No. 835,120. PATENTED NOV. 6, 1906.

H. L. SULMAN, H. F. KIRKPATRICK-PICARD & J. BALLOT.

ORE CONCENTRATION.

APPLICATION FILED MAY 29, 1905.

2 SHEETS—SHEET 1.

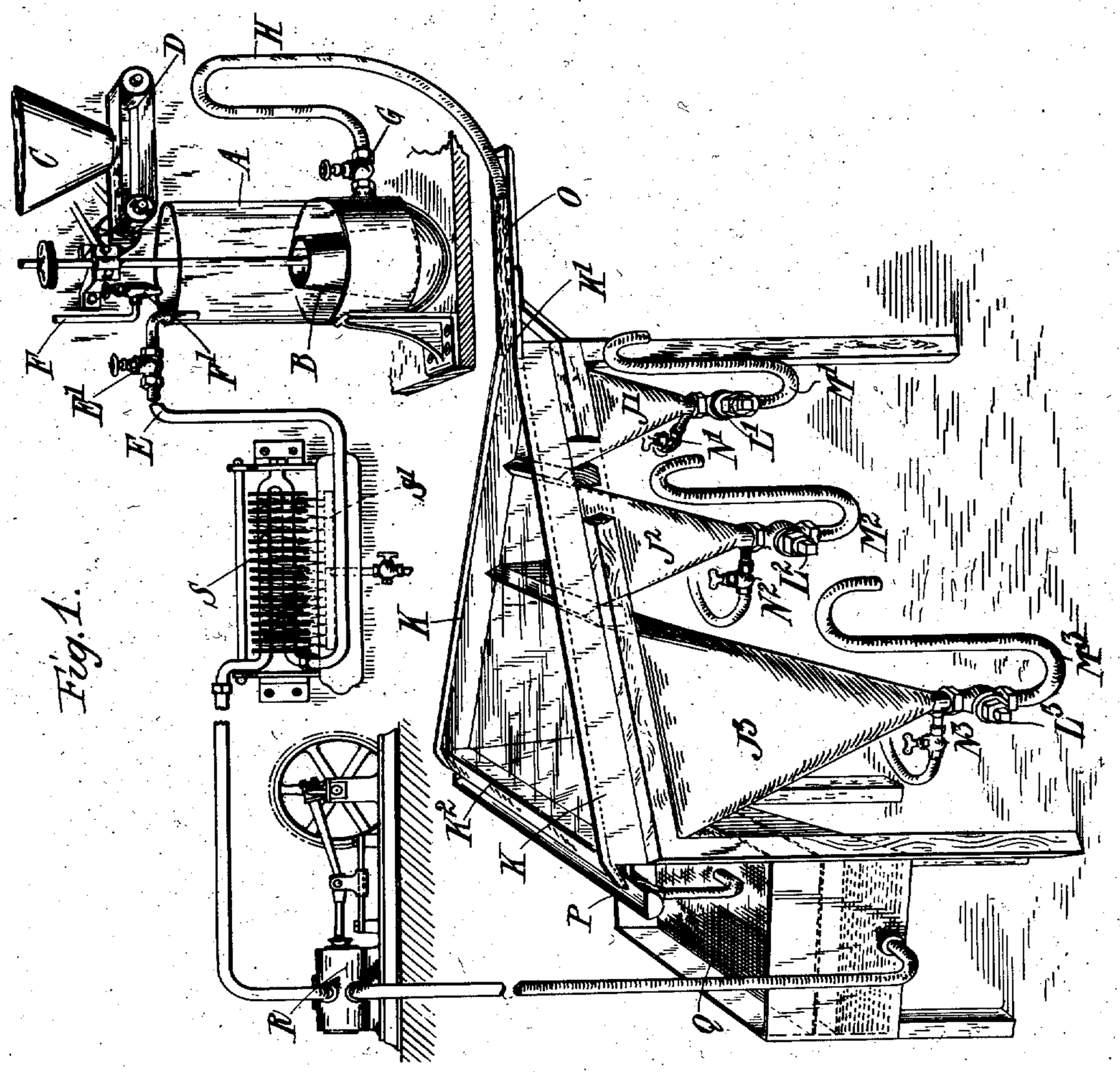

Fig. 1.

