

UNITED STATES PATENT OFFICE.

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CONCENTRATION OF ORES.

No Drawing. Continuation of application Serial No. 162,320, filed April 16, 1917. This application filed December 23, 1920. Serial No. 432,829.

To all whom it may concern:

Be it known that we, HENRY LIVINGSTONE SULMAN and EDWIN EDSER, subjects of the King of England, and residents, respectively, of London, England, and Brockley, London, England, have invented certain new and useful Improvements in the Concentration of Ores, of which the following is a specification.

This invention is for improvements in or relating to the concentration of ores and it refers more particularly to flotation separation, such as by the froth-flotation process described for example in the prior United States Patent Nos. 835,120 of November 6, 1906, 962,678 of June 28, 1910 and 1,064,723 of June 17, 1913. This application is a continuation of our application No. 162,320 filed April 16, 1917.

The froth-flotation process of concentrating ores as described in these prior specifications consists in agitating and/or aerating the crushed ore in water to which is added a minute proportion of a mineral-frothing agent, for the formation of a froth of metal-liferous particles which is allowed to float to the surface of the liquid separate from the gangue particles, whence it is removed.

Hitherto difficulties have been experienced in the treatment of certain ores by the froth-flotation process, and particularly in the recovery of oxidized metal particles such as oxides, carbonates, etc., though it has been proposed to coat such oxidized metalliferous particles with a sulphide and thereafter to separate them from the gangue particles by flotation.

The present invention provides a means whereby such hitherto experienced difficulties may be overcome, and oxidized metalliferous particles may be floated by the froth-flotation process without any such preliminary treatment.

According to this invention in a process for the separation of certain particles from other particles in a material containing them in which the finely ground material is mixed with water to which is added a mineral-frothing agent and then aerated for the formation of a froth, which is separated, there is used as the mineral-frothing agent a small quantity of one or more soluble soaps, such

as sodium oleate, sodium stearate, sodium palmitate, or sodium resinate.

The amount of fatty acid soap employed is such that in addition to the insoluble metallic or earthy soaps which may be formed, there must remain in the pulp, at the period of aeration, a small quantity of free, i. e. soluble, soap, but this must be less than the quantity which produces only a soap-air-water froth free from mineral contents.

It has now been found that soap, if used in the correct proportions, may be successfully employed for bringing about a separation of certain particles from other particles in a mixture containing them. In certain cases of metalliferous ores treated by the process according to the present invention, the metalliferous particles are floated in preference to the gangue particles, and in other cases gangue particles may be floated in preference to the metalliferous particles, the result depending on the nature of the ore and on the particular soap and the quantity employed. The circuit should be neutral or slightly alkaline in order to avoid undue decomposition of the soap.

In some instances both the gangue particles and the metalliferous particles tend to be floated together in the froth, and in such cases substances can be added to the pulp-liquor which improve both the recovery and the concentration of the mineral in the froth, and which do not decompose the soap. Such substances are designated in the following claims as "selectivity-modifying agents." Amongst the substances which have been found useful for this purpose are certain oils, such as kerosene oil, gasolium oil (a hydrocarbon oil known in the trade as a "gas" oil), or other hydrocarbon oils, or certain soluble salts of alkaline reaction, such as sodium silicate or sodium phosphate, or such a substance as silicic acid sol.

In certain cases the separation may be improved by adding to the pulp a small quantity of a caustic alkali, such as caustic soda.

The conditions for any particular ore or mixture of materials may be readily determined by experiment.

Sub-aeration, such as is described for example in the prior British Patent No. 16141 of 1913 gives good results with the present invention.

One method of carrying this invention into effect will now be described.

400 grammes of an oxidized copper ore, from Alderley Edge, Cheshire, England, as saying 5.7% of copper of which 4.27% was in the form of carbonate and silicate of copper and 1.43% in the form of sulphide of copper (chalcocite) was ground to pass a 100 mesh screen and then mixed with 1600 ccs. of soft water. The gangue was mainly quartzite. To this was added:

50 ccs. of silicic acid sol containing 0.36% of silica in the form of SiO_2 , the SiO_2 amounting to 0.9 lbs. per ton of ore;
2 lbs. of commercial sodium oleate per ton of ore in the form of a 5% solution;

2.4 lbs. of sodium resinate per ton of ore in the form of an 8% solution, and
0.48 lb. of kerosene oil per ton of ore.

