No. 865,194. PATENTED SEPT. 3, 1907.

A. P. S. MACQUISTEN.

PROCESS FOR SEPARATING SOLIDS.

APPLICATION FILED JULY 3, 1905.

3 SHEETS—SHEET 1.

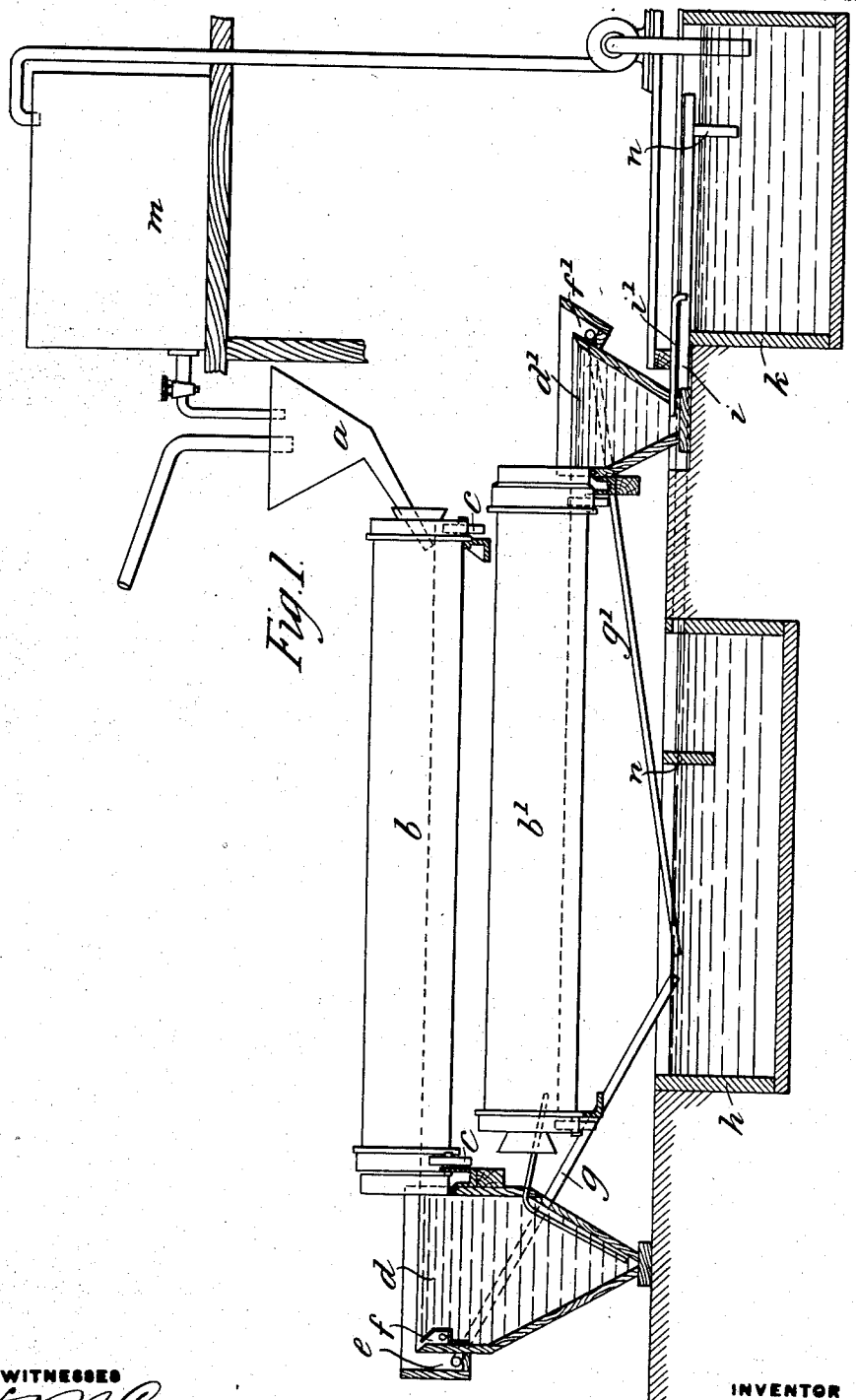

Fig. 1.

WITNESSES

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3 SHEETS—SHEET 2.