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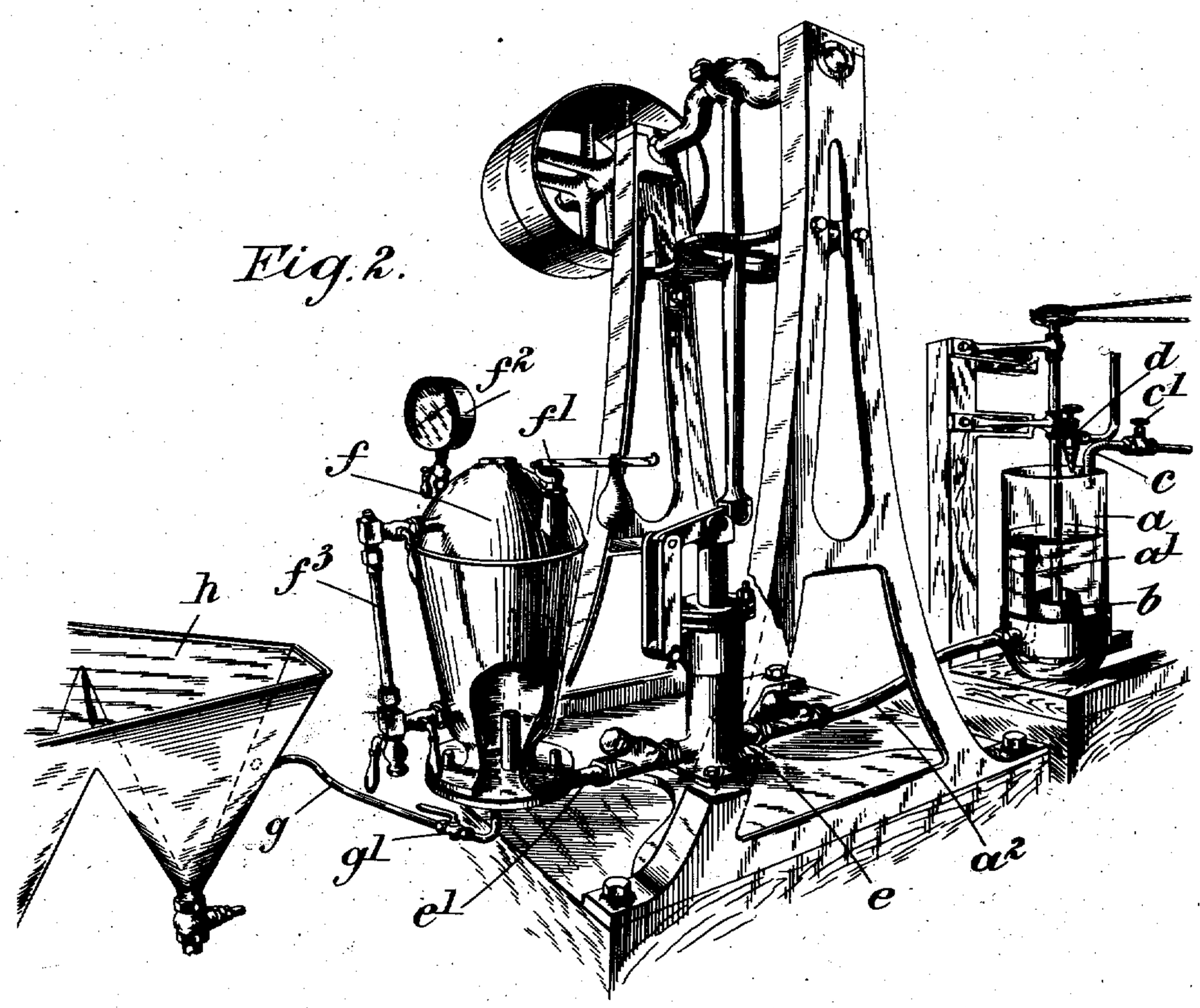
2 SHEETS—SHEET 2.

Fig. 2.



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UNITED STATES PATENT OFFICE.

HENRY LIVINGSTONE SULMAN, HUGH FITZALIS KIRKPATRICK-PICARD, AND JOHN BALLOT, OF LONDON, ENGLAND.

ORE CONCENTRATION.

No. 835,120. Specification of Letters Patent. Patented Nov. 6, 1906.

Application filed May 29, 1905. Serial No. 262,389.

