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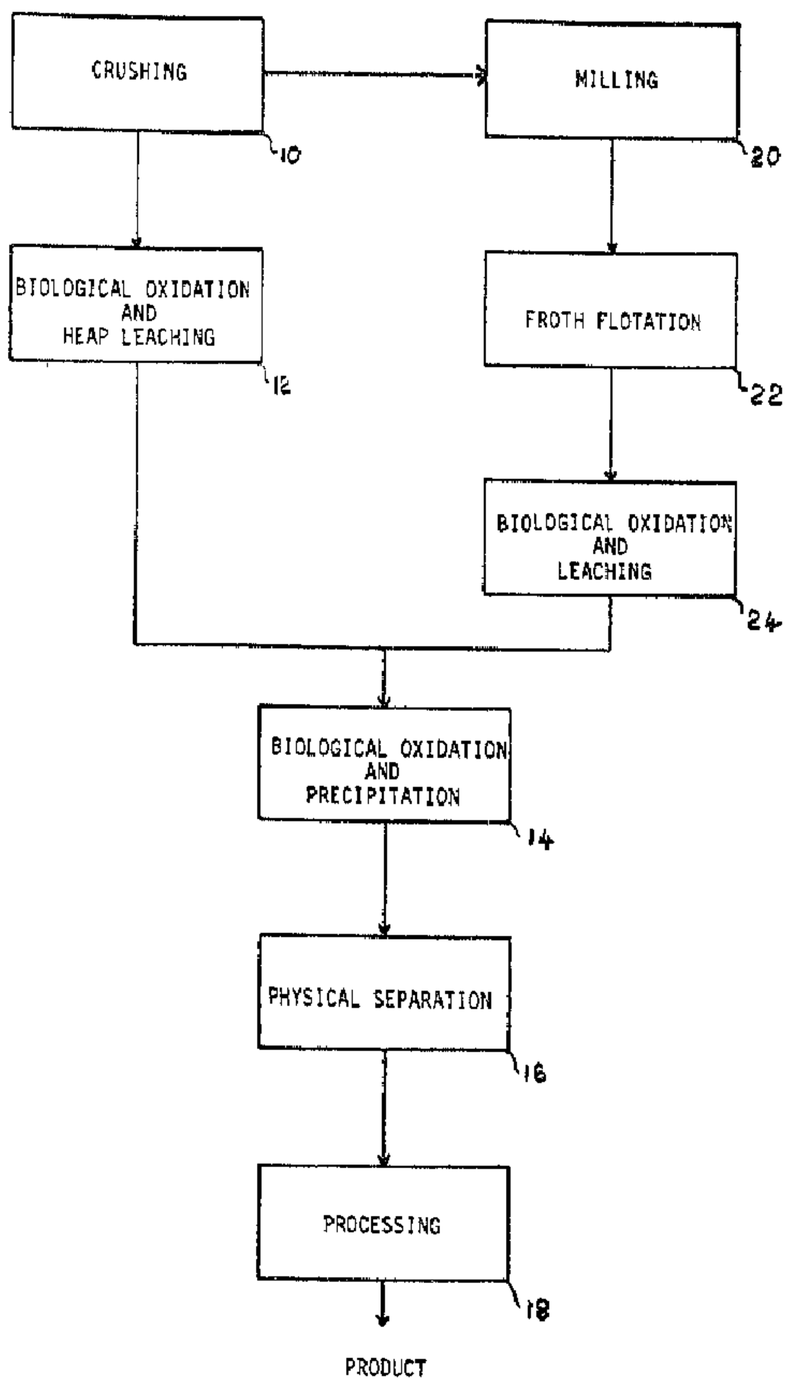


(57) Abrégé/Abstract:
A method of extracting metal from sulphide ores, which includes the steps of solubilizing the metal into a sulphate solution, and generating sulphide by anaerobic bacterial action in the sulphate solution, thereby to cause the metal in the solution to be precipitated as an insoluble sulphide, thus upgrading the metal into a highly concentrated form.

ABSTRACT OF THE DISCLOSURE

A method of extracting metal from sulphide ores, which includes the steps of solubilizing the metal into a sulphate solution, and generating sulphide by anaerobic bacterial action in the sulphate solution, thereby to cause the metal in the solution to be precipitated as an insoluble sulphide, thus upgrading the metal into a highly concentrated form.

BACKGROUND OF THE INVENTION

This invention relates to the recovery of metal such as nickel, copper, cobalt or the like, from sulphide ores.

SUMMARY OF THE INVENTION

According to the invention there is provided a method of extracting metal from sulphide ores, which includes the steps of solubulizing the metal into a sulphate solution which is generated by means of an acid dissolution process, and generating sulphide by anaerobic bacterial action in the sulphate solution, thereby to cause the metal in the solution to be precipitated as an insoluble sulphide, thus upgrading the metal into a highly concentrated form.

