of the tank 10 into the solution in tank 18, near the bottom thereof, whence it passes upward through the solution, and finally escapes by the pipe or passage 20. A number of screens 21, provided with small openings, may be placed in the tank to break up the flow of the gas and bring about a more intimate contact of the solution therewith.

22 typifies a compressor of any suitable construction which receives the air or gas delivered from the regenerator after it has passed through the in-take controlled by a valve, and is thus illustrated by an in-take controlled by a valve, and is thus indicated, by which air may be taken directly into the compressor for the purpose of providing the initial charge of air or gas used in the operation, or for the purpose of introducing air together with the gas received through pipe 20 into the compressor, should it be so desired at any time during the operation. Ordinarily the in-take 23 is closed and the operation of the compressor 22 is obviously to produce circulation of the air or other gas or gaseous mixture through the dissolving-tank 10 and regenerator-tank 18 in a continuous circulation over and over.

The apparatus so far described is the preferred and desirable form of apparatus suitable for carrying on the process which we claim to be a new and useful form of apparatus might be employed. The construction shown is especially desirable, however, for use in the process wherein air or gas is used to agitate the charge in the treating tank or vat.

In practice, our invention in connection with ores, tailings, slimes, or other material free from ingredients which would tend to consume or decompose the cyanid used as a solvent to no useful purpose, the process will be conducted as follows: The cyanid solution of the required strength and volume, depending upon the nature of the material to be treated as ascertained by a preliminary test, is introduced into the tank 10, and then, by preference, the air or gas is introduced into the tank by opening valve 4 and, if desired, valves 1 and 2 also, the valve 5 being at such time closed. By this means the solution is agitated, and into the agitated solution is charged the material to be treated, which, as well understood in the art, should be of the proper fineness. By this means the material as soon as it is introduced through the opening 3 is at once mixed thoroughly with the cyanid solution. The charge-opening 3 is then tightly closed and the valve 5, which at the preliminary stage should be closed, is then opened and the air or gas after circulating through the charge is permitted to pass, together with any hydrocyanic acid set free in the solution, to the regenerator-tank 18, where it comes into contact with the caustic solution and in order to escape has to pass upward through the same and thence is carried by the pipe 20 back to the receiver 12 by the action of the compressor. By this means the hydrocyanic acid freed from the tank 10 and which may exist in a considerable amount when a large amount of air is used for agitation will be absorbed in the caustic solution, and thus produce the cyanid salt, which is useful as a solvent, in the tank 10. By using the air or gas after it has passed through the regenerator-tank again for agitating the solution we avoid the action of the carbonate acid and oxygen, whose presence in the air brings about the liberation or freeing of the hydrocyanic-acid gas in the solution, and at the same time recovery of such of the hydrocyanic gases may be freed in the form in which it may be used again as a solvent. As will be obvious the expense of this is practically only the cost of the caustic lime, soda, or other material that may be required in the regenerator-tank. While the operation is carried on in this manner there will be in the dissolving tank or vat a pressure which may be regulated practically by the height of the solution in the regenerator, and this pressure will much accelerate the action in the dissolving-tank. The operation having been carried on until the
cious metals have been dissolved in the charge, the flow of the air or gas through the solution is stopped by closing valve 5, and valve 6 is opened so that the pulp may be allowed to flow to the filter-press, carrying the solution containing mercury or amalgam so far as the solution is freed from the gangue and is then in the usual manner conducted to the precipitating apparatus, after which it may be used again on a fresh charge of material or until it becomes foul or inert. While the pulp is passing to the press its movement may be accelerated, if desired, by allowing the valve 1 to remain partially open. If desired, the valve 5 may be kept closed during the operation of treating the material and only opened in case the tank should become clogged at the outlet or apex. After the charge is in the filter-press the air-pressure may be raised, so as to press out all the solution possible, and then in order to displace the small amount of valuable metal so left in the solution, water may be forced through them while yet in the press to replace the remainder of the valuable solution, and the cleansing-water may also be carried to the precipitating apparatus, as well understood in the art. The press is then opened and the value-less gangue removed in any desired manner.

The solution produced in the tank 18 by the hydrocyanic acid and therein may, as occasion requires, be introduced into the tank 10 through pipe 17 or otherwise. By this process we not only secure a valuable solvent from the hydrocyanic acid released or disengaged in the treating tank or vat, but also remove danger to workmen met in all operations where hydrocyanic acid is set free and allowed to escape to the atmosphere. In case the ores, tailings, slimes, or other materials are of an acid nature or contain ingredients which consume or decompose cyanid solutions to no useful purpose—such as soluble sulfates, arsenates, arsenites, &c., or a semisoluble acid salt or those which are only acted upon by alkalies or alkaline earths—the material may be given a preliminary treatment in the dissolving vessel or in any other vessel by treating it with a solution containing some caustic alkali or alkaline earth, usually caustic lime or caustic soda. In this preliminary treatment the charge may be agitated, as already described, until the objectionable elements have been removed or changed to inert ones. Thus, for instance, if the material contains ferrous sulfate (FeSO₄) and the solution contains caustic lime and the reaction is as follows:

\[ \text{FeSO}_4 + \text{Ca(OH)}_2 = \text{Fe(OH)}_2 + \text{CaSO}_4 \]

Calcium sulfate does no harm in a cyanid solution, but Fe(OH)₂ (ferrous hydrate) consumes as much cyanid as the ferrous sulfate, and consequently the treated with it, where not reduced the cyanid-consuming quality of the ore; but ferrous hydrate in contact with air is quickly changed to ferrie hydrate, and this latter compound is inert with soluble cyanids. When the objectionable ingredient to be treated has thus been changed or removed, then we simply add the required amount of the cyanid solution to the charge, and the treatment already described is carried on.