The pulp was agitated for one minute and the froth which formed was removed. This froth weighed 56 grammes and assayed 26.4% of copper. Two more froths were formed and removed without any further addition of reagents; together these weighed 30 grammes and assayed 11.2% of copper. The tailings weighed 310 grammes and assayed 1.5% of copper. The recovery made by the three froths was 79.65% of the total copper contents of the ore.

The amount of soap employed in the example described above is not to be taken as indicating the proportion of soap required in all cases. The amount can be reduced in many cases, but may vary from 0.01% to 1% on the ore. A preliminary trial will give the desired indication as to the quantity most suitable for treating any particular ore. In several instances we have been able to obtain successful results with a quantity of soap equivalent to 2 to 3 lbs. per ton of ore treated.

It is found that the addition of a small quantity of sodium silicate reduces the amount of soap necessary for the formation of a froth, and it is particularly advantageous in preventing the inclusion in the froth of gangue when the latter is ferruginous, in which case it floats more readily than if uncontaminated.

The amount of the substance such as kerosene oil, sodium silicate or sodium phosphate, which will prevent the floatation of the gangue is usually in the neighborhood of 1.0% or less on the ore. The most suitable quantity of this substance and of the soap may be easily found by experiment.

If desired, the ore may be made into a thick pulp with the soap solution before it is finally diluted to the requisite consistency.

The water employed in carrying the process into effect should preferably be free from calcium or other salts which decompose soap.

In certain cases it may be advantageous to add to the circuit liquors a small quantity of a mineral-frothing agent together with the soap.

It is to be understood that the present invention is equally applicable to the concentration of sulphide ores and also to the separation of materials such as sulphur or carbonaceous particles from other particles, for the separation of hornblende from felspar and quartz, or for the separation of haematite from quartz.

In the following claims the term "selectivity-modifying agent" is intended to include such substances as are commonly added to the pulp for the purpose of increasing or modifying the selective action of the frothing agent. Selectivity-modifying agents which have been employed or proposed include among other materials, sodium carbonate, sodium silicate and caustic alkalies, such as sodium hydroxide.

An example of the use of the present invention for the concentration of a sulphide ore is as follows:

1200 grammes of an ore from the Braden copper mine in Chili containing 1.7% of copper as sulphide (chalcopryite) in a gangue consisting mainly of felspar were crushed to pass through 80 mesh. 5000 grammes of tap water were agitated in a single cell circulating flotation machine with enough caustic soda to give a very feeble alkaline reaction. The ore was then introduced; sodium silicate at the rate of 5 lbs. per ton of ore, and sodium resinate at the rate of 0.25 lbs. per ton of ore, were added and the mixture agitated for the formation of a froth of the metalliferous particles. The froth removed during a ten minutes run was found to weigh 90 grammes and to assay 17.4% of copper, and the tailings assayed 0.42% of copper, giving a recovery of 77.4%.

It has of course been heretofore generally understood that the soluble soaps which we employ would produce an air-water soap suds or froth, but it is our own discovery that such soaps can be employed as mineral-frothing agents to produce a mineral-bearing froth in an ore pulp, and in our appended claims the words "mineral-frothing agent" designate this mineral-bearing attribute of the soaps which we employ in the practice of our invention.

The term floatation agent as used in the following claims is intended to describe such a substance as caustic soda, sodium silicate, sodium phosphate or silicic acid sol as well as an oil, whether a mineral-frothing oil or a mineral-non-frothing oil.

What we claim as our invention and desire to secure by Letters Patent is:

1. The process of froth-flotation separation of oxidized metalliferous materials

consists in mixing a material containing the same in a finely ground condition with water and with a soluble fatty-acid soap as a mineral-frothing agent in such proportion as to float the said oxidized metalliferous materials in a froth, aerating said mixture to form a froth carrying the said oxidized metalliferous materials, and removing said froth.

