

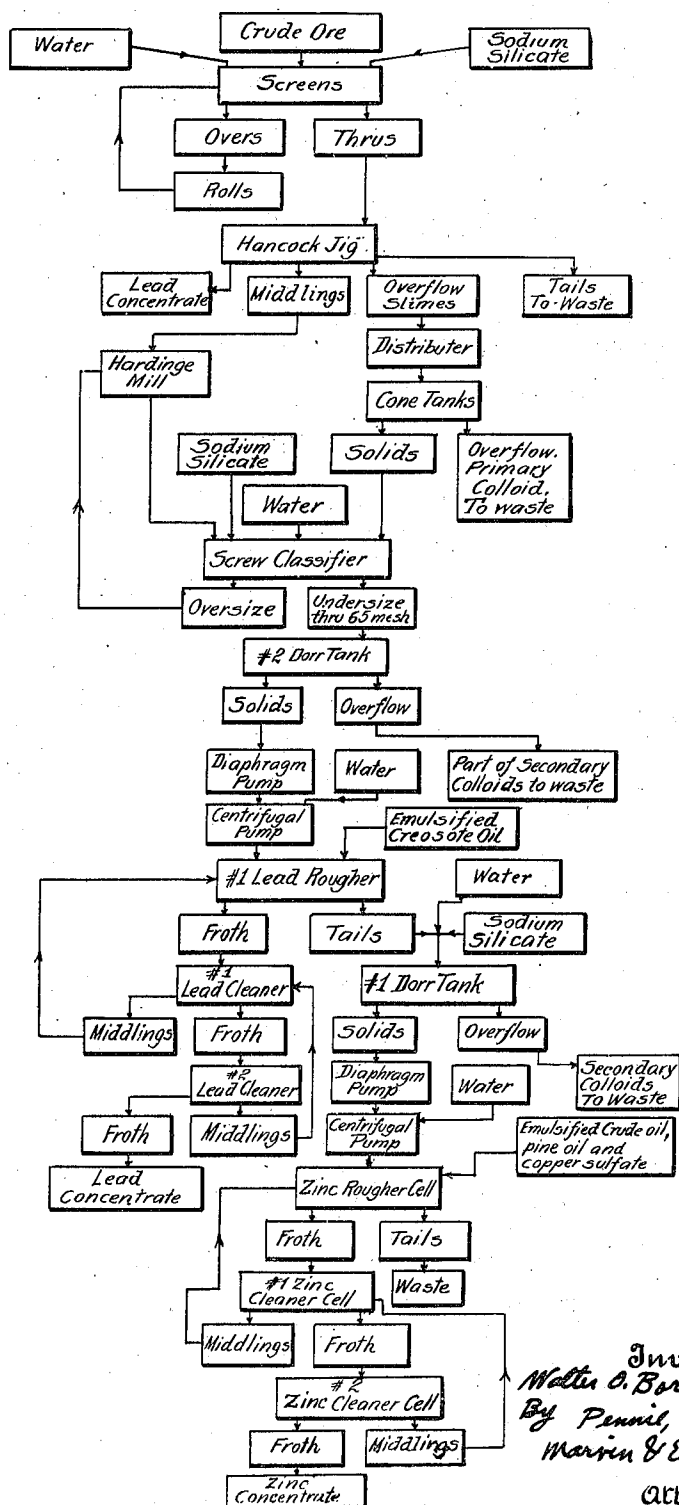
May 8, 1923.

1,454,838

W. O. BORCHERDT

CONCENTRATION OF MINERALS

Filed March 19, 1919



Inventor
Walter O. Borchardt
By Pennell, Davis
Marvin & Edmunds
Attorneys

Patented May 8, 1923.

1,454,838

UNITED STATES PATENT OFFICE.

WALTER O. BORCHERDT, OF AUSTINVILLE, VIRGINIA, ASSIGNOR TO THE NEW JERSEY ZINC COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

CONCENTRATION OF MINERALS.

Application filed March 19, 1919. Serial No. 283,628.

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 reliefs 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 wherewith 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 ores, although it is not unlikely that valuable 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 rainfall, when surface waters containing mud and other suspended matters, and heav-

ily charged with both organic and inorganic colloids, run into the stream 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 suspensoids, 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.

The present invention in its broad aspect contemplates, as an improvement in the concentration of minerals by flotation, and as a preliminary step to the flotation operation proper, the removal, in whole or in part, of colloidal constituents in a dispersed or deflocculated condition from a mineral or ore pulp. The removal of the colloidal constituents may be effected in various ways. The

present invention more particularly relates to the removal of these constituents in a dispersed or deflocculated condition by sedimentation and decantation while in the process more particularly described and claimed in my copending application Ser. No. 283,629 filed March 19, 1919 the removal of the colloidal constituents is effected by a preliminary flotation operation in which a froth or scum containing part or the whole of the colloidal constituents, with a relatively small proportion of the valuable minerals contained in the pulp, is separated from the bulk of the mineral ore pulp. After the removal of the colloidal constituents in accordance with the principles of the present invention the ore pulp is subjected to a flotation treatment in accordance with any of the usual practices.

