

UNITED STATES PATENT OFFICE.

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CONCENTRATION OF MINERALS.

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To all whom it may concern:

Be it known that I, WALTER O. BORCHERDT, a citizen of the United States, residing at Austinville, in the county of Wythe, State of Virginia, have invented certain new and useful Improvements in the Concentration of Minerals; 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 by flotation.

It is well known that colloids and colloidal slimes, both organic and inorganic, often are present in mineral ore pulp, and when present in considerable amount, may have an unfavorable effect upon the concentration of such ore pulp by flotation. When considerable amounts of colloids or colloidal slimes are thus present it is usually necessary to operate in a more dilute pulp; or the froth produced is rendered thick, viscous and difficult to break down or reliquefy and to handle in launders, pumps and pipes, in which condition it is spoken of as being "over stabilized", because of its content of colloids or colloidal slimes, and gives a dirty concentrate.

It has been proposed to treat such ore pulps, containing considerable amounts of colloidal slimes, with a coagulating or flocculating agent, in order to neutralize in part the objectionable effect of such slimes; but the coagulated or flocculated constituents remain admixed with the ore pulp and often seem to form therewith adsorption compounds or colloidal complexes where-with the mineral particles are entangled or enmeshed and the flotation operation prejudiced thereby, as well as, in some instances by the coagulating or flocculating agents which remain in solution in the ore pulp.

The colloidal matters present in an ore pulp are probably derived for the most part from the gangue particles of the ore, although it is not unlikely that mineral particles may also be present in the pulp in the form of colloids. Such colloidal matters may also be introduced with the milling water which is used to form the ore pulp, and this source of colloidal matters may be considerable during periods of heavy rain-

fall, when surface waters containing mud and other suspended matters, and heavily charged with both organic and inorganic colloids, run into the source from which the milling water is customarily taken.

The colloidal matters may be present as pure colloids, organic or inorganic, or in a state bordering on the so-called "coarse suspensions". Throughout this specification and the appended claims, I intend to embrace in the expressions "colloids and (or) colloidal slimes" and "colloidal constituents" both true colloids and those quasi or borderland substances, which may not be truly colloidal but partake of the qualities of, or resemble, colloids, and without regard to the sources from which such colloidal matters are derived. Thus, for the purposes of the present invention, the colloidal constituents may be considered as ranging from just above the molecular size upward through the class of so-called suspensions, which, while possibly not true colloids, still, because of their relatively large specific surface, exhibit some, if not all, of the properties of colloids, and are capable of existing in both the sol or gel state, or of being dispersed and coagulated, or flocculated and deflocculated. By a colloidal slime, therefore, I mean a material which is not necessarily a true colloid, but exhibits colloidal characteristics to a sufficient degree to make it amenable to the manipulation hereinafter described.

As the result of my investigations, I believe that the injurious action on the flotation operation of colloidal matters present in the ore pulp may result merely from their presence in the ore pulp, or may be due to their attachment to, or adsorption by, the flotation agent, or the gaseous flotation medium, or the mineral particles, or all three. It is my belief that these colloidal matters interfere with the flotation operation whether they exist in a flocculated (or coagulated) or in a deflocculated (or dispersed) condition, but I have found that in general their action is less marked when dispersed or deflocculated.

I have discovered that the concentration by flotation of the mineral particles of an ore pulp is often very considerably aided and improved by removing the flotation-in-

hibitory colloidal constituents, in whole or in part, from the pulp prior to the flotation operation proper, and in my copending application, Ser. No. 283,628, filed Mar 19, 1919 one aspect of this improvement in the method of concentrating minerals by flotation is described and claimed. In the aforementioned application I have particularly described the removal of the colloidal constituents from the ore pulp by dispersing or deflocculating them and bringing about the sedimentation of the mineral particles and separating the dispersed or deflocculated colloidal constituents by decantation. The present invention involves the removal of the flotation-inhibitory colloidal constituents from the ore pulp by a flotation treatment under conditions permitting the removal by flotation of a part or the whole of the colloidal constituents while substantially inhibiting the flotation of mineral particles.