To all whom it may concern:

Be it known that we, HENRY LIVINGSTONE SULMAN, HUGH FITZALIS KIRKPATRICK-PICARD, and JOHN BALLOT, subjects of the King of England, residing in London, England, have invented certain new and useful Improvements in Ore Concentration, of which the following is a specification.

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite, and the like from gangue by means of oils, fatty acids, or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the previous United States patent, No. 777,273, granted to A. E. Cattermole, an amount of oil varying from four per cent. to six per cent. of the weight of metalliferous matter present is agitated with an ore pulp, so as to form granules which can be separated from the gangue. In the previous United States patent, No. 777,274, granted to A. E. Cattermole and others, a similar method of separation is employed, oleic acid being produced *in situ* in the ore pulp.

We have found that if the proportion of oily substance be considerably reduced—say to a fraction of one per cent. on the ore—granulation ceases to take place, and after vigorous agitation there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum. This tendency is dependent on a number of factors. Thus the water in which the oiling is effected is preferably slightly acidified by adding, say, a fraction of one per cent. up to one per cent. of sulfuric acid or other mineral acid or acid salt, the effect of this acidity being to prevent gangue from being coated with oily substance, or, in other words, to render the selective action of the oil more marked; but it is to be understood that the object of using acid in the pulp according to this invention is not to bring about the generation of gas for the purpose of flotation thereby, and the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present. Again, we have discovered that the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated is increased if the pulp is warmed. The formation of froth is assisted by the fine pulverization of the ore, and we find that slime mineral most readily generates scum and rises to the surface, while larger particles have less tendency to be included in the froth. The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilizing the facts above mentioned in the concentration of any particular ore a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired.

The following is an example of the application of this invention to the concentration of a particular ore. An ore containing ferruginous blende, galena, and gangue consisting of quartz, rhodonite, and garnet is finely powdered and mixed with water containing a fraction of one per cent. or up to one per cent. of a mineral acid or acid salt, conveniently sulfuric acid or mine or other waters containing ferric sulfate. To this is added a very small proportion of oleic acid, (say from 0.02 per cent to 0.5 per cent on the weight of ore.) The mixture is warmed, say, to 30° to 40° centigrade and is briskly agitated in a cone mixer or the like, as in the processes previously cited, for about two and one-half to ten minutes, until the oleic acid has been brought into efficient contact with all the mineral particles in the pulp.

When agitation is stopped, a large proportion of the mineral present rises to the surface in the form of a froth or scum which has derived its power of flotation mainly from the inclusion of air-bubbles introduced into the mass by the agitation, such bubbles or air-films adhering only to the mineral particles which are coated with oleic acid. The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical.

If the ore were crushed to ninety mesh to the linear inch, (half of which ore will pass through one hundred and fifty mesh sieve,) the froth may contain about seventy per cent. to eighty per cent. of the metalliferous matter

present in the ore. This froth is removed from the pulp by spitzkast, upcast, skimming, draining, or otherwise. After subsidence the oil-coated metalliferous matter removed as froth is separated from any liquid which may have accompanied it and treated with a dilute solution of caustic alkali, which removes the oleic acid in the form of a solution of soap.

If desired, the oleic acid used in the first instance may be produced *in situ* in the pulp by decomposing a dilute soap solution with mineral acid, as described in the previous patent, No. 777,274, cited above. The oleic acid or other fatty acid forming the coating on the metalliferous matter which produces the froth may give rise to insoluble soaps on the surface of the metalliferous matter if soluble lime, iron, or other salts are present in small quantity during the production or on the breaking down of the froth with alkali. Such insoluble soaps are difficult to remove and are capable of adhering to air and causing flotation, much the same as the fatty acids do.

The metalliferous matter which did not form part of the froth (generally the larger particles) remains in admixture with the gangue in the pulp. To recover this, the pulp is distributed in a thin layer on a shaking-table, convex buddle, or the like, whereon the mineral is exposed to a free-air surface, which exposure may be increased by the application of air-blast or air-jets or the like and thereafter brought onto the edge or surface of liquid, whereby the metalliferous matter floats and is separated from the gangue, which sinks, as described in the specification of our previous United States application Serial No. 246,637, filed February 20, 1905.

The proportion of mineral recovered in the froth and that recovered by table flotation may be considerably varied; but, generally speaking, the froth will separate the slime mineral while the larger particles are recovered by the latter method.

In the accompanying drawings, Figure 1 is a diagram in perspective illustrating one form of apparatus suitable for carrying this invention into practice, and Fig. 2 represents in perspective an apparatus for carrying out a secondary step in the process.