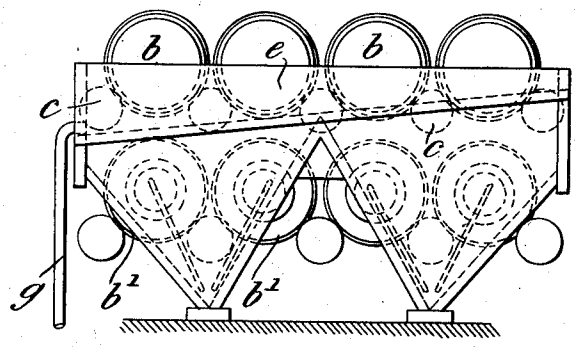


Fig. 2.

Fig. 3

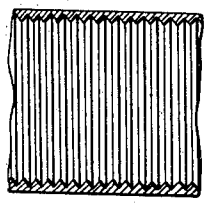


Fig. 4

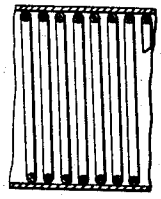
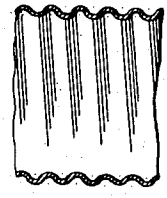


Fig. 5.



WITNESSES

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3 SHEETS—SHEET 3.

Fig. 6.

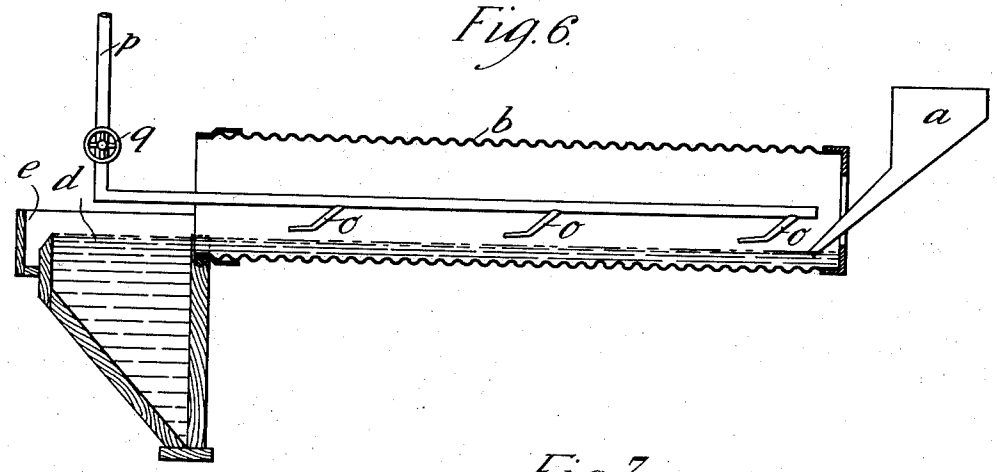
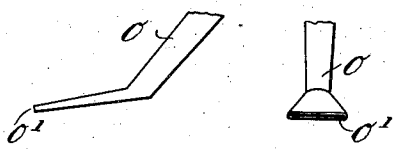


Fig. 7.



WITNESSES

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UNITED STATES PATENT OFFICE.

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PROCESS FOR SEPARATING SOLIDS.

No. 865,194. Specification of Letters Patent. Patented Sept. 3, 1907.

Application filed July 3, 1905. Serial No. 268,276.

To all whom it may concern:

Be it known that I, ARTHUR P. STANLEY MACQUISTEN, a subject of the King of Great Britain, residing at 33 Renfield street, Glasgow, Scotland, N. B., chartered accountant, have invented a certain new and useful Improved Process for Separating Solids, of which the following is a specification.

This invention relates to an improved method for separating solid particles of different characters in a mixture of such particles and is more particularly designed for the separation of the metalliferous particles from the gangue of crushed ore.

The method is based on the fact that some substances, when conveyed through the surface of a liquid, are more readily retained at or on that surface than other substances due to their different surface affinities for liquids, and that consequently in a mixture of such substances those which are more readily retained at or on the surface can, on account of such property, be separated by flotation from those which are not, and which therefore sink into the body of the liquid. Thus when the particles of a suitable pulverized mineral bearing ore, immersed in water or other liquid and mixed so as to form a pulp, are caused to pass through the surface of such liquid by a conveyer or other means, the metallic or metalliferous particles, if of suitable size and if properly presented to the liquid, will be retained at the liquid surface by the tension of the surface film, while the gangue will not be so retained. The separated metalliferous particles constituting the concentrates can then be floated away, by causing a surface current, for example, and collected or deposited in any convenient manner, while the gangue is otherwise dealt with.