The removal, by sedimentation and decantation, from the mineral ore pulp of the colloidal constituents depends for its effectiveness upon the relative difference in the rate of settling or sedimentation of the ore particles and the colloidal constituents. For this reason it is desirable to cause the colloidal constituents to settle at a much slower rate than the mineral and gangue particles in the ore pulp, whereby, after a predetermined settling of the mineral and gangue particles, any desired portion of the supernatant liquor containing the slower-settling colloidal constituents can be decanted in any suitable way to effect the removal from the mineral ore pulp of the desired quantity of the colloidal constituents. In this connection, the present invention contemplates the dispersion or deflocculation of the colloidal constituents so as to cause them to settle at a very much slower rate than would be the case if they were coagulated or flocculated, so that they will remain in more or less permanent suspension in quiet pulp, thus permitting settling or sedimentation of the sands and slimes containing the valuable minerals, and decantation by displacement, or otherwise, of the water containing the suspended colloids or colloidal slimes.

The colloidal constituents of ore pulps are rarely, if ever, naturally deflocculated and dispersed to their maximum possible extent. Since aggregated or flocculated colloid masses act like solid particles of greater magnitude the removal of the partially flocculated colloidal constituents of an ore pulp by means of settling processes, or even washing with water on tables or vanners, is generally incomplete and inadequate. The agencies which promote the flocculation of the colloidal constituents of an ore pulp also in general seem to promote the adsorption or other form of attachment which exists between such colloidal constituents and the granular constituents of the ore pulp. It

follows, therefore, that when the colloidal constituents of an ore pulp have been thoroughly deflocculated and minutely dispersed, they no longer exist in the form of aggregates resembling the coarser solid particles of the pulp, but behave more like substances in solution, and are, in fact, spoken of as being in colloidal solution, in which condition the forces tending to maintain them in suspension are greater than the effect of gravity, thereby greatly facilitating their separation by sedimentation and decantation, and as, at the same time, their adsorption or other bond for the coarser solid particles of the ore pulp is weakened, the removal of such colloidal constituents from the ore pulp is greatly facilitated over what is possible in their natural partially flocculated condition.

Even when the colloidal constituents of the ore pulp are originally deflocculated or have been deflocculated early in the treatment of the pulp, they may have become flocculated during the treatment to which the pulp is subjected or agents may have been added which cause them to flocculate, and in such cases the same general method of treatment is applied to secure deflocculation in accordance with the principles of this invention as would be applied to a pulp containing naturally flocculated colloidal constituents.

The present invention thus relates to a process of concentrating such ore pulps as contain objectionable amounts of colloids or colloidal slimes, according to which the ore pulp is treated with a deflocculating or dispersing agent in order to convert the colloids or colloidal slimes into a deflocculated or dispersed state (if they are not already present in such a state of dispersion or deflocculation) and separating the dispersed or deflocculated colloids or colloidal slimes, in whole or in part, by decantation, or otherwise, from the ore pulp prior to the flotation operation. As a result of this removal of the colloids or colloidal slimes in a dispersed or deflocculated state, the ore pulp is thereby freed from such colloidal matter, to the desired extent, so that the flotation operation can thereafter be carried out without being prejudiced or inhibited by the colloidal constituents which have been removed.

I have found further, that for certain purposes, it is desirable to retain part of the colloidal constituents in the ore pulp, and that, when a proper amount of such constituents is present, it is possible to effect a differential separation, by flotation, of certain mineral constituents or species of a mixed ore pulp, while the flotation of other mineral constituents or species is retarded or inhibited by the colloids or colloidal slimes; and that, thereafter, by a further removal of a part or all of the remaining colloids or

colloidal slimes, in the manner above referred to, flotation of other or the remaining mineral constituents or species can be effected.

5 As the result of the work which I have done in the removal of colloids and colloidal slimes, prior to flotation, I am led to believe that the colloidal constituents present in the ore pulps have an effect upon the flotation operation, and the manner in which it proceeds, which is comparable in importance to the effect which the oil employed has upon the flotation operation. Thus, where colloids or colloidal slimes are present
10 in large amount, an over stabilized froth tends to be produced, which is difficult to break up and which gives a dirty concentrate, and which often leads to heavy losses of valuable minerals in the tailings, whereas, if the colloidal constituents are present in regulated amount, the flotation operation seems to be promoted thereby in many cases, these colloidal constituents cooperating with the oil and valuable mineral particles in producing a froth of the desired consistency; while it is also possible, by proper regulation of the colloidal constituents, to bring about a differential flotation of certain constituents, as above referred to.

