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ART OF CONCENTRATION OF MINERAL SUBSTANCES.

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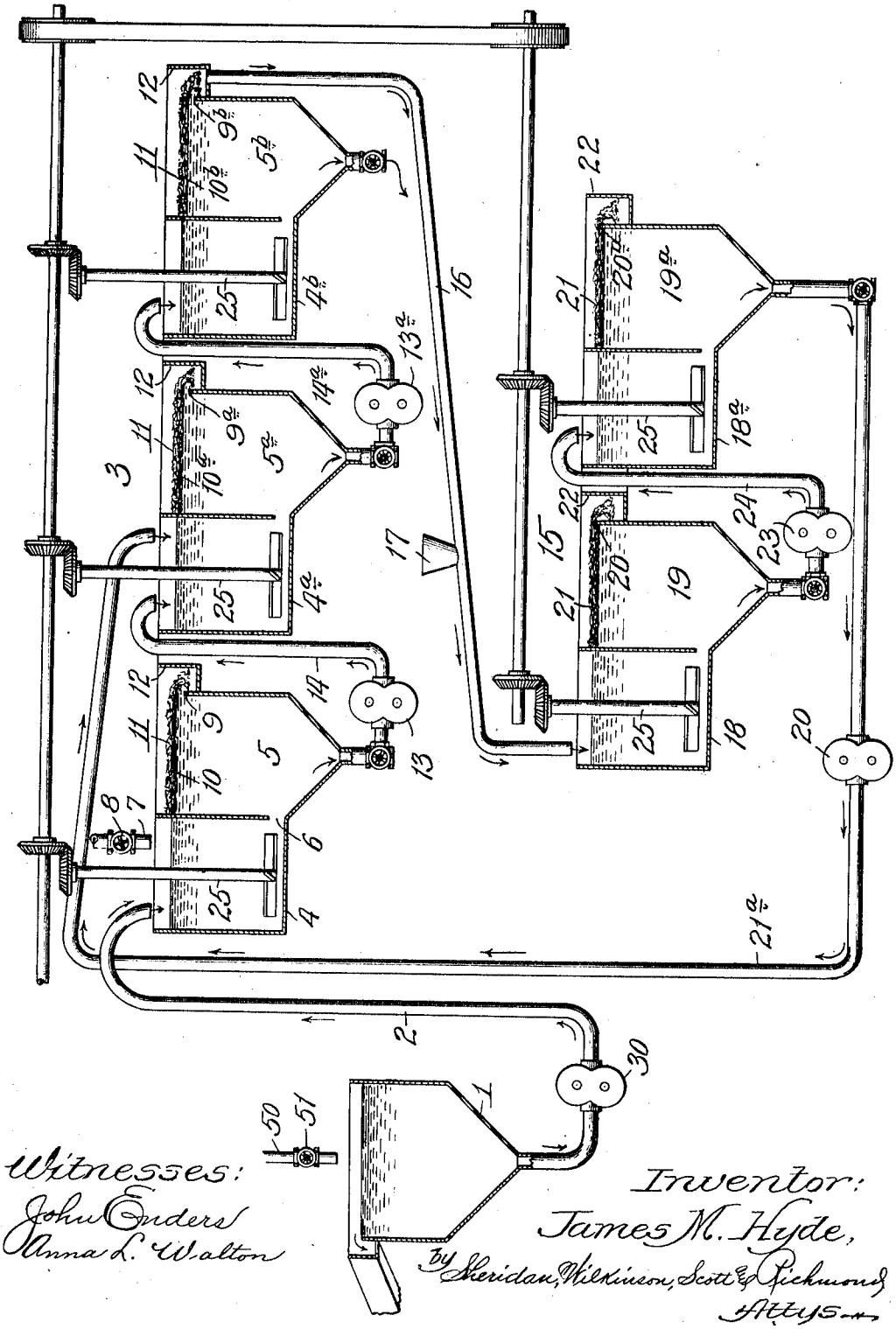

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UNITED STATES PATENT OFFICE.

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ART OF CONCENTRATION OF MINERAL SUBSTANCES.

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To all whom it may concern:

Be it known that I, JAMES M. HYDE, a citizen of the United States, residing at Basin, in the county of Jefferson and State of Montana, have invented certain new and useful Improvements in the Art of Concentration of Mineral Substances, of which the following is a specification.

My invention relates to the separation by a flotation process of a part of the mineral substances composing an ore consisting of a plurality of mineral components.