The water or other liquid which is utilized in the process may have its properties modified in respect of surface tension or capillarity, particularly in regard to the mineral matter to be separated, by means of any effective chemical or physical agency, or substances or matter may be added to or dissolved in the liquid with the object of modifying or altering the chemical or physical conditions of the surface of the particles to be separated, or the material to be treated may be subjected to a prior treatment with the same object.

One arrangement whereby the process may be conveniently carried into practice is illustrated in the accompanying drawings in which

Figure 1 is a longitudinal section of such an arrangement; Fig. 2 is an end view thereof, and Figs. 3, 4 and 5 are details showing various arrangements of conveyers in the treating device. Fig. 6 is a diagrammatic longitudinal section of part of the apparatus fitted with air jets to accelerate the surface stream; and Fig. 7 shows detail views of a suitable nozzle drawn to an enlarged scale.

In the arrangement shown, the crushed metalliferous ore or pulp is fed into a hopper *a* which conveys it, together with the water or other liquid through whose agency the separation is effected, into a cylindrical vessel *b* suitably mounted as on rollers *c* to be rotated about its axis which may be horizontal or slightly inclined thereto. The feed end of the vessel is partially closed to enable a suitable depth of liquid to be maintained while the delivery end opens into a tank *d* with the wall of which it makes a liquid-tight joint. Part of the whole of the edge of the tank *d* is at the liquid level and constitutes a weir over which a continuous stream passes to the launder *e*. Preferably, in order to facilitate the passage of the liquid-borne particles over the weir, an annular channel *f* is provided round its inner edge supplied with liquid under pressure and having a suitable narrow opening round its upper edge by which such liquid is directed towards and over the lip of the weir.

The launder is connected by a pipe *g* with a settling tank *h* which in turn is connected by pipe *i* with a collecting tank *k* for the liquid which is thence pumped to the elevated storage tank *m* whence it passes gravitationally through a suitable regulating cock to the hopper *a* to be used over again.

The contents of the tank *d* may be treated in a similar manner to the original mixture of ore and liquid in a second separating vessel *b'* situated at a lower level into which the material is fed by the pressure of the superincumbent liquid through a pipe extending to the bottom of the tank *d*. The material passes from the vessel *b'* to a tank *d'* over the edge of which the liquid-borne particles and the liquid fall into the launder *f'* whence it is conveyed by pipe *g'* to the settling tank *h*. A pipe *i'* connects the tank *g'* with the collecting tank *k*.

The tanks *h* and *k* are preferably provided with transverse hanging partitions *n* which prevent continuous surface streams along the tanks and assist the deposit of the solid particles, the deposit being collected from the tanks at suitable intervals, or removed by conveyers or other suitable means.

The separating vessels *b b'* may be arranged in batteries as shown in Fig. 2 and if necessary more than two series of these may be employed. The rotation of the separating vessels brings the mixture of metalliferous particles and gangue supported thereby up through the liquid surface, where they become subject to the action of capillary forces with the result that the metalliferous particles are thereby retained at the surface of the liquid and float away with the stream, whereas the

gangue particles slide back and again subside in the liquid. As the particles emerge above the surface of the liquid, owing to the steep angle at which they are carried which is greater than the angle of repose of the mass, they roll back upon and over the ascending mass, forming a constantly shifting inclined mass of pulp, so that fresh metalliferous particles are repeatedly exposed to the action of the surface and are caused to float, this operation being effected very often and so gently by the rotation of the cylinder that a very thorough separation takes place. The liquid stream flowing through the vessel in a direction transverse to the rotation thereof carries both classes of particles with it, the one on the surface and the other in the body of the liquid, the latter being collected in a suitable vessel as described and the former being deposited in another vessel by agitation of the particles or the liquid or other suitable means. In some cases it may be preferable to convey the gangue particles in the direction opposite to that of the flow of the metalliferous particles. The particles which adhere on emergence from the liquid to the surface of the separating vessel, or the film of liquid covering it, are carried round and returned to the liquid level by a rolling motion transverse to the flow of the stream and in the process of submergence the metalliferous particles are floated off by the stream while the gangue particles are carried downwards or subside into the body of the liquid. The rotation of the cylinder or separating vessel brings the material repeatedly to the surface, and thus progressively separates out portions of material which overcome the surface tension on the preceding contacts; the material, moreover, is moved to the surface and returns thereto in a direction transverse to the direction of flow, thus rendering the separation more nearly independent of an impetus in the direction of flow, as well as permitting a greater number of surface contacts per unit length of liquid surface. Since the particles reach the surface at an angle at which most cannot remain on the wall of the rotating vessel, they roll back to the surface immediately on passing the same, and thus do not attain a backward impetus sufficient to overcome the surface tension in the case of the particles to be floated off.