30 As the result of the investigations which I have made I have been led to believe that colloidal adsorption takes place upon metallic surfaces and upon the surfaces of sulfides and other minerals, but that the strength of the adsorption varies considerably, depending upon the character of the colloid, its relative concentration, the kind and character of adsorbing material, and its temperature and condition of electrical charge; that the combination of the colloids present
35 in many flotation pulps with the oil and other constituents of the froth, with the resulting production of a viscous or "over-stabilized" froth and consumption of oil, is due to such colloidal adsorption; and that it is due, in whole or in part, to the removal of such adsorbed colloids that the combination of the oil and air with the valuable minerals is facilitated, with resulting advantage to the flotation operation. I do not, however, desire to limit myself by any theoretical explanation of the process of the present invention. Whatever may be the correct explanation of the prejudicial effect of colloids when present, and of the advantages resulting from their removal, the process of the present invention involves such separation of the colloids, in whole or in part, (whether adsorbed by or otherwise combined or admixed with the sulfides or other minerals) as a preliminary step to the flotation operation.

60 If the ore pulps contain the colloids or colloidal slimes in a naturally sufficiently dispersed condition, then the treatment with

a dispersing or deflocculating agent may not be necessary and the ore pulp may be subjected directly to differential sedimentation or decantation for the removal of the colloidal constituents to the desired extent. 70

With the removal of the colloidal slimes there will, of course, also be removed a corresponding portion of the water of the ore pulp, together with such constituents as are dissolved therein. 75

If the colloidal slimes of the ore pulp are not naturally sufficiently dispersed, the ore pulp is treated with a dispersing or deflocculating agent to bring about the desired dispersion or deflocculation, after which decantation is effected for the purpose of removing a portion or the whole of the dispersed colloidal slimes and accompanying water containing the added agent or agents. The dispersing agent which I have used to particular advantage with lead-zinc sulfid ores is sodium silicate, but, in general, other agents may be employed which will bring about the desired dispersion or deflocculation, such, for example, as gum arabic (acacia) foundry molasses, tri-sodium phosphate, etc. The nature of the agent will vary somewhat with different ore pulps, because the colloidal slimes vary, in some cases being of a basic character and in others of an acid character, and in some cases being positively charged, and in other cases being negatively charged. The dispersing or deflocculating agent should be properly chosen with reference to the colloidal properties of the ore pulp and in accordance with the known principles of colloid chemistry so that the desired deflocculation or dispersion will take place. Using sodium silicate, I have found that good results have been obtained with an exceedingly small amount, for example, from 4 pounds down to a fraction of a pound of the sodium silicate per ton of dry ore treated. 100

The dispersion of the colloids (whether adsorbed by the mineral particles or otherwise coagulated or flocculated) may be promoted, or even brought about, to a greater or less extent, by rapid circulation and agitation of the pulp, which will serve to distribute the deflocculating agent, if any is used, and cause abrasion of the mineral particles with each other and with floccules or coagules of colloidal matter in which the mineral particles may be enmeshed, so that the separated and dispersed colloids may be more readily removed by decantation. Increase in temperature may similarly be of assistance in bringing the colloids into a state permitting their removal from the ore pulp. The optimum temperature, in the case of any particular ore, for effecting dispersion of the colloidal constituents contained in the ore pulp may be determined by tests, in which the other factors are held 130

constant and the temperature is varied through the range from freezing up to boiling. Where this optimum temperature is higher than the normal temperature of the ore pulp, the ore pulp may be heated to such optimum temperature by direct heating or by the use of steam-heating coils, or by steam blown into the pulp, and where this optimum temperature is found to be lower than the normal temperature of the ore pulp, the ore pulp may be cooled by dilution with cold water, by cooling coils, or by cooling towers.

I have found that an extremely convenient and effective way of securing the necessary distribution of the dispersing or deflocculating agent through the mass of the ore pulp, and of securing the desired degree of dispersion or deflocculation of the colloids or colloidal slimes present in said ore pulp, consists in adding the deflocculating or dispersing agent to the pulp at some point prior to the admission of the ore pulp to the ball or pebble mills, or other fine grinding machines. Such machines almost invariably form a part of the equipment of ore dressing plants, as a preliminary step in the process of preparing ores for treatment by flotation.

By so adding the deflocculating or dispersing agent to the ore pulp ahead of the fine grinding mills, the necessary mixture is secured without inconvenience or added expense, and the dispersion or deflocculation of the colloids or colloidal slimes may take place under the most favorable conditions of rising temperature and violent agitation. Under these conditions flocules or coagules are readily broken up and prevented from re-forming, or particles already coated with colloids or enmeshed within flocules are cleaned or released; such colloids as are released from a solid or indurated condition by the grinding are immediately placed in the dispersed or deflocculated state, and the fresh mineral surfaces exposed by the grinding are prevented from being coated with inhibitory coatings of colloidal material. This procedure may with some ores be sufficient to effect the desired degree of deflocculation without the use of a deflocculating agent, provided the decantation of the colloidal constituents is effected immediately after the pulp leaves the grinding machine, but while the pulp is quiescent.

Whatever may be the preliminary treatment, or combination of treatments, to which the ore pulp is subjected for the dispersion or deflocculation of its colloids, (in case such preliminary dispersion is necessary) these colloids are, according to the present invention, removed from the ore pulp, as by decantation, to the extent necessary to prevent them from interfering with the subsequent treatment of the pulp by flotation.