The sulphide is generated in a reactor. The sulphate solution may be passed through a bed of inert material to which bacteria become attached and use may be made of the bacterium Desulfovivrio Desulfuricans to effect sulphide generation.

Nutrients may be used to enhance sulphide generation and inert gas such as nitrogen may be used for maintaining the anaerobic environment.

The method includes the step of generating the sulphate solution for example by means of an acid dissolution process.

Acid may be generated by treating the ore by bacterial action.

In one embodiment of the invention the ore is crushed and treated by heap leaching with iron sulphate solutions which, optionally, carry bacteria. The bacteria may be Thiobacillus ferrooxidans, Thiobacillus thiooxidans, or Leptospirillum ferrooxidans. Sulphuric acid is then generated and the sulphate solution is formed.

Alternatively the metal sulphates are solubilized directly by bacterial action using one or more of the aforementioned bacteria.

Sulphuric acid or an alkali such as lime may be added to the solution to maintain the pH within the range of 1,2 to 3,0, and preferably within the range of 2,0 to 2,5.

The metal sulphate solution may alternatively be generated by treating a froth flotation concentrate. In this case a finely milled ore may be treated by froth flotation to form a metal sulphide flotation concentrate. The concentrate may then be treated to form the sulphate solution. This may, for example, take place in a series of tanks with a solution containing one

or more of the aforementioned bacteria.

The metal sulphide which is precipitated may be separated from the solution by any physical separation method, for example filtration or the like. The precipitation step may take place in the vessel in which the sulphide is generated, or in a separate vessel. Thereafter the precipitate can be processed in any suitable way, e.g. smelting, roasting or the like, to recover the metal.

BRIEF DESCRIPTION OF THE DRAWING

The invention is further described by way of example with reference to the accompanying flow sheet which illustrates two methods of extracting metal from sulphide ores according to the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

The process of the invention is applicable to the extraction of metal, in particular nickel, copper and cobalt, contained in sulphide ores. The following description is however made with reference to a nickel recovery process only. It is to be understood though that the following principles

can be applied equally to the recovery of copper and cobalt.

Referring to the flow sheet the mined ore is crushed at a stage 10 and the crushed ore is piled on a prepared base and treated in a leaching process 12. In the leaching process 12, iron sulphate solutions carrying Thiobacillus ferrooxidans, Thiobacillus thiooxidans, or Leptospirillum ferrooxidans, or a mixture of any two or all three of the bacteria, are percolated through the heap. In this way nickel sulphate, iron sulphate and sulphuric acid are generated.

According to the alkalinity of the ore further sulphuric acid or lime may be added to maintain the pH within the preferred range of 1,6 to 2,5 in which the viability of the bacteria is ensured.

The solution then passes to a biological sulphide reduction process 14 where, under anaerobic conditions and in a suitable reactor or in a series of reactors, soluble sulphates are converted to sulphide. In the presence of the soluble sulphide the nickel is precipitated as an insoluble nickel sulphide. Precipitation may be effected in the same reactor or reactors, or in a separate vessel or vessels. Iron in the solution is reduced to the ferrous state and does not precipitate with the nickel sulphide. This step is more fully described in the specification of South African patent No. 89/7731 issued July 25, 1990.

In a stage 16 the precipitated nickel sulphide is physically separated by means of filtration or any other appropriate method. This may be accomplished in the vessel in which the sulphide is generated, or in a separate vessel.

In a subsequent step 18 the nickel sulphide is further processed in any appropriate way, such as smelting, roasting or the like, to recover the nickel.

Where the grade of the deposit is sufficiently high to justify additional mechanical processing costs the ore is finely milled in a step 20 and subjected to a froth flotation process 22 whereby a nickel sulphide flotation concentrate is produced. As is indicated by the numeral 24 this concentrate is subjected to biological oxidation in one or more tanks using one or more of the bacteria Thiobacillus ferrooxidans, Thiobacillus thiooxidans and Leptospirillum ferrooxidans, thereby to dissolve the nickel to form the sulphate solution. The oxidation step may take place at a pH of from 1,2 to 3,0, and preferably the pH lies in the range of 2,0 to 2,5.

The sulphate solution can then be treated as described hereinbefore.

CLAIMS

1. A method of extracting metal from sulphide ores, which includes the steps of solubulizing the metal into a sulphate solution which is generated by means of an acid dissolution process, and generating sulphide by anaerobic bacterial action in the sulphate solution, thereby to cause the metal in the solution to be precipitated as an insoluble sulphide, thus upgrading the metal into a highly concentrated form.

2. A method according to claim 1 wherein the sulphate solution is passed through a bed of inert material to which bacteria become attached and use is made of the bacterium Desulfovivrio Desulfuricans to effect sulphide generation.

