B. H. DOSENBACH AND W. A. SCOTT.
E. M. DOSENBACH, DISTRIBUTEE OF B. H. DOSENBACH, DEC'D.
PROCESS OF CONCENTRATING ORE.
APPLICATION FILED JULY 19, 1917. RENEWED MAY 6, 1921.

1,401,055. Patented Dec. 20, 1921.

4 SHEETS—SHEET 1.

Fig. 1.

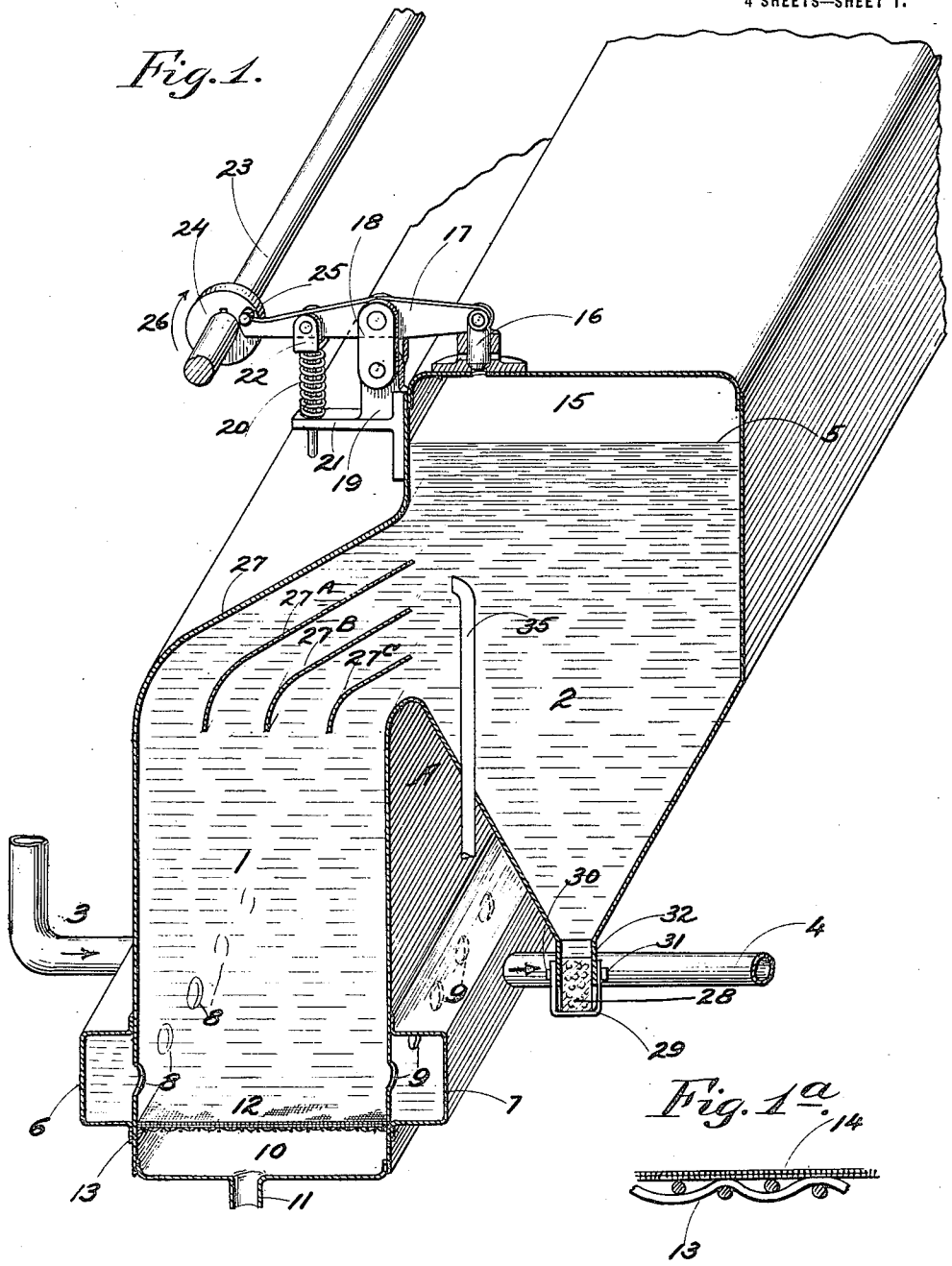


Fig. 1a.

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4 SHEETS—SHEET 2.

Fig. 2.

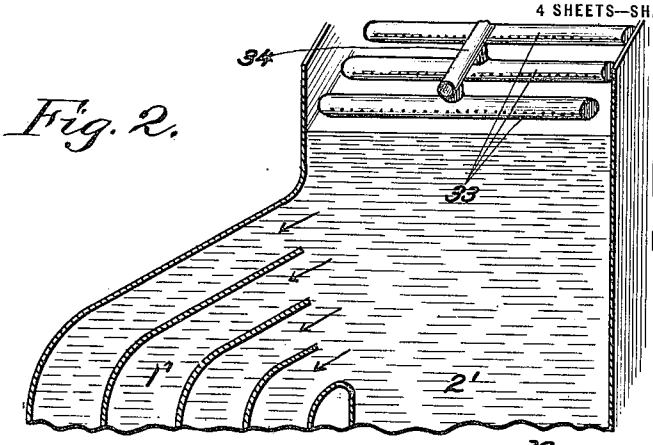


Fig. 3.