It has heretofore been demonstrated that certain metallic and non-metallic elements, and certain natural chemical compounds of the metallic elements differ from the ordinary less valuable or valueless gangue minerals with which they occur in ore deposits, in that under certain conditions they are preferentially coated by oils, fats, oleaginous and fatty substances and derivatives thereof, and certain other organic compounds, and that when so coated they exhibit markedly different surface tension phenomena from, and can by various devices and methods be separated from, the gangue minerals, and, in certain instances at least, to a certain extent from one another.

Many ores containing a plurality of mineral components are of such a nature that when they are crushed a considerable amount of the resultant pulverized material consists of particles which are so fine and of such a colloidal nature that they settle very slowly and interfere with obtaining a high grade concentrate by the use of a flotation process. In the treatment of ores of this class I have found that their treatment is greatly facilitated, and a considerable economy is effected, by introducing a small amount of sulfuric acid with or without copperas, alum or some other such coagulant, into the pulp while in transit to the flotation device, instead of by using a larger amount of acid in the flotation device as has been done in previous practice. The acid apparently performs the following, among other functions:—the partial or complete coagulation of the slimes so that they settle much more quickly, thus making possible the thickening of the pulp in an intermittent or continuously acting pulp thickener, by the removal of a considerable amount of clear water or water containing a lessened amount of suspended solid matter, and also greatly facilitating the separation of the concentrates from the gangue in the flotation machine; the cleaning of the surface of the particles of the floatable minerals, so that they may be more readily coated by the chosen coating reagent; the generation of minute bubbles of gas in the pulp and on the surface of the floatable mineral particles, which bubbles assist in the desired separation of the mineral components of the ore; and in neutralizing any alkalinity of the ore or treatment water. The addition of the acid to the pulp before it reaches the flotation machine, rather than in the machine as has heretofore been done, affords a longer period of contact with the ore and greatly reduces the amount of acid which it is necessary to use. It precludes the necessity of having the pulp show any free acid when the flotation treatment takes place. By following this method, I have been able to get highly satisfactory results when using as little as one quarter of a pound of crude acid per ton of ore treated, whereas in previously used methods, several pounds have been found necessary.

I have further discovered that the concentrates produced, when the acid is used substantially as hereinbefore described may be retreated and raised in grade, when they contain free particles of the gangue matter, by being put through a treatment similar to that by which they were made, and that this retreatment can, in certain cases at least, be satisfactorily made without the use of additional amount of acid or coating reagent in the "cleaner machine."

Any fats or oils, fatty or oleaginous substances or derivatives thereof, and any other organic compounds which preferentially coat mineral substances may be used in this process for the coating of such mineral particles as can be made to float on the surface of water for any of the following reasons:—because of the lower specific gravity of the oily or fatty substances to which they are attached, because of their tendency to form a film on the surface of the water when properly coated, or because of their tendency to attach themselves to and be raised by bubbles of any gas which may be generated in, or introduced into the pulp.

A suitable apparatus for carrying out this process consists of launders or pipes, used in connection with or without pulp thick-

eners, and a combination of mixing boxes and spitzkastens, or overflow separating devices. Any one of a number of devices now in use, or any simple and apparent modification thereof may be made use of for this purpose.

In the drawing I have diagrammatically illustrated an apparatus whereby my process can be conveniently practiced.