3. A method according to claim 1 wherein the ore is crushed and treated by heap leaching with iron sulphate solutions which carry at least one of the following bacteria: Thiobacillus ferrooxidans, Thiobacillus thiooxidans, and Leptospirillum ferrooxidans.

4. A method according to claim 1 wherein the metal sulphates are solubilized directly by at least one of the following bacteria: Thiobacillus ferrooxidans, Thiobacillus thiooxidans, and Leptospirillum ferrooxidans.

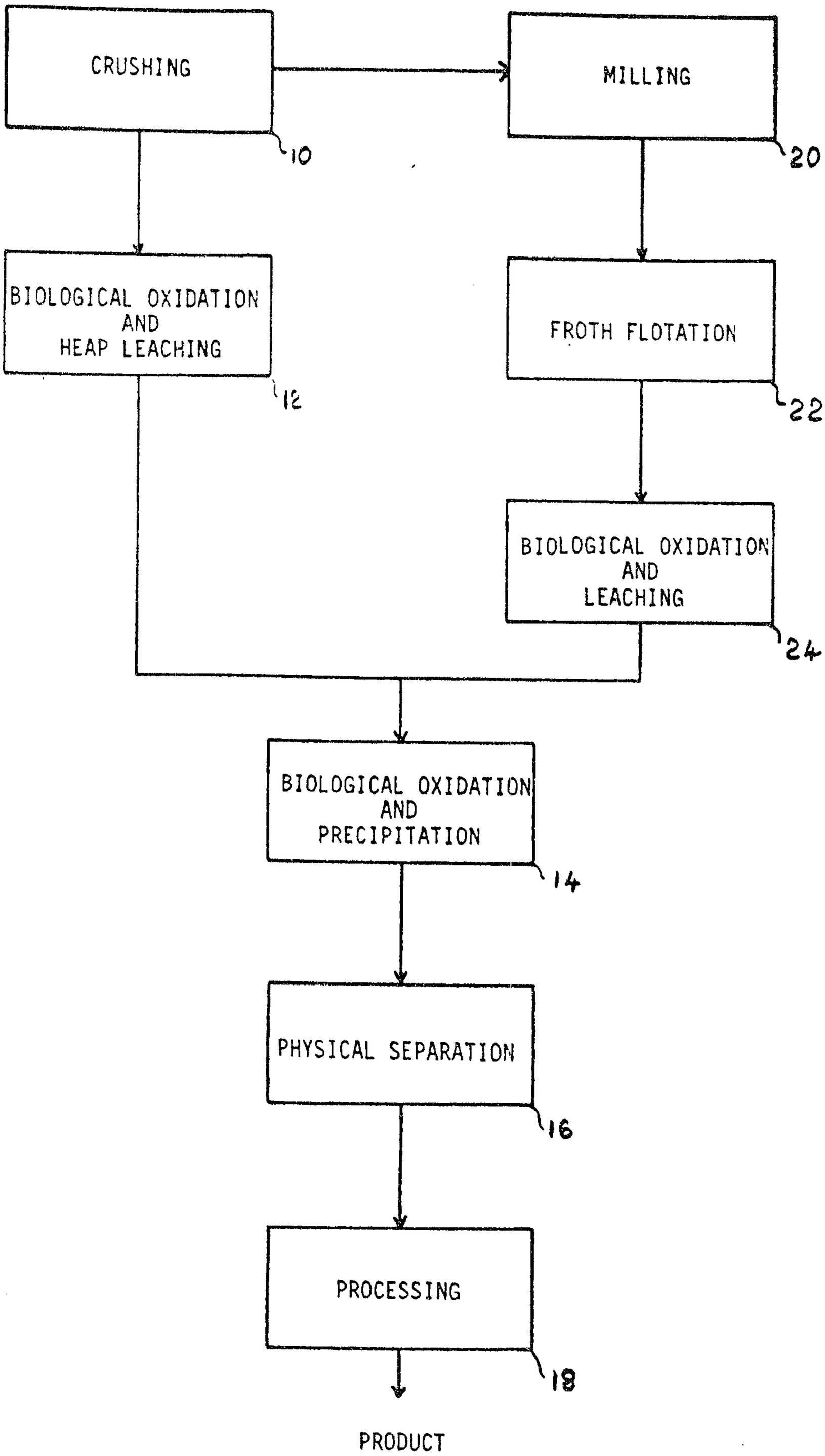
5. A method according to claim 1 wherein finely milled ore is treated by froth flotation to form a metal sulphide flotation concentrate which is treated in one or more tanks using at least one of the following bacteria: Thiobacillus ferrooxidans, Thiobacillus thiooxidans, and Leptospirillum ferrooxidans.