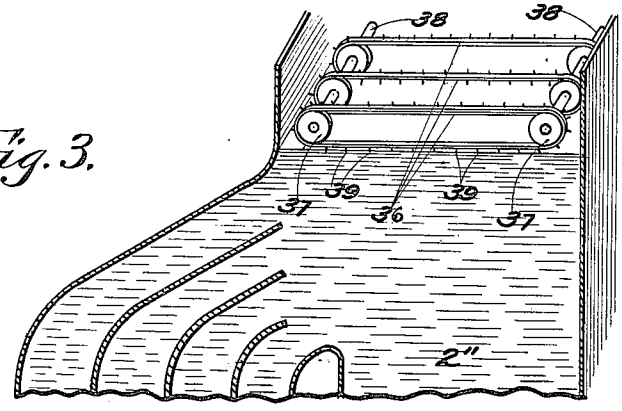
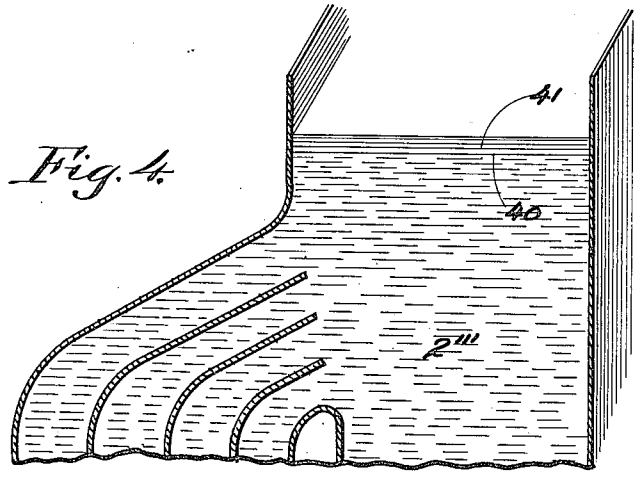


Fig. 4.



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4 SHEETS—SHEET 3.

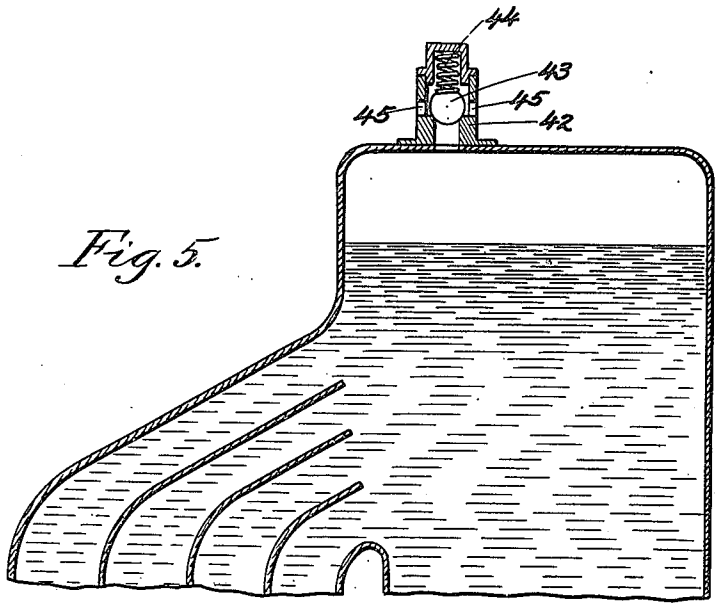


Fig. 5.

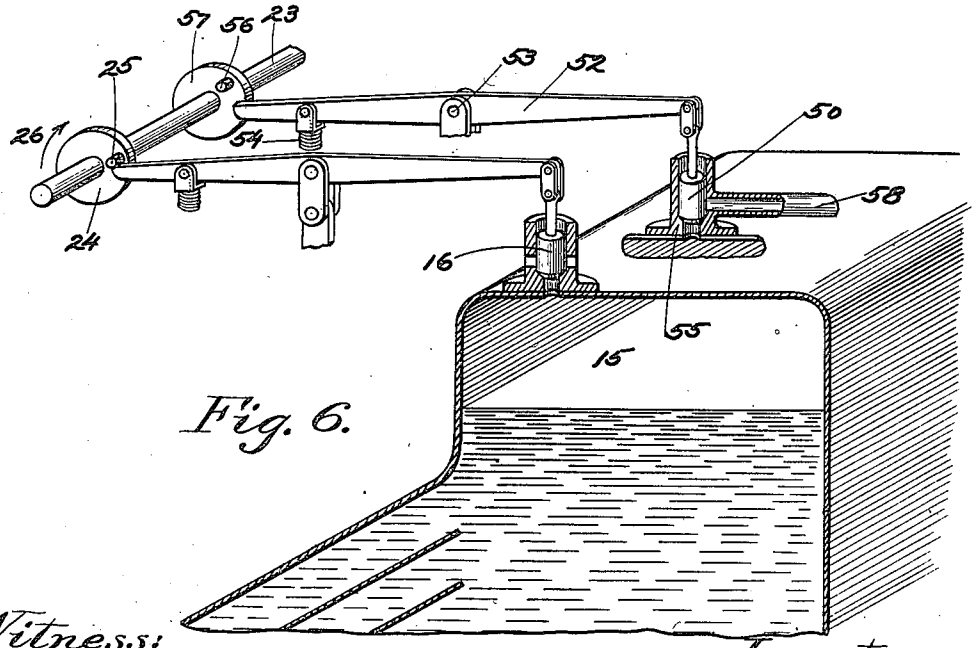


Fig. 6.

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4 SHEETS—SHEET 4.