Acid is added to the pulp in or prior to reaching the pulp thickener 1, which is used if the prior treatment of the ore has given rise to a pulp containing more water than is suitable for the practice of my process. The acid whether added to the pulp in the thickener or before reaching the thickener is supplied through means under the control of the operator, such as the pipe 50 leading from the acid supply, which pipe is provided with a hand valve 51. The pulp thickener may consist of any of the ordinary devices used for that purpose, such as pointed boxes having provision for overflow of the clear water. The thickened pulp is drawn off from the bottom of the thickener 1 and the waste water allowed to flow from the top thereof. The thickened pulp is conducted from the thickener 1 through the pipe or launder 2 to the flotation machine designated generally by the numeral 3, a pump 30 being used for this purpose, if necessary. The flotation machine as illustrated consists of three agitator tanks 4, 4^a and 4^b, and three settlement boxes 5, 5^a and 5^b. Each of the agitator tanks may, if necessary, consist of a plurality of connected compartments each provided with an agitator. The agitator tank 4 is connected near its lower end at 6 with the settlement box 5, the agitator tank 4 and settlement box 5 constituting the first unit of the flotation or separation apparatus. The other two units consist respectively of the agitator tank 4^a with its settlement box 5^a and the agitator tank 4^b with its settlement box 5^b. The three units are of similar construction. The pulp is first received in the agitator tank 4 and thoroughly agitated with oil from the pipe 7, which is provided with a hand valve 8 under the control of the operator. The pulp flows continuously through the machine, its rate of flow being regulated in such manner as to produce the best results. After agitation in the tank 4 the pulp passes through the passage 6 into the settlement tank 5. The sulfid particles having become coated with oil in the agitator tank 4 rise to the surface of the settlement tank 5 in the form of a froth or scum. The level of the pulp in the apparatus is so regulated by means of suitable valves that at the overflow lips 9, 9^a and 9^b of the settlement boxes 5, 5^a and 5^b the lower surface 10 of the froth 11 is sufficiently above the lip to insure the overflow of all of the froth 11 into the launder 12. This arrangement permits more or less water to pass over with the froth into the launder 12. The partially treated pulp, still containing more or less of the sulfids or other ore values, is drawn off from the bottom of the settlement box 5 and by means of a pump 13 is forced through the pipe 14 and discharged into the agitator tank 4^a of the second unit of the flotation machine. The apparatus is preferably so arranged that the pulp stands at the same level in the different units of the flotation device, and in the second unit of the cleaner machine which is described below, in which event the pumps are not necessary to lift the pulp but merely serve to assist in its movement. The arrangement of the apparatus may, however, be varied when necessary or desirable. In this unit the same operation takes place as in the first unit, namely, agitation in the tank 4^a, overflow of froth with more or less water from the settlement box 5^a into the launder 12 and discharge of the pulp from the bottom of the settlement box 5^a. From the bottom of the settlement box 5^a the pulp is forced by means of a pump 13^a through pipe 14^a and discharged into the agitator tank 4^b of the third unit where the pulp is agitated and discharged into the settlement box 5^b where the froth with some water is drawn off into the launder 12. The pulp after treatment in the third unit is discharged from the bottom of the settlement box 5^b as tailings or waste, the treatment above described in the three units of the flotation machine having practically exhausted the ore of its valuable parts. In practice I have attained by the treatment described a separation running as high as 95% of the sulfids.

In conducting my process the operator constantly observes the condition of the material in the agitator tanks and on the surface of the settlement boxes 5, 5^a and 5^b of the flotation machine, and likewise observes the condition of the tailings being discharged from the machine. By such observation the operator is enabled to determine whether the sulfids or other ore values are being properly separated from the gangue. The appearance of flocculent masses of sulfids in the tailings indicates the use of too large an amount of oil, while the appearance of finely divided sulfids in the tailings indicates the use of too little oil. Other indications are apparent to an operator after a little experience and by properly manipulating the valve 8 which regulates the oil supply he is able to control the operation in such manner as to secure a maximum recovery, equal, as above stated, in some cases to 95% of the entire value contained in the ore.

The launder or pipe 12 receives the sulfids, together with some water and gangue from all three units of the flotation ma-

chine 3 and these sulfids are conducted from the launder 12 to the cleaner machine which is designated generally by the numeral 15. In transit from the flotation machine to the cleaner machine the froth is conducted through a launder or pipe 16 and more water is supplied thereto, if necessary, through a pipe 17. The concentrates thus diluted are discharged into the agitator tank 18 of the cleaning apparatus and are there agitated with or without the addition of further oil, acid or other chemicals as may be desirable. From the agitator box 18 the concentrates with the water carrying them are conducted to the settlement box 19. The froth obtained in the primary or flotation machine 3 contains more or less gangue which is entrapped in the froth, and it is to purify the concentrates that I employ the secondary or cleaner machine 15. The agitation of the concentrates in the secondary machine has the effect of breaking them up to a considerable extent thereby causing the entrapped gangue to become separated from the oil coated concentrates. After agitation of the concentrates in the tank 18, as above stated, the concentrates, together with the water added thereto, are conducted to the settlement box 19, in which the gangue which has been freed from the concentrates settles to the bottom with a certain amount of the sulfids. The level of the material in the cleaning machine 15 is so regulated by means of suitable valves that the overflow lips 20 and 20ª of the settlement boxes 19 and 19ª extend slightly above the lower surface of the froth 21, the purpose being to prevent any escape of free flowing water with the froth 21 into the launder 22. As a result of this arrangement some of the froth and all of the slime carrying water will be prevented from overflowing into the launder 22 and will be carried down to the bottom of the settlement box 19. From the bottom of the settlement box 19 the water carrying with it such gangue as has been freed from the froth and also carrying such of the sulfids as have failed to flow over the lip 20 is forced by the pump 23 through the pipe 24 and discharged into the second agitator tank 18ª of the cleaning machine. The operation in the second unit of the cleaning machine is precisely the same as that described in the first unit, the overflow at the lip 20ª being adjusted as described in connection with the first unit to prevent foul water from overflowing into the launder 22. The discharge from the bottom of the settlement box 19ª will therefore contain not only such of the gangue as has been freed from the oil-coated sulfids, but will also contain a small amount of the sulfids. The discharge from the bottom of the second settlement box 19ª of the cleaner machine is therefore forced by a pump 20 or otherwise conducted through pipe 21ª and discharged into the agitator tank 4 or 4ª of the flotation machine and carried through the rest of the apparatus, together with the fresh pulp.