2. The froth-flotation process of separating oxidized metalliferous particles from commingled material which consists in mixing the same with water and with a mixture of soluble soaps including a fatty-acid soap as a mineral-frothing agent in such proportions as to float the said oxidized metalliferous particles in a froth, aerating said mixture to form a froth carrying said oxidized metalliferous particles, and removing said froth.

3. The process of froth-flotation separation of oxidized metalliferous materials which consists in mixing a material containing the same in a finely ground condition with water and with a mixture of soluble soaps including a fatty-acid soap as a mineral-frothing agent in such proportions as to float the said oxidized metalliferous materials in a froth, introducing a selectivity-modifying agent in a proportion tending to increase the selectivity of such flotation by the soluble soap, aerating said mixture to form a froth carrying said oxidized metalliferous materials and removing said froth.

4. The process of froth-flotation separation which consists in mixing the finely ground material to be treated with water and with a soluble soap as a frothing agent in such proportion as to float a concentrated portion of said material in a froth, introducing a modicum of a caustic alkali and an alkaline silicate in a proportion tending to increase the selectivity of such flotation by the soluble soap, aerating said mixture to form a froth carrying said concentrated portion of said materials and removing said froth.

5. The froth-flotation process of separating oxidized metalliferous particles from commingled material which consists in mixing the same with water and with a soluble fatty acid soap as a mineral-frothing agent in such proportions as to float the said oxidized metalliferous particles in a froth, introducing a selectivity-modifying agent in a proportion tending to increase the selectivity of such by the soluble soap, aerating said mixture to form a flotation froth carrying said oxidized metalliferous particles, and removing said froth.

6. The froth-flotation process of separating oxidized metalliferous particles from commingled material which consists in mixing the same with water and with a soluble

fatty-acid soap as a mineral-frothing agent in such proportions as to float the said oxidized metalliferous particles in a froth, introducing a modicum of a caustic alkali in a proportion tending to increase the selectivity of such flotation by the soluble soap, aerating said mixture to form a froth carrying said oxidized metalliferous particles, and removing said froth.

7. A process of froth-flotation separation which consists in mixing with a pulp of finely ground mixed material a soluble fatty-acid soap in less proportion than the quantity which produces only a soapy-water-air non-selective froth, agitating and aerating to produce a selective froth, and separating the froth.

8. A process of froth-flotation separation which consists in mixing with a pulp of finely ground mixed material a flotation agent including soluble fatty-acid soap and substantially dependent on the presence of said soluble soap for froth producing qualities, the proportion of soluble soap being such that the soluble soap present during froth formation is less than the quantity which produces only a soapy-water-air non-selective froth, agitating and aerating to produce a selective froth, and separating the froth.

9. A process of froth-flotation separation which consists in mixing with a pulp of finely ground mixed material a caustic alkali and a flotation agent including soluble fatty-acid soap and substantially dependent on the presence of said soluble fatty-acid soap for froth producing qualities, the proportion of soluble soap being such that the soluble soap present during froth formation is less than the quantity which produces only a soapy-water-air non-selective froth, agitating and aerating to produce a selective froth, and separating the froth.

10. A process of froth-flotation separation which consists in mixing with a pulp of finely ground mixed material a caustic alkali and a flotation agent including a soluble fatty-acid soap and an oil and substantially dependent on the presence of said soluble soap for froth producing qualities, the proportion of soluble soap being such that the soluble soap present during froth formation is less than the quantity which produces only a soapy-water-air non-selective froth, agitating and aerating to produce a selective froth, and separating the froth.

11. A process of froth-flotation separation which consists in mixing with a pulp of finely ground mixed material a flotation agent including soluble fatty-acid soap and a soluble alkaline substance and substantially dependent on the presence of said soluble soap for froth producing qualities, the proportion of soluble soap being such

that the soluble soap present during froth formation is less than the quantity which produces only a soapy-water-air non-selective froth, agitating and aerating to produce a selective froth, and separating the froth.