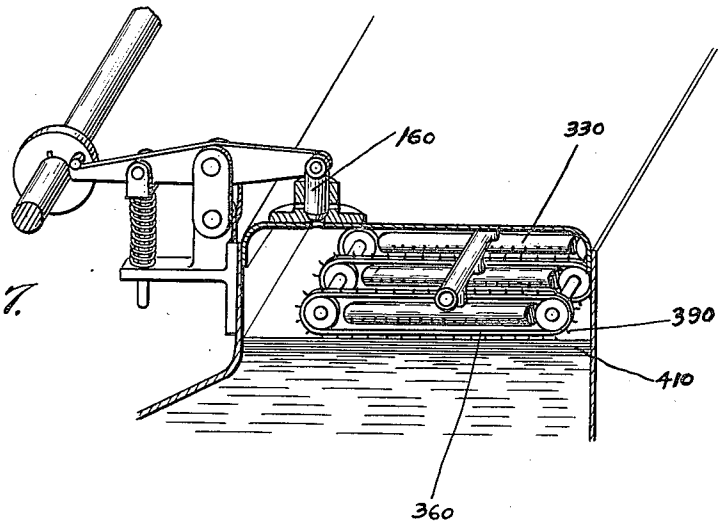


Fig. 7.

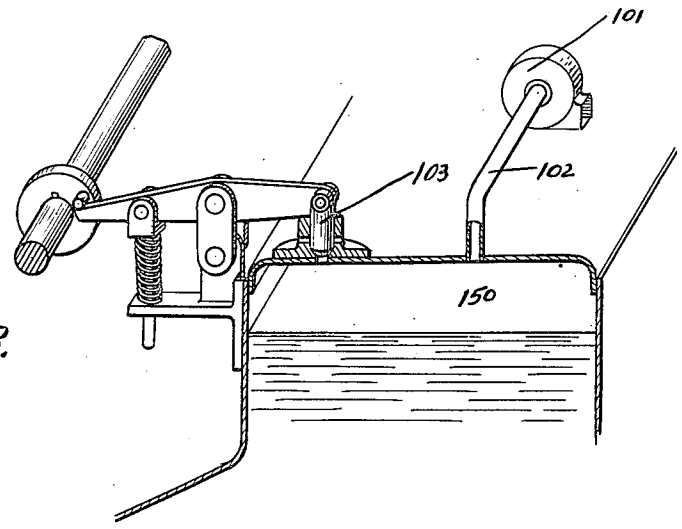


Fig. 8.

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UNITED STATES PATENT OFFICE.

BENJAMIN H. DOSENBACH, OF BUTTE, MONTANA, AND WALTER A. SCOTT, OF CHICAGO, ILLINOIS; SAID SCOTT ASSIGNOR TO MINERALS SEPARATION NORTH AMERICAN CORPORATION, A CORPORATION OF MARYLAND; EDNA M. DOSENBACH, DISTRIBUTEE BY ORDER OF COURT IN THE ESTATE OF SAID BENJAMIN H. DOSENBACH, DECEASED.

PROCESS OF CONCENTRATING ORE.

1,401,055. Specification of Letters Patent. Patented Dec. 20, 1921.

Application filed July 19, 1917, Serial No. 181,539. Renewed May 6, 1921. Serial No. 467,319.

To all whom it may concern:

Be it known that we, BENJAMIN H. DOSENBACH, a citizen of the United States, residing at Butte, in the county of Silver Bow and State of Montana, and WALTER A. SCOTT, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Processes of Concentrating Ore, of which the following is a specification.

The object of our invention is the provision of a new and improved process for concentrating ores. It is well known that bubbles of air or other gas in an ore pulp have the property of attracting particles of metallic sulfid or a free metal but do not so attract particles of gangue or other associated mineral. Such gaseous bubbles also have a preferential attraction for graphite and our invention is intended for application in connection with any product from which the particles attracted by gaseous bubbles are to be separated from other material.

As is well known, the attraction of gaseous bubbles for certain constituents of ores has been utilized in the well known flotation process in which air or other gas is introduced into a freely flowing ore pulp to which some modifying agent has been added, the result being the flotation of certain ingredients of the ore in the form of a froth of more or less permanency according to the conditions under which the operation is carried out. In the flotation process as generally practised the gas employed is air and the air is introduced into the pulp either by violent mechanical agitation which has the effect of beating air into the mixture, or by introducing the air through a porous bottom provided in the vessel containing the pulp, the air pressure being just sufficient to overcome the hydraulic head and to cause the air to overcome the resistance of the pores in the permeable bottom of the vessel and to produce the necessary agitation. As implied by the term flotation process, the part of the ore which is to be separated from the remainder is floated on the surface of the pulp, the mineral particles forming a coating more or less continuous around the air bubbles. After the mineral coated bubbles have been brought to the surface in the form of a floating froth the froth is removed by overflow and in the process as ordinarily carried out constitutes the concentrate.

One of the advantages of our improved process is the collection of the concentrate in a more convenient form than the floating froth referred to, this being accomplished by breaking the gaseous bubbles as soon as they reach the surface of the pulp and causing the mineral carried by them to be dropped in a body of water separate and apart from the pulp from which the bubbles gather the mineral. By this means, the concentrate instead of being gathered as a bulky froth, the clean cut separation of which from the pulp presents more or less difficulty, is separated as a precipitate of metalliferous mineral particles which settle to the bottom of the vessel provided therefor. In addition to the convenience of this new process as distinguished from the separation and handling of bulky froths carrying considerable amounts of water, we have found that our new process effects superior results in the way of percentage of recovery and grade of concentrate.

In order to set forth our process more clearly we will describe one form of apparatus, with several modifications thereof, suitable for use in carrying out the process, it being understood, however, that the apparatus can be varied through wide limits and that the process is in no way restricted in its application to the use of any particular form of mechanical device.

In the drawings Figure 1 is a perspective view partly in section of one form of apparatus in the use of which the rising bubbles are broken by varying gaseous pressure above the surface of the pulp.