After the deflocculated or dispersed col-

loids or colloidal slimes have been removed to the desired extent, that is, in whole or in part, depending upon the result desired, the remaining ore pulp, which is now in a more concentrated state, is diluted to the proper consistency and is then subjected to a flotation operation to secure separation of the valuable constituents from the waste minerals. The removal of the colloids from the ore pulp often enables the ore pulp to be treated in a state of greater density, that is, in a more concentrated form, with the result that an increased tonnage of ore can be handled by a given plant.

If the original ore contains a mixture of valuable ingredients, such as sulfids, the process may be carried out in a number of stages in order to take advantage of the differential inhibition of the colloids or colloidal slimes toward the flotation of certain of the minerals. For example, in a mixed sulfid ore, containing sulfids of lead, zinc and iron, the ore pulp may be treated for the removal of a portion only of the colloidal slimes in the manner above referred to, so that there will be retained sufficient of the colloids to prevent any considerable flotation of the iron and zinc sulfids while permitting the flotation of the lead sulfid, so that a lead concentrate can be obtained relatively free from zinc and iron. The ore pulp is then treated for the removal of an additional portion of the colloidal slimes, so that, for example, flotation of the zinc is permitted, or flotation of the zinc and iron. Where the zinc is floated without flotation of the iron, a still further removal of the colloidal slimes may then be effected in order to permit flotation of the iron sulfid. In carrying out differential flotation of the different constituents, advantage may also be taken, in each case of the well known selective qualities of certain oils, or other flotation agents, for the various constituents, such selective qualities supplementing the selectively inhibitory action of the colloidal constituents.

The colloidal slimes which are separated from the ore pulp are commonly of a character such that they can be run to waste. In case, however, these slimes carry sufficient values, they may be themselves subjected to a further treatment for the recovery of the values therefrom. For example, they may themselves be subjected to a further flotation treatment, for the separation of valuable constituents therefrom, or they may be coagulated and subjected to other treatment for the recovery of values.

The water accompanying the removed colloids may be separated and recovered for reuse. The colloidal slimes contained therein may thus be coagulated, and settled or filtered out. The water separated from the colloids may be purified, if necessary, to free

it from dissolved salts prejudicial to the flotation, or prejudicial to the maintenance of the desired state of dispersion of the colloidal matter in the ore pulp to which it may be subsequently added.

The process of the present invention may be combined with other than flotation operations. For example, the ore pulp may be subjected to a preliminary separation by jigs, or subjected to other preliminary methods of treatment prior to the flotation operation. In such cases, the colloidal slimes may be removed either just prior to the flotation operation or at some previous period of treatment of the ore pulp; and the addition of the dispersing agent, where such addition is necessary or desirable, may similarly take place at any suitable point or points prior to the removal of the colloids, so that the colloids will be in a dispersed state at the time of their removal.

The invention will be further illustrated by the following more detailed description, taken in connection with the diagrammatic flow sheet of the accompanying drawing. I will describe the process as applied to a zinc-lead-iron sulfid ore, with a dolomitic gangue, of the character occurring at Austinville, Va. The crude ore is crushed to about three-eighths inch mesh and mixed with water and with about one-quarter pound of sodium silicate per ton of ore, and the ore is then passed through a six mesh screen from which the over-size is passed to the rolls and returned to the screens. The ore passing through the screens then goes to the Hancock jig from which a lead concentrate is obtained and from which the overflow slimes, the tails, and the mixed lead-zinc-iron sulfide middlings are separately removed. The tailings go to waste. The overflow slimes pass to a distributor and thence to a series of two cone tanks from which a portion of the colloidal slimes, which I will refer to as primary colloid, is removed by overflow decantation and run to waste. The solids or thickened ore pulp then passes to a screw classifier where it is combined with water and with a further small amount of the sodium silicate, for example, about one pound per ton of original feed. The middlings from the Hancock jig pass to a Hardinge mill and thence to the screw classifier. From the classifier the over-size is returned to the Hardinge mill, while the under-size (through 65 mesh) goes to a Dorr tank or thickener.

The small amount of sodium silicate combined with the ore pulp serves to bring about and maintain a dispersed condition of the colloids or colloidal slimes so that these may be removed, to the desired extent, by overflow or decantation. Such removal may take place in tanks such as those of the Dorr, Allen or Callow types. With the

overflow there will be removed a corresponding amount of water so that the ore pulp will thereby become thickened. So much of the water may in fact be removed so that only sufficient water and accompanying slimes remain to permit the handling of the pulp as by pumping and its preparation for the next step in the process. The colloids or colloidal slimes in the operation illustrated in the accompanying flow sheet, are in part removed in the form of the so-called primary colloids, and in part in the form of what I will refer to as secondary colloids, in the over-flow from the Dorr tank.

From the Dorr tank, from which a part of the secondary colloids are removed and run to waste, or to a place of further treatment, the thickened ore pulp passes to a diaphragm pump and thence to a centrifugal pump, where it is diluted with water to the proper degree for flotation. It is then passed to the first flotation cell which is indicated as #1 lead rougher, and in which a differential flotation of the lead takes place with the aid of a suitable flotation agent, such as emulsified creosote oil.