By the means above described, I remove a large portion of the impurities from the concentrates formed in the flotation machine, and by conducting the material drawn off from the bottom of the settlement tank 19ª of the cleaner machine and retreating the same in the primary or flotation machine I effectually guard against any loss of concentrates in the cleaning operation. The agitators 25 shown in the agitator tanks of the flotation and cleaning machines may be of any preferred form and rotated by any means available.

As an example of the way in which these improvements may be used the following description is given of the treatment of a parcel of ore by this method. The material treated was the slimy portion of an ore consisting principally of quartz, blende (the sulfid of zinc) and varying amounts of decomposed granite in which the feldspars were largely kaolinized. About 92% of this material was fine enough to pass through a 150 mesh screen. Unless a coagulant were used a portion of the slime containing a valuable amount of zinc would remain in suspension for over 24 hours. The pulp as produced contained from 20 to 100 or more parts of water by weight to one part of ore, whereas the ratio should have been from two and one half to one to four to one. To this pulp while in transit to the thickeners, was added an amount of commercial sulfuric acid equivalent to from one quarter to one half pound per ton of ore treated. At times a decided odor of hydrogen sulfid could be noticed around the pulp thickeners. The thickened pulp, usually showing no free acidity, was led to the flotation machine in which it was heated by live steam to enlarge and expand the gas bubbles generated by the acid and to facilitate the coating of the sulfid particles with the coating reagent which was added in the flotation machine. The amount of oil necessary to produce the proper result cannot be determined in advance owing to variations in the rate of flow of pulp through the apparatus, differences in the degree of dilution of the pulp, *i. e.* differences in the amount of ore carried by the water, and variations in the composition of the ore, the ore sometimes running much higher in sulfids than at other times. There may also be other factors which have an effect upon the quantity of oil necessary to float the maximum percentage of the sulfids or other ore values. At any rate, I have found in practice that the only efficient mode of carrying out the process is to constantly observe the results produced and to vary the

supply of oil accordingly. The flotation or separation machine used in the test was of a character similar to that illustrated and described above. The pulp was thoroughly agitated to insure the coating of all of the sulfid particles with the proportionately very small amount of "candle maker's red oil" which was used as the coating agent.

After treatment in the three units of the separation machine the gangue matter as tailings was run to waste from the bottom of the settlement box of the third unit. The concentrates which had overflowed from the three settlement boxes of the primary machine were collected in the same launder and conducted to the secondary or cleaner machine, and in the cleaner machine the concentrates were treated without further addition of oil or acid. From the cleaner machine high grade concentrates were collected and rich tailings were returned to the second unit of the primary machine for retreatment. In this test run the ore fed contained 23.3% zinc, the concentrates 51.4% zinc, and the tailings 3.2% zinc, giving an indicated recovery of 91% of the zinc in the ore treated. These results were in large part due to the method of using the acid and retreating the concentrates made in the primary machine, which concentrates contained but from 38% to 42% of zinc before retreatment.

It will be understood that the apparatus diagrammatically illustrated in the drawing may be varied in form, the illustration and description of the apparatus referred to being introduced merely for the purpose of clearly setting forth the several steps of my process.

I claim:

1. The process of concentrating ore pulps comprising a separation treatment which consists in adding to the pulp a material which preferentially coats the valuable particles of the ore, agitating the mixture, permitting the valuable parts of the ore to float in the form of a froth, separating the froth by overflowing it together with some of the water in order to insure overflow of the entire mass of the froth, subjecting the separated froth to a cleaning treatment which consists in reagitating the concentrated material to free impurities entrapped therewith, permitting the concentrates to again form a froth and allowing the impurities to settle, overflowing the froth without any free flowing water, and returning the settled impurities and the part of the froth not carried into the overflow to the part of the pulp which is undergoing the separation treatment.

2. A continuous process of concentrating the valuable constituents from ore pulps comprising the addition to the pulp of an acid precipitant adapted to react upon the ore, allowing a time interval to elapse prior to subjecting it to the separation treatment, then subjecting the pulp to a separation treatment comprising the steps of adding a material which will preferentially coat the valuable particles of the ore and separating said coated particles as a concentrate by flotation.