Fig. 1[a] is a detail view of a porous medium through which air is introduced into the pulp.

Fig. 2 is a modified form of apparatus in which a water spray above the surface of the pulp serves to rupture the rising bubbles and also serves another purpose hereinafter to be specifically pointed out.

Fig. 3 represents another modification in which provision is made for rupturing the air bubbles by mechanical means.

Fig. 4 is another modification in which illustration a layer of oil is shown upon the surface of the pulp, it having been found that such a layer of oil has the effect of stripping mineral particles from bubbles rising through the underlying liquid and generally of causing the bubbles to break.

Fig. 5 represents another modification in which an automatic or check valve is employed for intermittently establishing communication with the outer atmosphere.

Fig. 6 is a detail view of a structure similar to that shown in Fig. 1 with the exception that an inlet valve is provided in addition to the outlet valve, the inlet valve communicating with a source of air under pressure.

Fig. 7 is a view of the upper part of an apparatus similar to that shown in the other views and embodying the bubble making devices illustrated in Figs. 1, 2, 3 and 4.

Fig. 8 is a view of the upper part of an apparatus similar to that illustrated in Fig. 1 but with the addition of means for exhausting the air above the pulp level.

The apparatus shown in Fig. 1 comprises a vessel designated generally by the letter "A". This vessel comprises a pulp compartment 1 and a settling chamber 2. The pulp compartment and settling chamber communicate one with the other and together form the closed vessel A. The apparatus may be of any length desired. The pulp enters the pulp compartment through the pipe 3 and is discharged through the pipes 4. The pipe 3 receives the pulp from an elevation sufficient to maintain the level of liquid in the apparatus at about the position indicated by the horizontal line 5. The requisite level may be controlled by a variety of means such as the relation between the inflow through the pipe 3 and outflow through the pipe 4. If the apparatus is constructed of an elongated form as illustrated in Fig. 1, the pulp may be properly distributed to flow across the apparatus in an even stream by means of distributing boxes 6 and 7, which take the form of rectangular extensions, one upon each side of the pulp compartment and near the lower part thereof. The inlet pipe 3 and outlet pipe 4 communicate with these distributing boxes and the distributing boxes communicate with the pulp compartment through inlet openings 8 and outlet openings 9 respectively. The distribution of the openings 8 and 9 and the size of the inlet and discharge distributing boxes 6 and 7 are matters of regulation to meet the needs of the particular ore being treated and the best arrangement of these parts can be easily determined by trial. An air chamber 10 is provided at the bottom of the pulp compartment 1 and air is supplied to the chamber 10 through the pipe 11 under sufficient pressure to overcome the hydraulic head of the liquid contained in the vessel A and to cause the air to pass through the pores of the permeable bottom 12 of the pulp compartment, this permeable medium 12 forming the top of the air chamber 10. This permeable medium may be of any suitable material, such as unglazed earthenware or other porous substance. In the present instance we have shown a usual form of construction of the permeable medium, consisting of a wire screen 13 to which one or more plies of canvas or other fabric 14 is secured. The pulp compartment 1 thus forms a gas supply region for the pulp.

As above stated, the vessel A is completely closed, openings being provided for the inlet and outlet of pulp and for the inlet of air as above described. In the upper part of the vessel A, however, means are provided for intermittently establishing communication between the space above the liquid level 5 and the atmosphere. The object of establishing such intermittent communication is to cause a series of variations or pulsations in the pneumatic pressure in the space 15 above the liquid level in the settling chamber 2. The particular means illustrated in Fig. 1 for intermittently establishing communication with the atmosphere is a valve 16 pivoted to one end of a lever 17 centrally mounted on a link 18, which, in turn is pivotally mounted on a bracket 19 extending from the wall of the vessel A. The valve is kept normally closed by means of a compression spring 20, the lower end of which abuts against an extension 21 of the bracket 19 and the upper end of which bears against a yoke 22 pivoted to the lever 17 adjacent the end thereof opposite the valve. To a rotatable shaft 23 a collar 24 is keyed and a pin 25 projecting from the collar 24 engages the end of the lever 17 opposite the valve 16. The shaft 23 revolves in the direction indicated by the arrow 26 and serves to depress the left hand end of the lever 17 once during each revolution, thus opening the valve 16 for a brief interval during each revolution of the shaft 23. By properly adjusting the relation between the pin 25 and the end of the lever 17 and properly adjusting the speed of the shaft 23 and the distance of the pin 25 from the center of said shaft, the valve 16 can be opened with the proper degree of frequency, for the proper interval, and with the necessary speed of opening and closing to produce pulsations of pressure such as will best accomplish the purpose desired.

In operation the pulp flows in through the pipe 3 to the distributing box 6, thence into the pulp compartment through the openings 8. The pulp then flows in a horizontal cur-

rent across the pulp compartment and is discharged through the openings 9 into the discharge box 7 and leaves the apparatus through the outlet pipe 4. By this means a horizontal current of pulp is established through the pulp compartment 1. Previous to entrance into the apparatus or while in the apparatus the pulp is modified preferably by the addition of a suitable modifying agent such as some oil, or other soluble or insoluble organic or inorganic substance. Under some conditions, however, we have found that the addition of such a modifying agent may not be necessary.