From the #1 lead rougher the froth or concentrate passes to the #1 lead cleaner from which the middlings are returned to the #1 lead rougher while the froth or concentrate passes to the #2 lead cleaner from which the final lead concentrate is obtained, while the middlings are returned to the #1 lead cleaner.

The tails from the #1 lead rougher are combined with a further small amount of sodium silicate, for example, about one-half pound per ton, and with dilution water, and pass to another Dorr tank where the dispersion of the colloids is completed and a further portion of the colloids separated by decantation or over-flow and run to waste. The solids from the Dorr tank pass to a diaphragm pump and thence to a centrifugal pump where they are diluted with the proper amount of water and then pass to the zinc rougher cell in which flotation of the zinc is effected with the aid of a suitable flotation agent or agents, for example, emulsified crude oil, pine oil and copper sulfate. The tails from this rougher cell are run to waste while the froth or concentrate is passed to the #1 zinc cleaner cell and the froth or concentrate therefrom to the #2 cleaner cell from which the final zinc concentrate is obtained. The middlings from the respective cleaner cells are returned to the preceding cell for re-treatment.

The flotation cells indicated on the flow sheet as rougher cells, or cleaner cells, respectively, may be of common construction, for example, cells of the Callow type, or the Minerals Separation, Janney, or K. and K. type, and their operation may be carried out in a manner similar to that commonly prac-

ticed in the art, as will be readily understood.

In the process above described and illustrated on the accompanying flow sheet, the flotation process is preceded by a preliminary jiggling operation and the flotation operation itself is carried out progressively and with differential flotation of the lead and zinc. A part of the colloidal slimes is removed prior to the separation of the lead by flotation while sufficient of the colloids are retained to inhibit the flotation of zinc, this differential flotation being further promoted by the character of the oil employed. A further separation of the colloids is then effected so that their inhibiting action is sufficiently overcome and flotation of the zinc sulfid permitted, this flotation operation being also promoted by the addition of a suitable oil or other flotation agent.

It will be understood that other ores than lead and zinc ores can be treated in a similar manner and with proper selection of the agent or agents added for bringing about or maintaining the dispersed state of the colloids, (where the addition of such agent or agents is necessary for this purpose) depending upon the so-called colloidal charge, (whether electro-positive or electro-negative), of the constituents of the ore pulp being treated, this treatment being based upon tests made in accordance with the general principles of colloid chemistry. The agent or agents may thus be of an acid character, in case the colloidal constituents are such as are dispersed by an acid reagent, or of an alkaline character, if the preliminary tests indicate this to be desirable. The agent or agents may themselves partake of a colloidal character, as, for example, silicic acid or sodium or potassium silicates, or soaps which also display acid or alkaline characteristics, or they may be organic colloids, for example, gum arabic (acacia) in small amounts, may be added to promote the desired dispersion and separation of the colloids.

It will be seen that the process of the present invention involves the separation, from the ore pulp, prior to the flotation, of colloidal constituents, so that the flotation operation is carried out without interference therefrom, or with such regulated action of the remaining colloids as is desirable for the particular object in view, as in case a differential separation of certain constituents is desired. This preliminary separation may be readily effected by a simple overflow or decantation of the dispersed colloids, water being subsequently added to dilute the pulp if necessary to secure the desired separation. Where the colloids are not already present in a sufficiently dispersed state, a suitable agent for bringing them into such a state may be added, and the separation thereafter effected. In each case

there is separated from the ore pulp, along with the separated colloids, a corresponding amount of the water with its dissolved constituents so that the ore pulp is also freed from any objectionable constituents contained therein. This water, however, after a suitable purification, may be returned to the operation and used over and over again.

The decantation may be carried out on the counter-current principle by the use of a series of tanks arranged for counter-flow of the ore pulp and of the over-flow, so that a more or less complete separation of the colloids may be effected and the amount thereof regulated.

The process of the present invention can also be applied to the treatment of concentrates, as well as to the treatment of the original ore pulp, either for the purpose of effecting a re-treatment of the concentrates by flotation, or for the purpose of separating a mixed concentrate into its different constituents. For example, a mixed concentrate containing lead and zinc sulfides in substantially the relative proportions in which they existed in the ore, together with colloidal slimes which have been carried into the froth and concentrate, may be treated in the manner above referred to for the dispersion and removal of part of the colloidal constituents. The concentrate may then be subjected to a flotation operation with the addition of a proper amount of water to give the required dilution, and with the addition of a small amount of a flotation agent which will promote the flotation of the lead, and a lead concentrate may be thus obtained. Thereafter, the ore pulp may be given a further treatment for the separation of further amounts of the colloidal constituents and again subjected to flotation with the aid of a suitable flotation agent or agents to give a zinc concentrate. As the result of such a re-treatment the mixed concentrate will be separated into its constituents, and further concentration thereof will be effected.

