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CONCENTRATION OF ORES.

No Drawing.

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To all whom it may concern:

Be it known that I, CHARLES KENNETH McARTHUR, Jr., a subject of the King of Great Britain, residing at Butte, in the county of Silver Bow, State of Montana, have invented certain new and useful Improvements in the Concentration of Ores; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to the concentration of ores or minerals by flotation, and more particularly to the differential separation by flotation of sulfide minerals in a mixed sulfide product such, for example, as a mixed sulfide flotation concentrate. The invention has for its object the provision of an improved method of differentially separating by flotation different minerals in a mixed sulfide product. More particularly, the invention aims to provide an improved method of separating by differential flotation different sulfide minerals in a mixed sulfide product containing oil or a similar flotation agent, such, for example, as a mixed sulfide flotation concentrate.

Complex or mixed sulfide ores, concentrates and the like, such, for example, as a mixed sulfide product carrying sulfides of lead and/or copper and/or silver together with sulfides of zinc and/or iron, present difficult problems to the metallurgist concerned with the separation of the different sulfide minerals therein. I have found that in the differential treatment of many mixed sulfide ores and other mixed sulfide products, it is advantageous to subject the crude ore or product to a preliminary collective concentration to separate the sulphides from the gangue prior to the differential treatment. This collective concentration may be advantageously effected by subjecting the crude ore or similar mixed sulfide product to a flotation operation in which substantially all of the sulfide minerals are removed in the resulting concentrate. The collective mixed sulfide flotation concentrate thus obtained carries with it a certain amount of the oil or other flotation agent employed in the flotation operation, and I have found that such oil or other flotation agent exercises a deleterious or inhibitory influence

upon the subsequent differential separation of the different sulfide minerals in the collective mixed sulphide concentrate.

My present invention particularly contemplates an improved method of differentially separating by flotation different sulfide minerals in such a rough concentrate, or in similar mixed sulfide products containing agents or substances, such as oil or other flotation agents, which exercise differential-flotation-inhibitory influences. Thus, the invention contemplates subjecting the mixed sulfide product to a treatment operation in the course of which the differential-flotation-inhibitory influence of the oil or other flotation agent upon the subsequent differential flotation operation is reduced to a desired extent. This treatment operation involves the conditioning of the oil or other flotation agent present in the mixed sulfide product in such manner and to such extent that the deleterious or inhibitory influence of the oil or other flotation agent in the subsequent differential flotation operation is overcome or appropriately reduced.

In carrying out my present invention, I make use of the selective action of cyanides such, for example, as sodium cyanide, in inhibiting the flotation of certain sulfide minerals (such as zinc and/or iron sulfides) while permitting the flotation of other sulfide minerals (such as lead and/or copper and/or silver sulfides). In the differential treatment of oiled concentrates and other mixed sulfide products containing substances possessing flotative properties, I have discovered that the selective action of the cyanide must be supplemented by appropriate treatment of the mixed sulfide product for modifying the deleterious or inhibitory influence of the oil or other differential-flotation-inhibitory substance. I have found that very satisfactory results are obtained by subjecting the oiled concentrate, or similar mixed sulfide product, to the action of a suitable cyanide in conjunction with a hydroxide, preferably a readily soluble hydroxide, such as sodium hydroxide, after which treatment the mixed sulfides are readily amenable to differential separation by flotation.

The treatment of the mixed sulfide product with a cyanide and a hydroxide, in accordance with my present invention, is preferably a time treatment, that is to say, the

mixed sulfide product is subjected to the action of a cyanide and hydroxide for a substantial period of time, for example, thirty minutes. This treatment is preferably carried out as a preparatory or preliminary step to the differential flotation operation although it will be understood that the preparatory aspect, as well as the time element feature, may be modified or dispensed with according to the requirements of the particular mixed sulfide product undergoing treatment.