According to the present invention, the ore pulp containing the colloids or colloidal slimes is subjected to a preliminary flotation treatment with an appropriate agent or agents, the object of which is to produce a froth or scum containing part or the whole of the colloids or colloidal slimes, with a relatively small proportion of the valuable mineral or minerals contained in the pulp, and to separate this colloid-bearing froth from the bulk of the ore pulp, after which the ore pulp is treated by flotation for the recovery of its valuable constituents by any desired flotation process and agents.

The colloid-bearing froth may itself be further treated for the recovery of such valuable minerals as it may contain, or it may be run to waste, but in either event the principal part of the mineral contained in the ore-pulp is by this process treated under conditions which facilitate and enhance the recovery of such mineral and permit of the flotation being conducted upon a more thickened pulp than would otherwise be the case, thereby increasing the effective capacity of the flotation plant, pumps, settling tanks, filters, etc., used in connection with it, by decreasing the bulk of pulp to be handled for a given tonnage of dry ore.

In some cases the colloid-bearing froth when produced as described may contain too much valuable mineral to permit of throwing it away. This mineral may be carried over in part mechanically entangled with floccules of colloidal material; in part as colloidal complexes or mineral particles with adsorbed colloid coating which cause them to act like gangue or colloidal particles rather than mineral particles; and in part simply in mechanical suspension in the froth, because of their fine size and the rapid formation of the froth. In order to separate this mineral from the colloid-bearing

froth and return it to the pulp which has been treated as described for the removal of colloidal material, the froth may be subjected to the action of water or air jets to break it down, as is commonly done in froth-flotation plants, and if the froth contains flocculent material, as would ordinarily be the case, a deflocculating agent may be added as well as water for dilution of the broken down froth-pulp to the desired degree. The kind and amount of deflocculating agent, and the amount of water required may be readily determined for a specified colloid-bearing froth by means of simple tests.

The deflocculated pulp resulting from the foregoing-described treatment may be then run to settling tanks, which may be of the continuous type, such as Dorr, Allen or Callow tanks or similar apparatus, or intermittent tanks, such as are commonly used in the arts and are too well known to require description. In these tanks sedimentation or settling may take place, the minerals and coarse gangue particles settling toward the bottom, and being removed continuously or intermittently and the deflocculated colloidal material, together with much of the agent used to form the colloid-bearing froth, having a much slower settling rate, remains in suspension and is continuously or intermittently overflowed to waste. The settled material, containing the mineral, may be further treated in a similar manner, if the first treatment has not sufficiently removed the colloidal material and the froth-forming agent and may be then diluted with water as desired and returned to the body of the pulp which has been treated for the removal of colloids, or be otherwise disposed of in any other manner.

In some cases, simple breaking down of the colloid-bearing froth and dilution with water may be sufficient to render possible the separation of the colloidal constituents from the mineral particles and the return of the latter to the main body of ore pulp, or in special cases leaching of the minerals with chemical agents, or treatment with sulfidizing agents to make oxidized minerals amenable to flotation, may be indicated to recover the valuable minerals but the need for such treatments and the procedures to be applied will in such cases be apparent to those skilled in the art to which this invention pertains.

I have also discovered that while colloids or colloidal slimes present in ore pulp generally have an inhibiting effect upon the flotation of the valuable minerals, that this effect varies in strength as respects different minerals; and also, as respects any one mineral, that the inhibitory effect varies approximately in proportion to the amount of colloidal material present; and that the state, in which the colloids exist also has a bearing,

the inhibitory effect being generally less marked when the colloidal constituents are dispersed or deflocculated.

The removal of the colloids or colloidal slimes by the production and separation of a colloid-bearing froth may be conducted in one step, as a preliminary operation, when only one valuable mineral is to be recovered by the subsequent regular flotation operation, or it may be conducted in two or more steps, each removal of colloids or colloidal slimes being followed by a flotation operation for the recovery of a valuable mineral.