The air introduced into the pulp in the pulp compartment 1 permeates the pores in the porous medium 12 and rises through the pulp in the form of bubbles, which, during their upward passage through the pulp gather the metalliferous mineral particles and carry them upward. When the air bubbles encounter the inclined part 27 of the upper part of the inclosing wall of the pulp compartment they are deflected in a horizontal direction to the settling chamber 2. In order to increase the capacity of the apparatus for deflecting bubbles horizontally to the settling chamber we provide a plurality of deflecting diaphragms 27^A, 27^B and 27^C substantially parallel to the wall 27 and arranged at intervals across the upper part of the pulp compartment 1. As the air bubbles rise throughout the cross-section of the pulp in the pulp compartment 1, those rising in the space between the lower edge of the diaphragm 27^A and the left hand wall of the compartment 1, will ride upwardly along the surface 27 of the outer wall of the compartment; those rising between the lower edges of the other diaphragms will ride upward and horizontally along the lower surface of the uppermost diaphragm. In this way a plurality of passages are provided for the rising bubbles and the extent of surface along which they may be deflected into the settling chamber is correspondingly increased.

During the interval when the valve 16 is closed, the air rising through the pulp will build up a pressure in the space 15 above the liquid surface in excess of atmospheric pressure and when the valve is suddenly opened by the action of the pin 25 upon the lever 17 this super-atmospheric pressure is suddenly relieved and the pressure in the space 15 reduced to that of the exterior atmosphere. This successive building up of pressure in the space 15 and the sudden relief of that pressure sets up a series of pulsations in the space 15 which has the effect of breaking the air bubbles as soon as they reach the surface 5 of the liquid in the settling chamber. Apparently the breaking of the air bubbles is due to the fact that the pulsations of pressure in the space 15 cause a difference in pressure inside and outside of the air bubbles, thus causing them to break. In any event when operated as above described, the bubbles disappear instantly upon reaching the surface 5 of the liquid in the settling chamber 2 and no froth or float of any character is formed. The breaking of the bubbles in the manner described releases the metalliferous mineral carried by them and this mineral thereupon settles in the settling chamber 2, from which it may be removed continuously or at intervals, preferably at intervals, through a valve at the lower tapering end of the settling chamber. In this instance we have shown the valve as taking the form of a plug 28 and a yoke 29 pivoted at 30 and 31 to the outlet spout 32, the yoke 29 serving to hold the plug 28 in position. By moving the yoke 29 to one side the plug may be withdrawn for the purpose of discharging the concentrate.

When operated as above described, the concentrate settles in the converging bottom of the settling chamber 2 and by properly proportioning the settling chamber a longer or shorter interval may be given for the settlement of the concentrate. By giving a sufficiently long interval for settlement of the concentrate between the periods when it is discharged through the valve the concentrate may be withdrawn with a minimum of water, that is, in the form of mineral carrying practically no water other than that adhering to the particles. If desired, however, the concentrate may be withdrawn in a state of greater dilution and this may be desirable when the concentrate is to be retreated for the purpose of raising its grade. When the latter procedure is followed the concentrate may be conducted from the discharge of the settling chamber 2 to another apparatus of the same form and subjected to a cleaning operation, the cleaner tailings preferably being returned to the first apparatus to be treated with original feed.

Obviously the concentrate may be cleaned more than once if desired and the cleaner tailings may be returned either to the first apparatus, that is, to the rougher machine, or may be returned to one of the preceding cleaner machines.

Our improved process can be used in connection with any other concentration process or apparatus or may be used, when desirable, as the sole means of concentration.

Instead of braking the bubbles by fluctuating air pressure the same end may be accomplished by means of a water spray playing upon the upper surface of the liquid in the separation chamber. We have shown an apparatus for this purpose in Fig. 2 of the drawings in which a series of pipes 33 are arranged just above the surface of the liquid in the separation chamber 2', these pipes be-

ing supplied with water under requisite pressure through a header 34 to which each of the pipes 33 is connected. The water for the spray may be clear water from outside of the system or if desirable to prevent over-dilution of the pulp, part or all of the water for the spray may be drawn from the settling chamber 2′. The presence of mineral particles in the spray water would not interfere with its efficiency. The pipes 33 are perforated on their lower sides whereby a spray of water is kept playing over the surface of the liquid in the separation chamber, thus effectually breaking the bubbles as fast as they rise to the surface. In this form of apparatus it is not necessary that the vessel be closed at the top inasmuch as air pressure or fluctuating air pressure above the surface of the liquid plays no part in the process when carried out with a spray of water. When a spray of water is employed as described, the water serves a function additional to that of breaking the bubbles, this function arising from the fact that the water entering through the spray pipes finds its outlet through the pulp compartment 1′ and flows out the discharge openings 9, discharge box 7 and outlet 4. This flow of water sets up a gentle current through the passage leading from the settling chamber to the pulp compartment in the direction indicated by the arrows in Fig. 2, thus effectually preventing the pollution of the liquid in settling chamber 2′ by the entrance thereinto of pulp from the compartment 1′.

In the form of apparatus shown in Fig. 1 clear water may, if desired, be supplied to the settling chamber 2 at any convenient point, as through the inlet pipe 35, such flow of clear water serving as above described to prevent any flow of pulp from the compartment 1 to the chamber 2.

When the apparatus shown in Fig. 1, however, is operated without any inflow of clear water into the settling chamber 2 practically no difficulty arises from pollution of the liquid in chamber 2 by the pulp in compartment 1, for the reason that the chamber 2 is out of the line of flow of pulp through the apparatus, the pulp flowing through the compartment 1 from side to side. The settling chamber 2 forms a relatively quiescent region which serves as a breaking-down region for the bubbles and where the concentrate released from the bubbles can be collected separate from the gangue. The only time when there is any tendency for pulp to flow from the compartment 1 to the chamber 2 is when the concentrate discharge valve is opened by withdrawing the plug 28. If a continuous flow of clear water into the settling chamber 2 is not desirable water may be allowed to enter the chamber 2 through the inlet 35 only during the periods when concentrate is being discharged from the settling chamber 2. Such inflow of water while concentrate is being discharged acts to replace the material withdrawn without permitting flow of pulp from the compartment 1 to the settling chamber 2.