The treatment operation characteristic of the invention accomplishes two primary results, to wit (1) a physical and/or chemical change in the oil (or other flotation agent) present in the mixed sulfide product whereby the deleterious or inhibitory influence of the oil (or other flotation agent) in the subsequent differential flotation operation is overcome or appropriately reduced, and (2) a selective action upon the sulfide minerals whereby the flotation of one or more (for example, zinc or iron sulfides) is in large measure inhibited, while the flotation of one or more (for example, lead, copper or silver sulfides) is permitted or even promoted. In the practice of the invention, I have found that the combination of a cyanide and a hydroxide generally gives the most satisfactory results, but I have also ascertained that the hydroxide may be in part, or even entirely, replaced by other substances capable of reacting as bases with the oil or other flotation agent present in the mixed sulfide concentrate or product. Thus, I have found that an alkali cyanide when used alone in sufficiently large amount serves not only to bring about the desired selective action but also the necessary conditioning or change in the characteristics of the oil or other flotation agent. When an alkali cyanide is thus used alone, the amount required for the purposes of the present invention is substantially in excess of that required for effecting differential separation by flotation of the same sulfide minerals in the absence of the oil or other flotation agent. And similarly, where the hydroxide is replaced in whole or in part by other substances capable of reacting as bases with the oil or other flotation agent in the mixed sulfide concentrate or product, the amount of such basic reagent required for the purposes of the present invention is substantially in excess of that required in conjunction with the cyanide for effecting satisfactory differential separation by flotation of the same sulfide minerals in the absence of the oil or other flotation agent.

The amount of cyanide and hydroxide to be employed in practicing the present invention varies with different mixed sulfide products. In general, satisfactory results can be obtained by the use of from 0.5 to 5

pounds of sodium cyanide per ton of dry product and from 2 to 15 pounds of sodium hydroxide per ton of dry product. In the treatment of a silver-lead-zinc-iron rough flotation concentrate, I have obtained excellent results using 6 pounds of sodium hydroxide and from 1.5 to 3 pounds of sodium cyanide per ton of dry concentrate. In the subsequent differential flotation operation, following the treatment of the mixed sulfide product with cyanide and hydroxide, lead, copper and silver sulfides will be found readily amenable to flotation and are recovered in the resulting froth, while the zinc and iron sulfides remain in large extent in the tailings or residue. In the treatment of oiled flotation concentrates, the differential flotation operation can generally be conducted without adding any flotation agent to the pulp. If desired, or necessary, however, an appropriate flotation agent for promoting the flotation of the lead, copper, or silver sulfides may be added to the pulp prior to the differential flotation operation.

In applying the present invention to the treatment of a mixed sulfide flotation concentrate, or product, such mixed sulfide concentrate or product may be taken direct from the flotation circuit or, after dewatering, direct from the thickeners, and passed into an appropriate container provided with suitable mixing instrumentalities. A cyanide alone or a hydroxide and a cyanide as the case may be and in sufficient quantities to condition the oil in the concentrate and to bring about the desired selective action between the different sulfide minerals is added to the container, or to the concentrate before the introduction of the concentrate into the container. The amount of the hydroxide and/or cyanide may be varied to meet any conditions of the concentrate that may arise. Thorough mixing for a period of about thirty minutes should preferably take place. The so-treated mixed sulfide product is then conducted to appropriate flotation apparatus, in which the differential flotation operation takes place. As hereinbefore stated, the oil present in the collective mixed sulfide concentrate, perhaps enhanced as a flotation agent by its conditioning for the purposes of the present invention, generally provides ample flotation agent for the differential flotation operation. It will, however, be understood that appropriate flotation agents may be added to the pulp, if desired, for the differential flotation operation.

The practice of the invention will be further illustrated by the following examples:

(1) 2000 grs. of a mixed or combined flotation product, with a density of 35% solids, assaying 14.8 ozs. Ag., 4.6% Pb., 56.8% Zn., and 2.3% Fe., was placed in a square glass mixing jar, mechanically driven, with an amount of sodium cyanide equivalent to

five (5.0) pounds per ton of dry product, and subjected to a time treatment of thirty (30) minutes. The product was then removed from the jar and, without the addition of further reagents, placed in a Callow laboratory flotation machine where a float assaying 40.0 ozs. Ag., 44.1% Pb., 26.4% Zn., and 3.6% Fe., and a residue assaying 12.0 ozs. Ag., 1.0% Pb., 60.0% Zn., and 2.1% Fe. was made.

(2) 2000 grs. of a mixed or combined flotation product, with a density of 35% solids, assaying 17.0 ozs. Ag., 6.0% Pb., 55.0% Zn., and 3.1% Fe., was placed in a square glass mixing jar, mechanically driven, with an amount of sodium hydroxide equivalent to seven and five tenths (7.5) pounds per ton of dry product, and sodium cyanide equivalent to two and two tenths (2.2) pounds per ton of dry product, and subjected to a time treatment of thirty (30) minutes. The product was then removed from the jar, and without the addition of further reagents, placed in a Callow laboratory flotation machine where a float assaying 45.0 ozs. Ag., 60.0% Pb., 14.0% Zn., and 2.4% Fe., and a residue assaying 12.0 ozs. Ag., 0.5% Pb., 60.0% Zn., and 3.0% Fe., was made.