12. A process of froth-flotation separation which consists in mixing with a pulp of finely ground mixed material a soluble soap including an oleate in less proportion than the quantity which produces only a soapy-water-air non-selective froth, agitating and aerating to produce a selective froth, and separating the froth.

13. A process of froth-flotation separation which consists in mixing with a pulp of a finely ground mixed material having a tendency to form insoluble soap in the presence of soapy material, a quantity of soluble soapy fatty-acid material sufficient to keep some soluble soap present during froth formation in addition to any insoluble soap produced by action of soapy material on the material treated, the proportion of soapy material being such that the soluble soap present during froth formation is less than the quantity which produces only a soapy-water-air non-selective froth, agitating and aerating to produce a selective froth, and separating the froth.

14. A process of froth-flotation separation which consists in mixing with a pulp of a finely ground mixed material having a tendency to form insoluble soap in the presence of soluble fatty-acid soap and resinate, a flotation agent including soluble fatty acid soap and a soluble resinate and substantially dependent on the presence of the soap and resinate for froth producing qualities, the proportion of soap and resinate being sufficient to keep some soluble soap or resinate present during froth formation in addition to any insoluble soap produced by action of soap or resinate on the material treated, the proportion of soap and resinate being such that the soluble soap and resinate present during froth formation is less than the quantity which produces only a soapy-water-air non-selective froth, agitating and aerating to produce a selective froth, and separating the froth.

15. A process of froth-flotation separation which consists in mixing with a pulp of a finely ground mixed material having a tendency to form insoluble soap in the presence of soluble soap, a flotation agent including soluble fatty-acid soap and alkaline material and substantially dependent on the presence of the fatty-acid soap for froth producing qualities, the proportion of soluble soap being sufficient to keep some soluble soap present during froth formation in addition to any insoluble soap produced by action of soapy material on the material treated, the proportion also being such that

the soluble soap present during froth formation is less than the quantity which produces only a soapy-water-air non-selective froth, agitating and aerating to produce a selective froth, and separating the froth.

16. A process of froth-flotation separation which consists in mixing with a pulp of a finely ground material having a tendency to form insoluble soap in the presence of soluble soap a flotation agent including soluble fatty-acid soap and substantially dependent on the presence of said soluble fatty-acid soap for froth producing qualities, the proportion of soluble soap being sufficient to keep some soluble soap present during froth formation in addition to any insoluble soap produced by action of soap on the material treated, the proportion also being such that the soluble soap present during froth formation is less than the quantity which produces only a soapy-water-air non-selective froth, agitating and aerating to produce a selective froth, and separating the froth.

17. A process of froth-flotation separation which consists in mixing with a pulp of a finely ground material having a tendency to form insoluble soap in the presence of soluble soap, a flotation agent including soluble fatty-acid soap and a caustic alkali and substantially dependent on the presence of the fatty-acid soap for froth producing qualities, the proportion of soluble soap being sufficient to keep some soluble soap present during froth formation in addition to any insoluble soap produced by action of soapy material on the material treated, the proportion also being such that the soluble soap present during froth formation is less than the quantity which produces only a soapy-water-air non-selective froth, agitating and aerating to produce a selective froth, and separating the froth.

18. A process of froth-flotation separation which consists in mixing with a pulp of a finely ground material having a tendency to form insoluble soap in the presence of soluble soap a flotation agent including a soluble oleate and substantially dependent on the presence of said soluble oleate for froth producing qualities, the proportion of soluble soap being sufficient to keep some soluble oleate present during froth formation in addition to any insoluble oleate produced by action of oleate on the material treated, the proportion also being such that the soluble oleate present during froth formation is less than the quantity which produces only a soapy-water-air non-selective froth, agitating and aerating to produce a selective froth, and separating the froth.

In testimony whereof, we have affixed our signatures to this specification.

HENRY LIVINGSTONE SULMAN.
EDWIN EDSER.