Referring to Fig. 1, a mixing vessel A (of which there may be any number in series) is provided with a rotatable stirrer B. Crushed ore is fed from a hopper C into the vessel by a band D. A pipe E, controlled by a tap E′, delivers circuit-water to the vessel, and oleic acid or other oil is introduced through the pipe F and tap F′. The outer cock G from the vessel A communicates through a swan-neck pipe H with the froth separating apparatus. In passing from the frothing apparatus A to the spitzkasten (say between O and K) the pulp may, if desired, be run in a thin layer over a smooth slightly-inclined plane.

The froth-separating apparatus comprises several (say three) pointed boxes J′ J² J³, which open at the top into a horizontal channel consisting of side walls K. The channel has a narrow inlet K′ and spreads out to a wide outlet K². The pointed boxes J′ J² J³ have fullway-cocks L′ L² L³ at the bottom, leading to swan-neck discharge-pipes M′ M² M³. An upcurrent of water may be led in at the bottom of each box through a tap N′ N² N³.

The boxes are all filled with circuit-water. The pulp from the vessel A is distributed horizontally from the flat trough O through the inlet K′. The heavy sands and coarser particles of mineral sink into the first box J′, from which they are led to a shaking-table, convex buddle, or the like, to be treated as above described. The middlings or medium sands fall into the box J², and if they contain any mineral may be removed for further treatment by agitation. The upcurrent of water from the taps N′ N² prevents the deposition of any slime in these boxes. The fine sands or gangue slimes settle in the last box J³, from which they are discharged to waste or further treatment.

The slime mineral in the form of froth or scum floats from the liquid and is carried by the stream over the outlet K² into a launder P and thence to a filter Q, where the metalliferous matter is removed from the circuit-water, which is returned to the vessel A by a pump R. The circuit-water may be brought to the proper temperature by passing it through a heater S, having a burner S′, before admitting the water to the vessel A.

An alternative method for the recovery of any sunk oiled metalliferous matter which may be deposited in the second and third spitzkasten is as follows: The products suspended in circuit liquor are removed from the spitzkasten and placed in a vessel in which they are submitted to an additional pressure of air or other gas of from, say, one to two atmospheres or over. On relief of such pressure the bubbles of air or other gas so generated throughout the mass at once sweep to the surface thereof all the metalliferous matter in the form of a froth which can be separated as before. This idea is not claimed broadly in this case, but forms the subject-matter of an application filed by us on January 9, 1906, Serial No. 295,326.

Referring to Fig. 2, a mixing vessel *a* (of which there may be several in series) is provided with a rotatable stirrer *b*. Crushed ore or similar finely-divided mineral is fed into the vessel *a*. A pipe *c*, controlled by a tap *c′*, delivers circuit-water to the vessel, and in cases where oil is used the oil is introduced through the pipe *d* in quantity sufficient to produce a thin coating of oil on these mineral particles for which oil has an affinity. The pulp mixed with oil escapes over the

lip of the discharge-conduit a' and passes through the pipe a^2 to a pump e. Hence the pulp is pumped through discharge-pipe e' into the closed chamber f, which is constructed to withstand a considerable internal pressure and is provided with a safety-valve f', the pressure-gage f^2, and a gage-glass f^3 to indicate the level of the pulp in the chamber. An outlet-pipe g, having a cock g', leads to a series of spitzkasten h, filled with circuit-water.

The operation is as follows: The cock g' is closed. Pulp is pumped into the chamber f, which contains air or other gas, and the pumping is continued until the pressure in the chamber rises to, say, fifty to one hundred pounds per square inch. The pressure is sufficient to cause the air or other gas to be dissolved to a considerable extent in the pulp. After the lapse of a few minutes for the due solution of the compressed air or a portion of it by the pulp or the liquid the cock g' is opened and the pulp is discharged into the open spitzkasten h, where the liquid is of course under atmospheric pressure. The pulp e may be stopped during this discharge. The whole of the mineral to which air bubbles are attached—say the oiled mineral—at once rises to the surface as a coherent scum or froth. A surface current of water is maintained in the spitzkasten, and the floating material is thus removed and separated from the gangue, which remains sunk or suspended in the liquid.

The nature and arrangement of the apparatus used may be varied without departing from this invention.