6. A method according to claim 1 in which the pH of the sulphate solution is maintained within the range of from 1,2 to 3,0 during the step of solubilizing the metal.

7. A method according to claim 6 wherein the pH is maintained within the range of from 2,0 to 2,5 during the step of solubilizing the metal.

8. A method according to claim 1 wherein the precipitated metal sulphide is separated from the solution and processed to recover the metal.

9. A method according to claim 1 wherein the acid is generated by bacterial leaching of the ore.


CRUSHING
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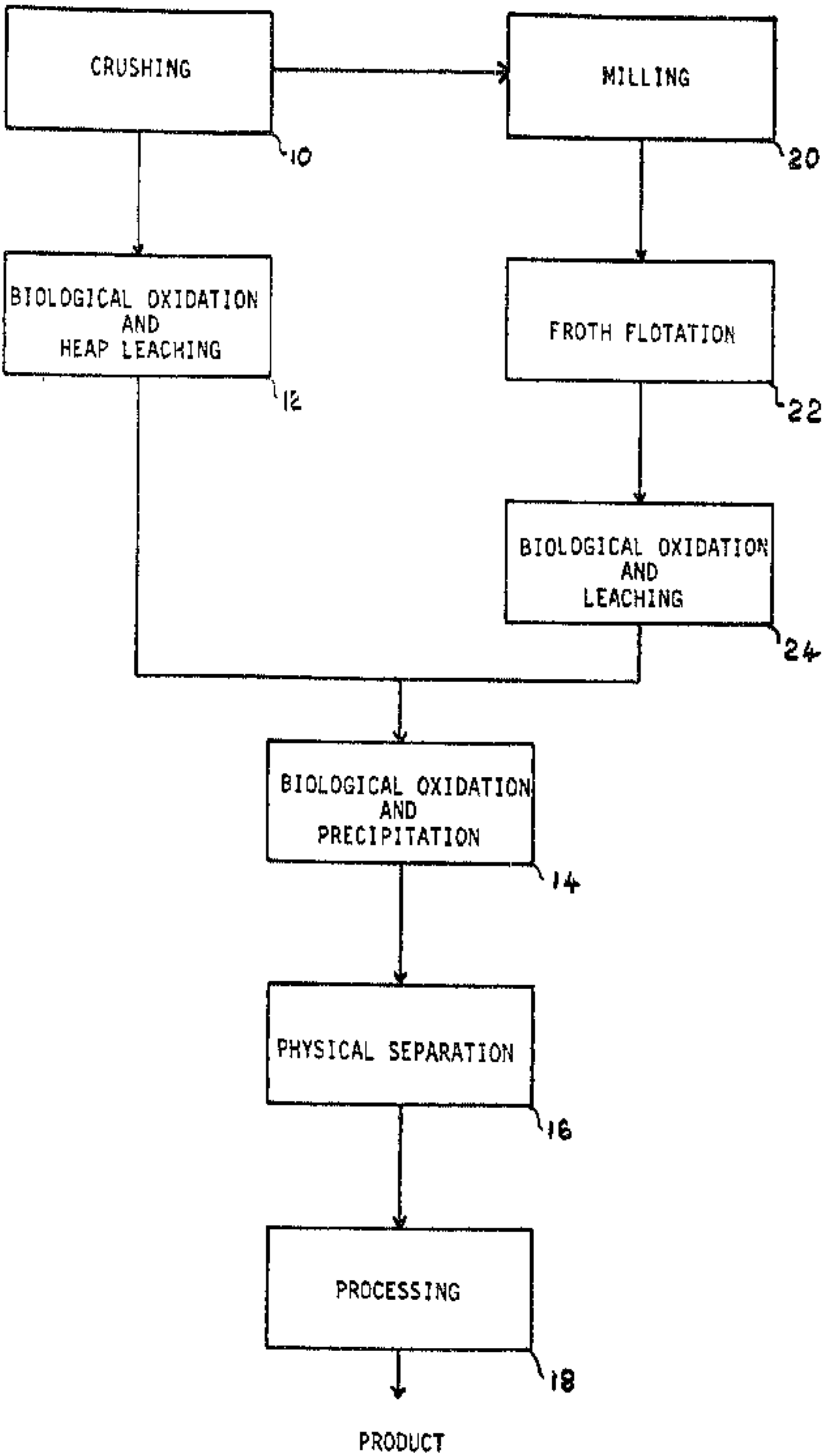
MILLING
20
BIOLOGICAL OXIDATION AND HEAP LEACHING
12
FROTH FLOTATION
22
BIOLOGICAL OXIDATION AND LEACHING
24
BIOLOGICAL OXIDATION AND PRECIPITATION
14
PHYSICAL SEPARATION
16
PROCESSING
18
PRODUCT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