In Fig. 3 we have illustrated mechanical means for breaking the bubbles as they rise to the surface, such mechanical means taking the form of a series of belts or sprocket chains 36 operated by sprocket wheels 37 mounted upon shafts 38, which may be driven from any suitable source of power. The sprocket chains or belts 36 carry projecting pins 39 which project just beneath the surface of liquid in the settling chamber 2″ and thus serve to mechanically rupture the bubbles as they rise to the surface. In this form of apparatus in which the bubbles are mechanically ruptured it, of course, is not necessary that the upper part of the vessel be closed, as fluctuating air pressure plays no part in the process when so carried out.

In Fig. 4 we have shown the upper part of the apparatus, the water level being indicated at 40, above which is shown a layer of oil 41. We have found that such a layer of oil tends to strip the mineral from the rising bubbles and to break the bubbles. When the process is so operated the concentrate can be collected as above described. While a considerable part of the concentrate will collect in the oil layer and in the inter-face between the oil layer and the underlying liquid, the oil layer and inter-face soon become overloaded, after which the mineral will drop to the bottom of the settling chamber. When dependence is placed upon the oil layer as described, the upper part of the vessel may be left open.

In Fig. 5 we have shown a form of apparatus operating in the same way as the apparatus shown in Fig. 1, the difference being solely in the form of mechanism. In the apparatus shown in Fig. 5 we have provided at the top of the settling chamber an upwardly projecting valve seat 42 upon which is seated a spring valve 43 held in place by a coil spring 44. Ports 45 permit air to escape from the space above the liquid level in the settling chamber when the valve 43 rises. In this form of device the tension of the spring 44 is so adjusted that when the air pressure in the space above the liquid rises to a predetermined point, a point sufficiently low not to interfere with the entrance of air through the porous bottom of the pulp compartment, the valve 43 rises from its seat against the spring pressure, thus permitting a sudden egress of air from the space at the top of the settling chamber.

In Fig. 6 we have shown a structure similar in its action to the structure shown in Fig. 1 except for the fact that means additional to the escape valve 16 are provided

for causing fluctuations in the gas pressure above the surface of the liquid. This additional means consists of a valve 50 actuated by connection with a lever 52. The lever 52 is pivoted centrally at 53 and a compression spring 54 normally holds the left hand end of the lever upward and the right hand end downward, thus keeping the valve 50 upon its seat 55. The lever 52 is actuated by a pin 56 upon a collar 57 keyed to the shaft 23. Once in each revolution the pin 56 contacts with the left hand end of the lever 52 and depresses it, thereby raising the valve 50 from its seat and permitting an ingress of air under pressure through the pipe 58. The pipe 58 is connected with any suitable source of gas under pressure. The relative angular positions of the pins 25 and 56 on the disks 24 and 57 is such that just after the valve 16 closes, thus terminating escape of air from the compartment 15 above the liquid level in settling chamber 2, the valve 50 is opened for a brief interval to admit air under pressure to the space 15. By this means the restoration of pressure in the space 15 is rendered more rapid and the shock to the rising bubbles is thereby increased in intensity. By rendering the increase in pressure more sudden than would be caused by the rising of air through the pulp from the perforated bottom of the pulp compartment, the rising bubbles are subjected to a more intense shock with the result that the tendency to rupture them is increased. Both the escape valve 16 and the pressure admission valve 50 are opened for but a comparatively brief interval, the object being to suddenly lower, then suddenly raise the gaseous pressure in the space 15 for the purpose of creating the pulsations in pressure referred to. Obviously other means than a source or reservoir of compressed air connected with the inlet 58 might be used for suddenly increasing the gas pressure in the space 15 just after the closing of the escape valve 16.

Either one of the means above described may be employed for rupturing the bubbles as they rise to the surface or several or all of said means may be employed in conjunction with each other. The water spray shown in Fig. 2, the mechanical bubble breaking means shown in Fig. 3 or the oil layer shown in Fig. 4 may be employed in a closed vessel in conjunction with the fluctuating air pressure secured in the apparatus shown in Figs. 1, 5 and 6, or a combination of any selected number of these different means may be used in conjunction.

In Fig. 7 we have illustrated an apparatus embodying several of the bubble breaking devices above described. In this view a valve 160 is employed for the purpose of permitting intermittent escape of air from above the pulp, the valve 160 and its actuating mechanism and function being similar to the valve 16 shown in Fig. 1. In Fig. 7 we have also embodied water spray pipes 330, these spray pipes being similar in purpose and function to the spray pipes 33 shown in Fig. 2. In the apparatus shown in Fig. 7 we have also embodied a series of belts 360 provided with spurs 390 as additional means for breaking the bubbles, these parts being similar in purpose and function to the belts 36 and spurs thereon 39, shown in Fig. 3. In Fig. 7 we have also shown a layer of oil 410 upon the surface of the pulp, the layer of oil corresponding in purpose and function to the layer 41 shown in Fig. 4.

While we have referred to air as the gaseous medium employed, it will be obvious that any gas may be used and that such gas may either be introduced through a porous medium as above described, or may be generated in the pulp by chemical means or otherwise. Furthermore, the apparatus shown in Fig. 1 may be operated by applying the requisite degree of sub-atmospheric pressure to the space 15 above the liquid in the settling chamber, this end being accomplished by simply attaching an exhaust air pump to a suitable outlet provided for that purpose in the settling chamber above the liquid level. When so operated the intermittent opening of the valve 16 serves to intermittently admit atmospheric pressure to the space 15, thus setting up the pulsations necessary for the rupture of the bubbles.