I have further discovered that by the proper application of these facts it is possible to secure the differential or preferential flotation of certain mineral or minerals while inhibiting the flotation of another or other minerals, and according to the present invention this result is brought about by forming a colloid-bearing froth by means of a suitable agent, employing for this purpose any of the flotation machines employed for the production of mineral froths in the ordinary flotation processes, such as the minerals separation, Callow, Janney, K. and K., etc., but preferably the Callow or other pneumatic machines, (since in these the action is more readily controlled) removing this froth from the ore pulp and either discarding it or subjecting it to further treatment separate from the ore pulp. After sufficient of the colloidal constituents have been removed the pulp is treated by flotation in the usual way, for example, in the flotation machines commonly used, and with such agents as the case requires, for the production and removal of a mineral froth, composed principally of one of the valuable minerals. The tailings pulp from this operation is then again treated with suitable agents in a suitable flotation machine for the production of a second colloid-bearing froth, which is also removed and discarded, or retreated, as may be desired; and the remaining pulp is then subjected a second time to a flotation treatment for the recovery of a concentrate composed principally of a second valuable mineral this sequence of operations being repeated as many times as is necessary for the separation of each of the valuable minerals in the original ore pulp, singly or in groups.

As an example of the application of the process of the present invention I will describe the treatment of an ore like that found at Austinville, Va., which contains the sulphides of lead, zinc and iron in dolomitic limestone and in which the colloids or colloidal slimes are present in such quantity as to seriously interfere with the recovery of the valuable minerals by the usual flotation processes. To the finely ground ore, which has been made into an ore pulp by admixture with water, is added a small

amount, for example, one-half pound per ton of dry ore, of a rosin soap in solution in water. After thorough mixture the pulp is passed into a Callow flotation cell, thru the porous bottom of which air under pressure is admitted in fine streams to form minute air bubbles. These air bubbles, with the rosin soap and the colloidal constituents of the ore pulp, form a colloid-bearing froth which rises to the surface of the pulp in the cell and overflows into an appropriately placed launder, which conveys it to a tank for further treatment, or to waste. After sufficient of the colloidal constituents have thus been removed the ore pulp is passed to another flotation cell where a mineral floating agent, as for example, emulsified wood creosote oil, is added and a galena froth is obtained. This froth is removed and further treated as is usual in the art for the production of a final high grade lead concentrate, and the ore pulp is then mixed with an additional small quantity of rosin soap, for example one quarter pound per ton of dry ore, in solution in water, and passed into another flotation cell where a second colloid-bearing froth is formed and removed as before. The ore pulp is then passed to another flotation cell and a small amount of pine oil and crude petroleum oil in emulsion are added and a flotation operation conducted for the formation of a blende froth, which is removed and further treated as is customary. To the ore pulp is then added a further small amount of rosin soap, for example one-quarter pound per ton of dry ore, in solution in water, and the ore pulp is then passed into another flotation cell where the remainder of the colloidal constituents of the ore are removed in the form of a colloid-bearing froth as before. The ore pulp is then mixed with a small quantity of sulphuric acid, for example one-half pound per ton of dry ore, and with emulsified pine oil and crude petroleum oil and passed into a flotation cell where a mineral froth containing the pyrite is formed and removed, while the final tailings pulp from the cell is sent to waste.

According to the present invention, the colloidal constituents of the ore pulp which are to be removed in whole or in part by the formation of a colloid-bearing froth, may be in either a flocculated or deflocculated condition, the preference being determined by economic considerations depending upon the kind of valuable mineral or minerals contained in the ore, the amount of colloidal matter present, the average fineness of the valuable minerals, the tendency or otherwise of the flocculated colloids to enmesh or entangle valuable mineral, the soluble contaminants of the ore pulp, the degree of dilution of the ore pulp, the sub-

sequent treatment to which the colloid-bearing froth and ore pulp or mineral concentrate, respectively, may be subjected, the tonnage to be treated, the cost of water and agents, etc. In any actual case the natural character of the ore and other fixed conditions will determine certain features of the exact method of treatment, while the preference as to other features may be readily determined by simple tests which will in each case be suggested by the problem itself.