When ores containing copper are treated by the cyanid method, the solutions soon become charged with copper, which makes them inactive and sluggish. In the old method attempts are made to free them from this copper by precipitating it on zinc. This is a tedious and expensive operation, one so much so that at most works where such ores are treated the “foul solutions” (solutions containing copper) are run to waste from time to time. The loss of precious metals and cyanid when such foul solutions are run to waste is large. In this case the foul solution is charged into the dissolving tank or vat and is then slightly acidified best and most inexpensively by the SO₂ gas, or, if desired, by sulfuric acid. The charge-hole is then closed air-tight and the solution agitated by the compressed air introduced through the pipe 11 or pipe 13, or both, and the air leaving the dissolving-tank charged with hydrocyanic-acid gas is carried to the regenerator, where it comes into contact with the caustic solution, as already described, and the hydrocyanic acid is absorbed with avidity by the caustic solution, the reaction being as follows:

\[ \text{Na(OH)} + \text{HCN} = \text{NaCN} + \text{H}_2\text{O} \]

or

\[ \text{Ca(OH)}_2 + 2\text{HCN} = \text{Ca(CN)}_2 + 2\text{H}_2\text{O} \]

After the copper, gold, and silver have been precipitated from the solution by the sulfuric acid and the hydrocyanic acid set free has been driven out the entire contents of the dissolving vessel are passed into the filter-press and the precipitate washed repeatedly and thoroughly, so as to free it from the adhering solution. The precipitate (cuprous auro-cyanid or the respective silver salt) is then removed from the press and treated like other products from cyanid works or sold to refiners.

The arrangement of air or gas pipes 11 and 13, whereby the air or gas under pressure may be introduced into the tank, as herein-after described, gives us this advantage: that by opening the valve 4 the liquid can be stirred or agitated, while by opening the valves 1 and 2 the heavier portions of the charge, which tend to settle into the outlet of the tank leading to the filter-press, may be kept from lodging in said outlet, thus keeping the pipe free, so that when the pipe 6 is open the charge will fall readily into the filter-press and a comparatively small pressure will be required to effect its movement. This is a very great improvement upon the devices heretofore employed, since if no means be
used to keep the outlet free or to dislodge any accumulation in the outlet an air-pressure even as high as two hundred pounds will not serve to dislodge the accumulation of heavier material which may exist at the outlet after the treatment or agitation of it by air through the pipe 11 alone. By this improvement we effectually prevent clogging, thus saving time and annoyance in that part of the operation which involves the removal of the pulp from the treating-tank to the filter-press.

Inasmuch as carbonic acid contained in the air or gas used to agitate the charge in cyaniding a gold or silver ore will always decompose more or less of the solvent for the gold and also in the preliminary treatment of the ore by caustic alkali or alkaline earth will convert part of the caustic to carbonate, and thus render it useless for the purposes for which it was introduced into the charge, it is desirable to have the air used in stirring the charge free from carbonic-acid gas. This can easily and cheaply be effected by placing between the compressor and the treating-tank a vessel similar to the regenerating-tank and charging it with a material which will absorb carbonic acid, such as milk of lime or a solution of a caustic alkali or alkaline earth. The air or gas passing through this will give up its carbonic acid and enter the charge of ore free from this deleterious substance. Such a vessel is indicated in outline at 40.

In the appended claims the term “gas” is to be taken as including air unless otherwise specified.

The apparatus herein described as employed in carrying out our invention is not claimed herein, since it forms the subject of claims in another application for patent filed by us December 24, 1901, Serial No. 87,060. We claim as our invention—

1. The herein-described improvement in the cyanid process of recovering precious metals from ores, slimes, tailings or concentrates, consisting in treating the ore, slime, tailings or concentrates with a suitable cyanogenic compound and passing the hydrocyanic-acid gas set free by such treatment through a regenerating caustic solution, as and for the purpose described.

2. The herein-described improvement in treating the foul or spent solution resulting from the cyanid process of extracting gold and silver from ores, consisting in passing sulfurous-acid gas through said solution and then filtering and washing to recover the metals precipitated by the acidification.

3. The herein-described improvement in treating ores by the cyanid process consisting in agitating the pulp containing the cyanid solution by a suitable gas under pressure, passing the gas and the hydrocyanic-acid gas liberated from the solution through a regenerating solution and using the gas after passing through said regenerating solution to agitate a fresh quantity of pulp.

Signed at Salt Lake City, in the county of Salt Lake and State of Utah, this 25th day of May, A. D. 1901.

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Witnesses:
W. A. BLACK,
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