The effective surface of the separating vessel may be increased by forming it with internal corrugations and if these are spirally arranged they serve to convey the submerged particles bodily through the vessel. Thus Fig. 3 shows a separating vessel having an internal screw-thread; Fig. 4 a spiral coil inside the vessel, and Fig. 5 a spiral corrugation. Further, it is obvious that any suitable mechanical device may be used for the purpose of bringing the particles to or through the liquid surface.

The pulverized material may be first classified into conveniently graded products which are then separately treated as above described, or the smaller mineral particles are first separated according to the process of the present invention, leaving the coarser particles to be dealt with in any suitable known manner.

The surface stream may be accelerated by suitable means such as by directing an air-blast along its surface in the direction of travel. Such an arrangement is shown in Figs. 6 and 7 in which nozzles *o* presenting narrow horizontal slits or orifices *o'* close to the surface of the liquid in the vessel *b* and substantially in the direction of the stream or flow of liquid, are connected to communicate with a supply pipe *p* leading to any suitable source of compressed air through a valve or cock *q* by which the jets of air may be regulated to produce any desired velocity of current in the liquid.

Usually water would be employed as the separating agent in the case of metalliferous ores, but obviously any liquid may be substituted therefor, which has the suitable constitution or properties to effect the separation in the manner herein described, or the properties of the water or other liquid with respect to its surface tension or capillarity may be modified by the addition of a suitable acid, or alkali or soluble salt or other substance. The surface condition of the particles to be separated may be modified or altered by suitable treatment with active chemicals which will attack the surface of the particles. In any case, however, the mixed particles are brought together through the liquid surface and the separation is effected at the surface by the molecular forces within the range of which the particles are thus brought and by virtue of which some particles are maintained suspended at or on the liquid surface film, while others are not. The liquid surface may be the surface of separation between the liquid and a gas, vapor or liquid, and would in general be the surface between the liquid and air.

Claims:

1. A process for separating solids having different surface affinities for liquids, consisting in forming a pulp of the mixture, bringing the commingled particles through the surface of a gently flowing stream of liquid and returning the same to the stream in a direction transverse to the flow of the stream, and collecting the concentrates thereby caused to float upon the stream; substantially as described.

2. A process for separating solids having different surface affinities for liquids, consisting in forming a pulp of the mixture, repeatedly bringing the commingled particles through the surface of a gently flowing stream of liquid and returning the same to the stream in a direction transverse to the flow of the stream, and collecting the concentrates thereby caused to float upon the stream; substantially as described.

3. A process for separating solids having different surface affinities for liquids, consisting in forming a pulp of the mixture, repeatedly bringing the commingled particles through the surface of a gently flowing stream of liquid and returning the same to the stream by a rolling motion in a direction transverse to the flow of the stream, and collecting the concentrates thereby caused to float upon the stream; substantially as described.

4. A process for separating solids having different surface affinities for liquids, consisting in forming a pulp of the mixture, bringing the commingled particles through the surface of a gently flowing stream of liquid and returning the same to the stream in a direction transverse to the flow of the stream, accelerating the surface flow of the liquid, and collecting the concentrates thereby caused to float upon the stream; substantially as described.

5. A process for separating solids having different surface affinities for liquids, consisting in forming a pulp of the mixture, bringing the commingled particles through the surface of a gently flowing stream of liquid and returning the same to the stream in a direction transverse to the flow of the stream, modifying the surface tension or capillarity of the liquid, and collecting the concentrates thereby caused to float upon the stream; substantially as described.

6. The process of separating materials having different surface affinities for liquids, consisting in repeatedly passing the material up through the surface of a gently flowing stream of liquid, exposing the material above the liquid surface to air currents, and collecting the materials floated by the liquid.

7. A process for separating solids having different surface affinities for liquids, consisting in forming a pulp of the mixture, repeatedly bringing the commingled particles through the surface of a liquid and returning the same to the liquid by a rolling motion, and collecting the concentrates thereby caused to float upon the stream.

8. The process for separating solids having different surface affinities for liquids which consists in forming a pulp of the material containing such solids and causing a constantly shifting inclined mass of such pulp to pass up through the surface of the liquid until the particles having a surface affinity for the liquid are held in suspension on the surface.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

A. P. STANLEY MACQUISTEN.

Witnesses:
ANDREW M. MACINTOSH,
JAMES YOUNG.