Where the mineral pulp or the concentrate contains in solution in the water thereof constituents which prevent dispersion or deflocculation, such constituents may be in part or in whole removed, as by the removal of the water from the ore pulp prior to the dispersion or deflocculation treatment, or they may be otherwise neutralized and rendered harmless by methods and agents which are generally known, and can be regulated by simple tests. For example, an excessive quantity of magnesium sulphate or of some other electrolyte in the pulp may interfere with the proper action of sodium silicate as a dispersing agent. Such a condition may be corrected by washing the ore for the removal of soluble salts. Where the

pulp is acid or where there is latent acidity due to the occlusion of sulphur dioxide, an alkali may be added to correct the acidity, whereby the sodium silicate is enabled to act
5 in the desired manner.

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
10 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
15 as in connection with other processes involving the principles of flotation.

The present invention is of general application in the concentration or segregation by the flotation process of any materials amenable to treatment by such process. Throughout the present specification and the appended claims, I have used the terms "ores"
20 and "minerals" to designate any material adapted to be treated by the flotation process, and it is to be understood that these terms are intended to cover generically sulfides and other metalliferous substances naturally or otherwise amenable to treatment by flotation,
25 ores and their concentrates, tailings, metallurgical products and residues, coal and all other materials naturally or otherwise amenable to treatment by flotation for the segregation or concentration of a particular constituent or constituents thereof.

35 I claim:—

1. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises
40 dispersing normally flocculated colloidal constituents in the mineral pulp, removing colloidal constituents in a dispersed or deflocculated condition from the mineral pulp to an extent sufficient to reduce the flotation-inhibitory effects thereof, and thereafter subjecting the remaining mineral pulp to a
45 flotation operation.

2. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises
50 treating the mineral pulp to promote dispersion or deflocculation of normally flocculated colloidal constituents therein, then removing from the mineral pulp to the desired extent the so dispersed or deflocculated
55 colloidal constituents, and thereafter subjecting the remaining mineral pulp to a flotation operation.

3. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises
60 adding to the mineral pulp a dispersing or deflocculating agent for promoting dispersion or deflocculation of flotation-inhibitory colloidal constituents therein, removing to the desired extent the dispersed or defloc-

culated colloidal constituents from the mineral pulp, and thereafter subjecting the pulp to a flotation operation.

4. The method of improving the flotation of minerals associated in a mineral pulp with
70 colloidal constituents, which comprises dispersing normally flocculated colloidal constituents in the mineral pulp, subjecting the mineral pulp to an overflow or decantation treatment for the removal therefrom of the
75 dispersed or deflocculated colloidal constituents, together with a corresponding portion of the water of the pulp, to an extent sufficient to reduce the flotation-inhibitory effects thereof, and thereafter subjecting the
80 remaining mineral pulp to a flotation operation.

5. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises
85 adding to the mineral pulp a dispersing or deflocculating agent for promoting dispersion or deflocculation of flotation-inhibitory colloidal constituents therein, subjecting the mineral pulp to a decantation treatment for the removal therefrom to the desired extent of the dispersed or deflocculated
90 colloidal constituents together with a corresponding portion of the water of the pulp, and thereafter subjecting the pulp to a flotation operation.

6. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises
100 treating the mineral pulp to promote dispersion or deflocculation of normally flocculated colloidal constituents therein, removing from the mineral pulp the dispersed colloidal constituents, together with a corresponding
105 portion of the water of the pulp, to an extent sufficient to reduce the flotation-inhibitory effects thereof, and subjecting the mineral pulp, freed as aforesaid of the dispersed or deflocculated colloidal constituents, to a
110 flotation operation.

7. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises
115 dispersing normally flocculated colloidal constituents in the mineral pulp, removing the colloidal constituents in a dispersed or deflocculated condition from the mineral pulp to an extent sufficient to reduce the flotation-inhibitory effects thereof, subjecting the remaining mineral pulp to a flotation
120 operation, and subjecting the removed colloidal constituents to appropriate treatment for recovering the values therefrom.

8. The method of improving the flotation of minerals associated in a mineral pulp
125 with colloidal constituents, which comprises agitating and heating the mineral pulp under conditions promoting dispersion or deflocculation of normally flocculated colloidal constituents therein, removing the
130

dispersed colloidal constituents from the mineral pulp to an extent sufficient to reduce the flotation-inhibitory effects thereof, and thereafter subjecting the remaining pulp to a flotation operation.

9. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises agitating the mineral pulp under conditions promoting dispersion or deflocculation of normally flocculated colloidal constituents therein, removing the dispersed or deflocculated colloidal constituents from the mineral pulp to an extent sufficient to reduce the flotation-inhibitory effects thereof, and thereafter subjecting the remaining pulp to a flotation operation.

10. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises heating the mineral pulp under conditions promoting dispersion or deflocculation of normally flocculated colloidal constituents therein, removing the dispersed colloidal constituents from the mineral pulp to an extent sufficient to modify the flotation-inhibitory effects thereof, and thereafter subjecting the remaining pulp to a flotation operation.

11. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises agitating and regulating the temperature of the mineral pulp in the presence of a dispersing or deflocculating agent for promoting dispersion or deflocculation of flotation-inhibitory colloidal constituents therein, removing to the desired extent the dispersed or deflocculated colloidal constituents from the mineral pulp, and thereafter subjecting the pulp to a flotation operation.

12. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises agitating the mineral pulp in the presence of a dispersing or deflocculating agent for promoting dispersion or deflocculation of flotation-inhibitory colloidal constituent therein, removing to the desired extent the dispersed or deflocculated colloidal constituents from the mineral pulp, and thereafter subjecting the pulp to a flotation operation.

13. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents which comprises regulating the temperature of the mineral pulp in the presence of a dispersing or deflocculating agent for promoting dispersion or deflocculation of flotation-inhibitory colloidal constituents therein, removing to the desired extent the dispersed or deflocculated colloidal constituents from the mineral pulp, and thereafter subjecting the pulp to a flotation operation.

14. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises subjecting the mineral pulp to a grinding operation under conditions promoting dispersion or deflocculation of normally flocculated colloidal constituents therein, removing the dispersed colloidal constituents from the mineral pulp to an extent sufficient to reduce the flotation-inhibitory effects thereof, and thereafter subjecting the remaining pulp to a flotation operation.

15. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises subjecting the mineral pulp to a grinding operation in the presence of a dispersing or deflocculating agent for promoting the dispersion or deflocculation of flotation-inhibitory colloidal constituents therein, removing to the desired extent the dispersed or deflocculated colloidal constituents from the mineral pulp, and thereafter subjecting the pulp to a flotation operation.

16. The method of effecting the differential flotation of minerals from a mixed-mineral pulp containing colloidal constituents, which comprises removing a part of the colloidal constituents from the mineral pulp to permit flotation of one mineral species thereof while retarding the flotation of others species, subjecting the mineral pulp to a flotation operation, removing a further amount of colloidal constituents from the mineral pulp to permit flotation of a further mineral species, and subjecting the mineral pulp to a further flotation operation.

17. The method of effecting the differential flotation of minerals from a mixed-mineral pulp containing colloidal constituents, which comprises treating the mineral pulp to promote dispersion or deflocculation of normally flocculated colloidal constituents therein, removing from the pulp sufficient of the dispersed or deflocculated colloidal constituents to permit flotation of one mineral species of the pulp while retarding the flotation of another mineral species thereof, and subjecting the pulp to a flotation operation.

18. The method of effecting the differential flotation of minerals from a mixed-mineral pulp containing colloidal constituents, which comprises treating the mineral pulp to promote dispersion or deflocculation of colloidal constituents therein, removing from the pulp sufficient of the dispersed or deflocculated colloidal constituents to permit flotation of certain of the mineral species of the pulp while retarding the flotation of other mineral species thereof, subjecting the pulp to a flotation operation effecting a further removal from the remain-

ing pulp of colloidal constituents to permit the flotation of a further mineral species of the pulp, and subjecting the pulp to a further flotation operation.

19. The method of effecting the differential flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises removing from the pulp a part of the colloidal constituents to permit flotation of certain mineral species of the pulp while retarding the flotation of other mineral species thereof, subjecting the pulp to a flotation operation with the aid of a flotation agent promoting the differential separation by flotation, removing from the pulp a further portion of the colloidal constituents to permit the flotation of other mineral species thereof, and subjecting the pulp to a further flotation operation with the aid of a flotation agent promoting the flotation of such other mineral species.

20. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises adding to the mineral pulp a small amount of sodium silicate for promoting dispersion or deflocculation of the colloidal constituents therein, subjecting the pulp to a decantation treatment to remove therefrom to the desired extent the dispersed or deflocculated colloidal constituents together with a corresponding portion of the water of the pulp, diluting the resulting mineral pulp, and subjecting the diluted pulp to a flotation operation.

21. The method of effecting the differential separation of lead and zinc sulfides from minerals containing the same and associated in a mineral pulp with colloidal constituents, which comprises removing from the pulp a portion of the colloidal constituents to permit flotation of the lead sulfide while retaining sufficient to retard flotation of the zinc sulfide, subjecting the pulp to a flotation operation to effect flotation of the lead sulfide, removing from the remaining pulp a further portion of the colloidal constituents therein to permit flotation of the zinc sulfide, and subjecting such remaining pulp to a further flotation operation to effect flotation of the zinc sulfide.

22. The method of effecting the differential flotation of lead and zinc sulfides from ores containing the same and associated in a mineral pulp with colloidal constituents, which comprises adding to the mineral pulp an appropriate agent for promoting dispersion or deflocculation of the colloidal constituents, decanting from the mineral pulp a portion of the dispersed or deflocculated colloidal constituents sufficient to permit flotation of the lead sulfide while retaining sufficient to retard flotation of the zinc sulfide, subjecting the pulp to a flotation operation with the aid of a flotation agent promoting

the differential flotation of the lead sulfide, removing from the remaining pulp a further portion of the colloidal constituents therein to permit flotation of the zinc sulfide, and subjecting such remaining pulp to a further flotation operation with the aid of a flotation agent promoting the flotation of the zinc sulfide.