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

1. The herein-described process of concentrating ores which consists in mixing the powdered ore with water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter, (amounting to a fraction of one per cent. on the ore), agitating the mixture until the oil-coated mineral matter forms into a froth, and separating the froth from the remainder by flotation.

2. The herein-described process of concentrating ores which consists in mixing the powdered ore with slightly-acidified water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent. on the ore), agitating the mixture until the oil-coated mineral matter forms into a froth and separating the froth from the remainder by flotation.

3. The herein-described process of concentrating ores which consists in mixing the powdered ore with slightly-acidified water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent. on the ore), warming the mixture, agitating the mixture until the oil-coated mineral matter forms into a froth and separating the froth from the remainder by flotation.

4. The herein-described process of concentrating ores which consists in finely powdering the ore, mixing it with slightly-acidified water, adding a small proportion of an oily substance having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent. on the ore), warming the mixture, agitating the mixture until the oil-coated mineral matter forms into a froth, separating the froth from the remainder by flotation, and removing the oily coating from the mineral.

5. The herein-described process of concentrating ores which consists in mixing the powdered ore with water, adding a small proportion of oleic acid amounting to 0.02–0.5 per cent. on the ore, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder by flotation.

6. The herein-described process of concentrating ores which consists in mixing the powdered ore with water containing a fraction of one per cent. of sulfuric acid, adding a small proportion of oleic acid amounting to 0.02–0.5 per cent. on the ore, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder by flotation.

7. The herein-described process of concentrating ores which consists in mixing the powdered ore with water containing a fraction of one per cent. of sulfuric acid, adding a small proportion of oleic acid amounting to 0.02–0.5 per cent. on the ore, warming the mixture to 30°–40° centigrade, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder by flotation.

8. The herein-described process of concentrating ores which consists in finely powdering the ore, mixing it with water containing a fraction of one per cent. of sulfuric acid, adding sufficient oleic-soap solution to produce oleic acid amounting to 0.02–0.5 per cent. on the ore, warming the mixture to 30°–40° centigrade, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, separating the froth from the remainder by flotation, filtering off the froth and removing the oleic acid therefrom by treatment with an alkali.

9. The process of concentrating powdered ores which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of

oil, agitating the mixture to form a froth, and separating the froth.

10. The process of concentrating powdered ores which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil, warming the mixture, agitating the mixture to form a froth, and separating the froth.

11. The process of concentrating powdered ores, which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil, and a quantity of acid insufficient to cause chemical action on the metalliferous minerals present, agitating the mixture to form a froth, and separating the froth.

12. The process of concentrating powdered ore which consists in separating the minerals from gangue by coating the minerals with oil in water containing a fraction of one per cent. of oil on the ore, agitating the mixture to cause the oil-coated mineral to form a froth, and separating the froth from the remainder of the mixture.

13. The herein-described process of concentrating ores which consists in finely powdering the ore, mixing it with water containing less than one per cent. of sulfuric acid, adding sufficient oleic-soap solution to produce oleic acid amounting to 0.02–0.5 per cent. on the ore, warming the mixture to 30°–40° centigrade, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth with the finer mineral, distributing the mixture on the surface of a current of water running over columns of water, so that the coarser minerals and sands, the finer sands and the gangue slimes successively deposit out while the froth is floated away by the current, filtering off the froth and removing the oleic acid therefrom by treatment with an alkali and separating the coarser mineral from the sands by exposing them alternately to air and water.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.
JOHN BALLOT.

Witnesses:
GEO. J. B. FRANKLIN,
T. J. OSMAN.

Disclaimer in Letters Patent No. 835,120.

DISCLAIMER.

835,120.—*Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard,* and *John Ballot,* London, England. ORE CONCENTRATION. Patent dated November 6, 1906. Disclaimer filed March 28, 1917, by the assignee, *Minerals Separation, Limited.*

"Your petitioner, therefore, for the purpose of complying with the requirements of the law in such case made and provided, and of disclaiming those parts of the thing patented which your petitioner does not choose to claim or hold by virtue of said Letters Patent No. 835,120, does hereby disclaim from claims 9, 10 and 11 of said Letters Patent No. 835,120, any process of concentrating powdered ores excepting where the results obtained are the results obtained by the use of oil in a quantity amounting to a fraction of one per cent. on the ore."

[*Official Gazette, April 3, 1917.*]

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[*Official Gazette July 11, 1922.*]

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