In Fig. 8 we have illustrated an apparatus similar to that shown in Fig. 1 but with the addition of an exhaust fan 101, the suction port of which is connected by a pipe 102 with the space 150 above the ore pulp. The purpose of the exhaust fan is to impose sub-atmospheric pressure in the space 150 above the ore pulp as referred to in the preceding paragraph. The pressure being sufficiently reduced in the space 150 air will be drawn through the porous medium forming the bottom of the pulp chamber, thus dispensing with the necessity of maintaining pressure above that of the atmosphere below the porous medium. In the device shown in Fig. 8 valve 103 corresponds in structure and means of actuation with the valve 16 shown in Fig. 1, but the intermittent opening of the valve 103 shown in Fig. 8 has the function of intermittently admitting atmospheric pressure to the space 150 above the ore pulp, thereby setting up the fluctuations in pressure which have the effect of breaking the bubbles. The exhaust fan may be operated continuously, as its operation during the brief intervals when the valve 103 is open will not be sufficient to prevent the raising of the pressure in the space 150 caused by

the inrush of air through the valve 103 when open.

It will be obvious that a wide variety of means may be employed for rupturing the bubbles and that vessels of a wide variety of forms may be employed for the purpose of conducting the mineral carrying bubbles to a position where when the bubbles are broken their load of mineral will be deposited in a compartment separate from that containing the pulp.

We are aware that efforts have been made to concentrate ores by introducing a gas such as air into an unmodified ore pulp and placing dependence upon the inherent fragility of the bubbles to break when they reach the surface, the deposited mineral being caught separate from the original pulp. We do not depend on the fragility of the bubbles but utilize air bubbles preferably in a modified ore pulp and then use positive means to break the bubbles as they rise to the surface. While we have attained the highest degree of success in the operation of this process by modifying the ore pulp by the use of a suitable oil or other reagent, we have found in certain instances that mineral will be carried by the bubbles without the use of a modifying agent in which case also we use positive means for breaking the bubbles as distinguished from relying upon the inherent tendency of the bubbles to break.

The kind of modifying agent used will depend upon the nature of the ore and the cost of the different available substances. A wide variety of substances has been used for this purpose including animal, vegetable and mineral oils, coal and wood tar, alcohols and various derivatives of these substances, including various hydroxy compounds. The word oil has been used to designate generally all of these substances and the oils, using the term in its generic sense, have been termed "frothing" oils and "collecting" or "carrying" oils, according to their effectiveness in collecting the mineral and in producing an efficient and stable froth. Frequently, in fact generally, mixtures of the two types of oil have been used in the frothing process. Inasmuch as the formation of a froth does not enter into our process it will be obvious that different conditions govern the selection of the oils and oil mixtures to be used. Experimental treatment of any ore will readily indicate the best oil or oil mixture to be used. In the claims we have used the term "modifying agent" instead of the word "oil" as a generic term covering the various substances heretofore used as above stated. While air is the gas used in the examples of our process herein described it will be obvious that other gases may be used and we therefore claim generally the use of any gas.

The modifying agent is preferably mixed with the pulp prior to its introduction into the vessel A, although in some cases the modifying agent may be introduced directly in said vessel. The emulsification of the modifying agent may be effected by mechanical agitation either of the agents with water prior to adding the same to the pulp or the agent may be agitated with the pulp, or air or steam jets may be employed for emulsifying the agent either with water preparatory to addition to the pulp or in the pulp. Any of the well known means of emulsifying the agent and distributing it through the pulp may be used in connection with our invention.

We claim:

1. An ore concentrating process comprising the operations of introducing gaseous bubbles into a freely flowing pulp, conducting said bubbles while submerged to a breaking-down region, applying fluctuating gas pressure to said bubbles to break them and release the mineral adhering to them, and collecting said mineral in said breaking-down region.

2. An ore concentrating process comprising the operations of introducing gaseous bubbles into a freely flowing pulp, conducting said bubbles while submerged to a breaking-down region, applying fluctuating gas pressure to said bubbles to break them and release the mineral adhering to them, and collecting said mineral below a water surface in said breaking-down region.

3. An ore concentration process comprising the operations of introducing gaseous bubbles into a freely flowing pulp, conducting the bubbles while submerged into a different vertical plane, breaking said bubbles by means of fluctuating gas pressure above the surface of the pulp to release the mineral adhering to the bubbles and collecting said mineral below a water surface.

4. An ore concentration process comprising the operations of introducing gaseous bubbles into a freely flowing pulp, conducting the bubbles while submerged to a breaking-down region above a concentrate receiver, breaking the gaseous bubbles by fluctuating gas pressure as they rise to the surface thereby permitting the mineral carried by the bubbles to settle in said receiver.

5. An ore concentration process comprising the operations of introducing a freely flowing pulp into a closed vessel, introducing a gas into the lower part of the pulp, thereby causing gaseous bubbles to rise through the pulp, intermittently permitting said gas to escape from a point above said pulp thereby rupturing the bubbles as they reach the surface, and collecting the mineral carried by the bubbles.

6. An ore concentration process comprising the operations of introducing a freely

flowing pulp into a closed vessel, introducing a gas into the lower part of the pulp thereby causing gaseous bubbles to rise through the pulp, conducting the bubbles while submerged into a breaking-down region, intermittently permitting said gas to escape from a point above said pulp thereby rupturing the bubbles as they reach the surface, and collecting the mineral carried by the bubbles.

7. An ore concentration process comprising the operations of introducing a freely flowing ore pulp into a closed vessel, introducing a gas into the lower part of the pulp thereby causing gaseous bubbles to rise through the pulp, conducting the bubbles while submerged to a point above a concentrate receiver, intermittently permitting said gas to escape from a point above said pulp thereby rupturing the bubbles as they reach the surface, and collecting the mineral carried by the bubbles.