I claim:—

1. A process of differentially separating by flotation different sulfide minerals, which comprises treating a flotation reagent-contaminated collectively floated sulfide product with a cyanide and an agent which substantially reduces the differential-flotation-inhibitory influence of the flotation reagent present in said product and thereby effecting a marked difference in the amenability to flotation between two different sulfide minerals in said product, and subjecting the so-treated product to a flotation operation whereby the flotation of one sulfide mineral is in large part effected while the flotation of another sulfide mineral is in large part inhibited.

2. A process of differentially separating by flotation different sulfide minerals, which comprises treating a flotation reagent-contaminated collectively floated mixed sulfide product with a cyanide and a basic hydroxide and thereby effecting a marked difference in the amenability to flotation between two different sulfide minerals in said product, and subjecting the so-treated product to a flotation operation whereby the flotation of one sulfide mineral is in large part effected while the flotation of another sulfide mineral is in large part inhibited.

3. A process of differentially separating by flotation different sulfide minerals, which comprises treating a flotation reagent-contaminated collectively floated mixed sulfide product with a cyanide and an appropriate basic agent capable of substantially reducing the differential-flotation-inhibitory

influence of the flotation reagent present in said product and thereby effecting a marked difference in the amenability to flotation between two different sulfide minerals in said product, and subjecting the so-treated product to a flotation operation whereby the flotation of one sulfide mineral is in large part effected while the flotation of another sulfide mineral is in large part inhibited.

4. A process of differentially separating by flotation different sulfide minerals, which comprises subjecting a collectively floated mixed sulfide product contaminated with a flotation reagent to the action of a basic hydroxide and thereby reducing to a desired extent the inhibitory influence of said flotation reagent upon the subsequent differential flotation operation, and subjecting the so-treated mixed sulfide product in the form of a pulp to a differential flotation operation in the presence of a cyanide whereby the flotation of one sulfide mineral is in large part effected while the flotation of another sulfide mineral is in large part inhibited.

5. A process of differentially separating by flotation lead and zinc sulfides, which comprises treating a flotation-reagent-contaminated collectively floated mixed lead and zinc sulfide product with a cyanide and an agent capable of substantially reducing the differential-flotation-inhibitory influence of the flotation reagent present in said product and thereby effecting a marked difference in the amenability to flotation between the lead and zinc sulfides, and subjecting the so-treated product to a flotation operation whereby the flotation of the lead sulfide is in large part effected while the flotation of the zinc sulfide is in large part inhibited.

6. A process of differentially separating by flotation lead and iron sulfides, which comprises treating a flotation reagent-contaminated collectively floated mixed lead and iron sulfide product with a cyanide and an agent capable of substantially reducing the differential-flotation-inhibitory influence of the flotation reagent present in said product and thereby effecting a marked difference in the amenability to flotation between the lead and iron sulfides, and subjecting the so-treated product to a flotation operation whereby the flotation of the lead sulfide is in large part effected while the flotation of the iron sulfide is in large part inhibited.

7. A process of differentially separating by flotation copper and iron sulfides, which comprises treating a flotation reagent-contaminated collectively floated mixed copper and iron sulfide product with a cyanide and an agent capable of substantially reducing the differential-flotation-inhibitory influence of the flotation reagent present in said product and thereby effecting a marked differ-

ence in the amenability to flotation between the copper and iron sulfide, and subjecting the so-treated product to a flotation operation whereby the flotation of the copper sulfide is in large part effected while the flotation of the iron sulfide is in large part inhibited.

8. A process of differentially separating by flotation copper and zinc sulfides, which comprises treating a flotation reagent-contaminated collectively floated mixed copper and zinc sulfide product with a cyanide and an agent capable of substantially reducing the differential-flotation-inhibitory influence of the flotation reagent present in said product and thereby effecting a marked difference in the amenability to flotation between the copper and zinc sulfides, and subjecting the so-treated product to a flotation operation whereby the flotation of the copper sulfide is in large part effected while the flotation of the zinc sulfide is in large part inhibited.

9. A process of differentially separating by flotation silver and iron sulfides, which comprises treating a flotation reagent-contaminated collectively floated mixed silver and iron sulfide product with a cyanide and an agent capable of substantially reducing the differential-flotation-inhibitory influence of the flotation reagent present in said product and thereby effecting a marked difference in the amenability to flotation between the silver and iron sulfides, and subjecting the so-treated product to a flotation operation whereby the flotation of the silver sulfide is in large part effected while the flotation of the iron sulfide is in large part inhibited.