3. A continuous process of concentrating the valuable constitutents from ore pulps comprising the addition to the pulp of an acid precipitant adapted to react upon the ore, allowing a time interval to elapse prior to subjecting it to the separation treatment, then subjecting the pulp to a separation treatment comprising the steps of adding a non-metallic material which will preferentially coat the valuable particles of the ore and separating said coated particles as a concentrate.

4. A continuous process of concentrating the valuable constituents from ore pulps comprising the addition of an acid precipitant to the pulp, allowing a time interval to elapse prior to subjecting it to the separation treatment, then subjecting the pulp to a separation treatment comprising the steps of adding a material which will preferentially coat the valuable particles of the ore and separating said coated particles as a concentrate by flotation, subjecting the concentrate thus produced to a cleaning treatment which consists in agitating the concentrated material, permitting the concentrates to float, removing the concentrates from the top of the mixture, and returning the material which settles after the cleaning agitation to the part of the pulp which has passed through the first two steps specified and which is undergoing the separation treatment.

5. A continuous process of concentrating the valuable constituents from ore pulps comprising the addition of an acid precipitant to the pulp, allowing a time interval to elapse prior to subjecting it to the separation treatment, then subjecting the pulp to a separation treatment comprising the steps of adding a material which will preferentially coat the valuable particles of the ore and separating said coated particles as a concentrate, subjecting the concentrate thus produced to a cleaning treatment which consists in agitating the concentrated material, removing the concentrates from the mixture, and returning the rest of the mixture to the part of the pulp which has passed through the first two steps specified and which is undergoing the separation treatment.

6. A continuous process of thickening and concentrating ore pulps comprising the addition to the thin pulp of an acid precipitant adapted to react upon the ore and producing a thickened pulp by separating water, then subjecting the thickened pulp to a separation treatment comprising the steps of adding a

material which will preferentially coat the valuable particles of the ore, and separating said coated particles as a concentrate by flotation.

7. A continuous process of thickening and concentrating ore pulps comprising the addition of an acid precipitant to the thin pulp, producing a thickened pulp by separating water, then subjecting the thickened pulp to a separation treatment comprising the steps of adding a material which will preferentially coat the valuable particles of the ore, and separating said coated particles as a concentrate by flotation, subjecting the concentrates thus produced to a cleaning treatment which consists in agitating the concentrated material, permitting the concentrates to float, removing the concentrates from the top of the mixture, and returning the material which settles after the cleaning agitation to the part of the pulp which is undergoing the separation treatment after the thickening step.

8. The process of concentrating ore pulps comprising a separation treatment which consists in adding to the pulp a material which preferentially coats the valuable particles of the ore, agitating the mixture, permitting the valuable particles of ore to float in the form of a froth, separating the froth with some of the water in order to insure separation of the entire mass of the froth, subjecting the separated froth to a cleaning treatment which consists in reagitating the concentrated material to free impurities entrapped therewith, permitting the concentrates to again form a froth and allowing the impurities to settle, removing the froth without water, and returning the settled impurities and the part of the froth not removed to the part of the pulp which is undergoing the separation treatment.

9. The process of concentrating ore pulps comprising a separation treatment which consists in adding to the pulp a material which preferentially coats the valuable particles of the ore, agitating the mixture to bring the coating material into contact with all of the particles which can be made to float, separating the floating coated material as a concentrate with some of the water thereby insuring removal of all of the floating material, subjecting this separated material to a cleaning treatment to permit the impurities remaining therewith to settle and refloating the concentrates, removing the upper purest part of the cleaned concentrates and returning the impurities and the remaining part of the concentrates to the part of the pulp which is undergoing the initial flotation treatment prior to the cleaning operation.

10. The process of concentrating ores which consists in adding to the ore a material which preferentially coats the valuable particles of the ore, separating said coated valuable particles from the gangue by floating said coated valuable particles on water, separating the floating coated particles as a concentrate with some of the water thereby insuring removal of all of the floating valuable particles, subjecting this separated material to a cleaning treatment to permit the impurities remaining therewith to settle and refloating the concentrates, removing the upper purest part of the cleaned concentrates, and returning the impurities and the remaining part of the concentrates to the part of the ore which is undergoing the initial flotation treatment prior to the cleaning operation.

In testimony whereof, I have subscribed my name.

JAMES M. HYDE.

Witnesses:
J. BRUCE KREMER,
WALTER A. SCOTT.