8. An ore concentration process comprising the operations of introducing a freely flowing pulp into a closed vessel, introducing a gas into the lower part of the pulp thereby causing gaseous bubbles to rise through the pulp, intermittently permitting said gas to escape from a point above said pulp and intermittently admitting gas under pressure above the pulp, thereby rupturing the bubbles as they reach the surface, and collecting the mineral carried by the bubbles.

9. An ore concentration process comprising the operations of introducing a freely flowing pulp into a closed vessel, introducing a gas into the lower part of the pulp thereby causing gaseous bubbles to rise through the pulp, conducting the bubbles while submerged into a breaking-down region, intermittently permitting said gas to escape from a point above said pulp and intermittently admitting gas under pressure above the pulp, thereby rupturing the bubbles as they reach the surface, and collecting the mineral carried by the bubbles.

10. An ore concentration process comprising the operations of introducing a freely flowing ore pulp into a closed vessel, introducing a gas into the lower part of the pulp thereby causing gaseous bubbles to rise through the pulp, conducting the bubbles while submerged to a point above a concentrate receiver, intermittently permitting said gas to escape from a point above said pulp and intermittently admitting gas under pressure above the pulp, thereby rupturing the bubbles as they reach the surface, and collecting the mineral carried by the bubbles.

11. An ore concentrating process comprising the operations of adding a modifying agent to a freely flowing pulp, introducing gaseous bubbles into said pulp, conducting said bubbles while submerged to a breaking-down region, applying fluctuating gas pressure to said bubbles to break them and release the mineral adhering to them, and collecting said mineral in said breaking-down region.

12. An ore concentration process comprising the operations of adding a modifying agent to a freely flowing pulp, introducing gaseous bubbles into said pulp, conducting the bubbles while submerged into a different vertical plane, breaking said bubbles by means of fluctuating gas pressure to release the mineral adhering to the bubbles and collecting said mineral below the water surface.

13. An ore concentration process comprising the operations of adding a modifying agent to a freely flowing pulp, introducing gaseous bubbles into said pulp, conducting the bubbles while submerged to a breaking-down region above a concentrate receiver, breaking the gaseous bubbles by fluctuating gas pressure as they rise to the surface thereby permitting the mineral carried by the bubbles to settle in said receiver.

14. An ore concentration process comprising the operations of introducing a freely flowing pulp into a closed vessel, adding a modifying agent to said pulp, introducing a gas into the lower part of the pulp, thereby causing gaseous bubbles to rise through the pulp, intermittently permitting said gas to escape from a point above said pulp thereby rupturing the bubbles as they reach the surface, and collecting the mineral carried by the bubbles.

15. An ore concentration process comprising the operations of introducing a freely flowing pulp into a closed vessel, adding a modifying agent thereto, introducing a gas into the lower part of the pulp thereby causing gaseous bubbles to rise through the pulp, conducting the bubbles while submerged into a breaking-down region, intermittently permitting said gas to escape from a point above said pulp thereby rupturing the bubbles as they reach the surface, and collecting the mineral carried by the bubbles.

16. An ore concentration process comprising the operations of introducing a freely flowing ore pulp into a closed vessel, adding a modifying agent thereto, introducing a gas into the lower part of the pulp thereby causing gaseous bubbles to rise through the pulp, conducting the bubbles while submerged to a point above a concentrate receiver, intermittently permitting said gas to escape from a point above said pulp, thereby rupturing the bubbles as they reach the surface, and collecting the mineral carried by the bubbles.

17. An ore concentration process comprising the operations of introducing a freely flowing pulp into a closed vessel, adding a modifying agent to said pulp, introducing a gas into the lower part of the pulp, there-

by causing gaseous bubbles to rise through the pulp, intermittently permitting said gas to escape from a point above said pulp and intermittently admitting gas under pressure above the pulp, thereby rupturing the bubbles as they reach the surface, and collecting the mineral carried by the bubbles.

18. An ore concentration process comprising the operations of introducing a freely flowing pulp into a closed vessel, adding a modifying agent thereto, introducing a gas into the lower part of the pulp thereby causing gaseous bubbles to rise through the pulp, conducting the bubbles while submerged into a breaking-down region, intermittently permitting said gas to escape from a point above said pulp and intermittently admitting gas under pressure above the pulp, thereby rupturing the bubbles as they reach the surface and collecting the mineral carried by the bubbles.

19. An ore concentration process comprising the operations of causing a body of ore pulp to flow through a region of gas supply, confining part of said pulp in a relatively quiescent region, the pulp extending continuously from said region of gas supply to said quiescent region, introducing a gas into said pulp in the region of gas supply, conducting the gas bubbles while submerged to said quiescent region, breaking said bubbles in said quiescent region by fluctuating gas pressure, and collecting the mineral carried by them.

20. An ore concentration process comprising the operations of causing a body of ore pulp to flow through a region of gas supply, adding a modifying agent thereto, confining part of said pulp in a relatively quiescent region, the pulp extending continuously from said region of gas supply to said quiescent region, introducing a gas into said pulp in the region of gas supply, conducting the gas bubbles while submerged to said quiescent region, breaking said bubbles in said quiescent region by fluctuating gas pressure, and collecting the mineral carried by them.

21. A process of concentrating ores comprising the operations of continuously commingling a gas with an ore pulp, allowing the gas bubbles to rise through the pulp, breaking said bubbles while submerged in the pulp, and collecting the mineral values raised by said bubbles.

In testimony whereof, we have subscribed our names.

BENJAMIN H. DOSENBACH.
WALTER A. SCOTT.