10. A process of differentially separating by flotation silver and zinc sulfides, which comprises treating a flotation reagent-contaminated collectively floated mixed silver and zinc sulfide product with a cyanide and an agent capable of substantially reducing the differential-flotation-inhibitory influence of the flotation reagent present in said product and thereby effecting a marked difference in the amenability to flotation between the silver and zinc sulfides, and subjecting the so-treated product to a flotation operation whereby the flotation of the silver sulfide is in large part effected while the flotation of the zinc sulfide is in large part inhibited.

11. A process of differentially separating by flotation lead, copper and silver sulfides from zinc sulfide, which comprises treating a flotation reagent-contaminated collectively floated mixed lead, copper, silver and zinc sulfide product with a cyanide and an agent capable of substantially reducing the differential-flotation-inhibitory influence of the flotation reagent present in said product and thereby effecting a marked differ-

ence in the amenability to flotation between the lead, copper and silver sulfides and the zinc sulfide, and subjecting the so-treated product to a flotation operation whereby the flotation of the lead, copper and silver sulfides is in large part effected while the flotation of the zinc sulfide is in large part inhibited.

12. A process of differentially separating by flotation different sulfide minerals which comprises treating a flotation reagent-contaminated collectively floated mixed sulfide product containing lead sulfide product with a cyanide and a basic hydroxide and thereby effecting a marked difference in the amenability to flotation between the lead sulfide and another sulfide mineral in said product, and subjecting the so-treated product to a flotation operation whereby the flotation of the lead sulfide is in large part effected while the flotation of another sulfide mineral is in large part inhibited.

13. A process of differentially separating by flotation different sulfide minerals which comprises treating a flotation reagent-contaminated collectively floated mixed sulfide product containing zinc sulfide product with a cyanide and a basic hydroxide and thereby effecting a marked difference in the amenability to flotation between the zinc sulfide and another sulfide mineral in said product, and subjecting the so-treated product to a flotation operation whereby the flotation of one sulfide mineral is in large part effected while the flotation of the zinc sulfide is in large part inhibited.

14. A process of differentially separating by flotation different sulfide minerals which comprises treating a flotation reagent-contaminated collectively floated mixed sulfide product containing copper sulfide product with a cyanide and a basic hydroxide and thereby effecting a marked difference in the amenability to flotation between the copper sulfide and another sulfide mineral in said product, and subjecting the so-treated product to a flotation operation whereby the flotation of the copper sulfide is in large part effected while the flotation of another sulfide mineral is in large part inhibited.

15. A process of differentially separating by flotation different sulfide minerals which comprises treating a flotation reagent-contaminated collectively floated mixed sulfide product containing silver sulfide product with a cyanide and a basic hydroxide and thereby effecting a marked difference in the amenability to flotation between the silver sulfide and another sulfide mineral in said product, and subjecting the so-treated product to a flotation operation whereby the flotation of the silver sulfide is in large part effected while the flotation of another sulfide mineral is in large part inhibited.

16. A process of differentially separating

by flotation different sulfide minerals which comprises treating a flotation reagent-contaminated collectively floated mixed sulfide product containing iron sulfide product with a cyanide and a basic hydroxide and thereby effecting a marked difference in the amenability to flotation between the iron sulfide and another sulfide mineral in said product, and subjecting the so-treated product to a flotation operation whereby the flotation of one sulfide mineral is in large part effected while the flotation of the iron sulfide is in large part inhibited.

17. A process of differentially separating by flotation different sulfide minerals which comprises treating a mixed sulfide product containing an oily substance which exercises differential-flotation-inhibitory influences with a cyanide and an agent which substantially reduces the differential-flotation-inhibitory influence of the oily substance present in said product and thereby effecting a marked difference in the amenability to

flotation between two different sulfide minerals in said product, and subjecting the so-treated product to a flotation operation whereby the flotation of one sulfide mineral is in large part effected while the flotation of another sulfide mineral is in large part inhibited.

18. A process of differentially separating by flotation different sulfide minerals which comprises treating a mixed sulfide product containing an oily substance which exercises differential-flotation-inhibitory influences with a cyanide and a basic hydroxide and thereby effecting a marked difference in the amenability to flotation between two different sulfide minerals in said product, and subjecting the so-treated product to a flotation operation whereby the flotation of one sulfide mineral is in large part effected while the flotation of another sulfide mineral is in large part inhibited.

In testimony whereof I affix my signature.
CHARLES KENNETH McARTHUR, Jr.