In the production of colloid-bearing froths, many agents or combinations of agents are available. One at least of the agents must be such as will be capable with air or gas bubbles in the pulp or forming a froth or scum which will rise to the surface of the pulp. In the investigation of this discovery I have found many agents, both organic and inorganic which are effective, but thier relative value in the case of any given ore will depend upon a variety of factors, some of which are mentioned above, and simple tests will in any event determine the most suitable agent or agents. I have found in practice that pine and hardwood tar oils, rosin oils, or in general oils with a high pitch content, make excellent agents for the formation of colloid-bearing froths, substantially non-selective for the valuable minerals present in the ore pulp. Soaps of various kinds, and especially rosin soaps, are excellent with some ores, and generally give abundant froths. In many cases the same oil or oils which are used for the production of a mineral froth with a given ore will yield an excellent colloid-bearing, substantially non-mineral selective froth for the purpose of the present invention, if simply used in excess over what would be practicable for the formation of a mineral-bearing froth. In such cases as the last a very simple operation may result, as it is well known that, when a frothing agent is added to water and a froth is produced, that the greater part of the frothing agent concentrates in the froth, and is consequently eliminated with it from the pulp, from which it results that after the colloidal constituents of a pulp have been removed by means of a colloid-bearing froth, that the remaining frothing agent in the ore-pulp may be sufficient for the prduction of a mineral froth according to the usual processes.

In such cases as it is necessary to use for the formation of the colloid-bearing froth an agent or agents whose residual presence in the ore would be objectionable in the subsequent mineral flotation, it is possible to neutralize such residual portions by commonly understood chemical means, and I have found, as a result of my investigations, that when an ore pulp has been approxi-

mately freed of its colloidal constituents, that mineral flotation can be conducted satisfactorily in the presence of much larger quantities of soluble impurities than would otherwise be practicable.

The present invention is applicable to different flotation processes and with various means or reagents or agents which are used to effect or facilitate flotation. Thus, while the invention has herein been more particularly described in connection with froth flotation, it is to be understood that the invention is equally advantageous in connection with surface film flotation processes, as well as in connection with other processes involving the principles of flotation.

I claim:

1. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises separating the colloidal constituents from the mineral pulp by a preliminary froth-flotation treatment, and thereafter subjecting the pulp to a flotation operation.
2. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises subjecting the mineral pulp to a preferential froth-flotation treatment by which the colloidal constituents are removed to a desired extent from the pulp, and thereafter subjecting the pulp to a flotation operation.
3. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises subjecting the mineral pulp to a preliminary froth-flotation treatment under conditions permitting the removal by flotation of the colloidal constituents while substantially inhibiting the flotation of mineral particles, and thereafter subjecting the pulp to a flotation operation.
4. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises subjecting the mineral pulp to a preferential froth-flotation treatment by which the colloidal constituents are removed to a desired extent from the pulp, thereafter subjecting the pulp to a flotation operation, and subjecting the removed colloid-bearing froth to further treatment for the separation therefrom of mineral particles carried thereby.
5. The method of effecting the selective flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises subjecting the mineral pulp to a preferential froth-flotation treatment by which the colloidal constituents are removed to a desired extent from the pulp to permit flotation of a certain mineral constituent thereof while substantially inhibiting the flotation of other mineral constituents thereof, subjecting the ore pulp to a flotation operation, subjecting the ore pulp to a further

preferential froth-flotation treatment for effecting a further removal of the colloidal constituents to permit the flotation of a further mineral constituent of the ore pulp, and
5 subjecting the ore pulp to a flotation operation for effecting the removal therefrom of said further mineral constituent.
6. The method of improving the flotation of minerals associated in a mineral pulp
10 with colloidal constituents, which comprises

subjecting the mineral pulp to a froth flotation treatment under conditions producing a colloid-bearing froth, removing such froth from the mineral pulp to an extent sufficient to reduce the flotation-inhibitory effects of the colloids therein, and thereafter
15 subjecting the remaining mineral pulp to a flotation operation.

In testimony whereof I affix my signature.
WALTER O. BORCHERDT.