23. The method of effecting the differential flotation of lead and zinc sulfides from minerals containing the same and associated in a mineral pulp with colloidal constituents, which comprises adding to the pulp a small amount of sodium silicate to promote dispersion or deflocculation of the colloidal constituents therein, removing a portion of the dispersed or deflocculated colloidal constituents from the pulp by a decantation treatment with accompanying removal of a corresponding portion of the water of the pulp, diluting the pulp and subjecting it to a flotation operation with the aid of a flotation agent promoting the flotation of the lead sulfide, adding to the remaining pulp a further small amount of sodium silicate and removing therefrom a further amount of the resulting dispersed colloidal constituents to permit flotation of the zinc sulfide, and subjecting such remaining pulp to a further flotation operation with the aid of a flotation agent promoting the flotation of the zinc sulfide.

24. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises regulating the temperature of the mineral pulp under conditions promoting the dispersion or deflocculation of normally flocculated colloidal constituents therein, removing the dispersed colloidal constituents from the mineral pulp to an extent sufficient to reduce the flotation-inhibitory effects thereof, and thereafter subjecting the remaining pulp to a flotation operation.

25. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises agitating the mineral pulp and regulating its temperature under conditions promoting dispersion or deflocculation of normally flocculated colloidal constituents therein, removing the dispersed colloidal constituents from the mineral pulp to an extent sufficient to reduce the flotation-inhibitory effects thereof, and thereafter subjecting the remaining pulp to a flotation operation.

26. The method of effecting the concentration by flotation of zinc sulfide from an ore containing the same and associated in a mineral pulp with colloidal constituents, which comprises treating the mineral pulp with sodium silicate for promoting dispersion or deflocculation of the colloidal constituents, removing to the desired extent the dispersed or deflocculated colloidal constituents from

the mineral pulp, and thereafter subjecting the pulp to a flotation operation to effect the removal therefrom by flotation of the zinc sulfide.

27. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises adding to the mineral pulp a small amount of sodium silicate for promoting dispersion or deflocculation of the colloidal constituents therein, removing from the mineral pulp to the desired extent the resulting dispersed or deflocculated colloidal constituents, and thereafter subjecting the pulp thus freed of the removed colloidal constituents to a flotation operation.

28. The method of effecting the concentration by flotation of lead sulfide from an ore containing the same and associated in a mineral pulp with colloidal constituents, which comprises treating the mineral pulp with sodium silicate for promoting dispersion or deflocculation of the colloidal constituents, removing to the desired extent the dispersed or deflocculated colloidal constituents from the mineral pulp, and thereafter subjecting the pulp to a flotation operation to effect the removal therefrom by flotation of the lead sulfide.

29. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises dispersing or deflocculating normally flocculated colloidal constituents therein, removing the dispersed or deflocculated colloidal constituents from the mineral pulp to an extent sufficient to reduce the flotation-inhibitory effects thereof, and thereafter subjecting the remaining pulp to a flotation operation.

30. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises adding to the mineral pulp a dispersing or deflocculating agent for promoting dispersion or deflocculation of colloidal constituents therein, removing the dispersed or deflocculated colloidal constituents from the mineral pulp to an extent sufficient to reduce the flotation-inhibitory effects there-

of, and thereafter subjecting the remaining pulp to a flotation operation.

31. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises adding to the mineral pulp a dispersing or deflocculating agent for promoting dispersion or deflocculation of colloidal constituents therein, subjecting the mineral pulp to a decantation treatment for the removal therefrom of the dispersed or deflocculated colloidal constituents, together with a corresponding portion of the water of the pulp, to an extent sufficient to reduce the flotation-inhibitory effects thereof, and thereafter subjecting the remaining pulp to a flotation operation.

32. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises treating the mineral pulp to promote dispersion or deflocculation of normally flocculated colloidal constituents therein, removing from the mineral pulp the so dispersed or deflocculated colloidal constituents, together with a corresponding portion of the water of the pulp, to an extent sufficient to reduce the flotation-inhibitory effects thereof, diluting the remaining mineral pulp with substantially colloid-free water, and subjecting the diluted pulp to a flotation operation.

33. The method of improving the flotation of minerals associated in a mineral pulp with colloidal constituents, which comprises adding to the mineral pulp a dispersing or deflocculating agent for promoting dispersion or deflocculation of colloidal constituents therein, subjecting the mineral pulp to a decantation treatment for the removal therefrom of the so dispersed or deflocculated colloidal constituents, together with a corresponding portion of the water of the pulp, to an extent sufficient to reduce the flotation-inhibitory effects thereof, diluting the remaining mineral pulp with colloid-free water, and subjecting the diluted pulp to a flotation operation.

In testimony whereof I affix my signature.

WALTER O. BORCHERT.