Apr. 10, 1923.

1,451,067

R. B. ELDER

HYDRAULIC CLASSIFIER

Filed Dec. 6, 1918

3 sheets-sheet 1

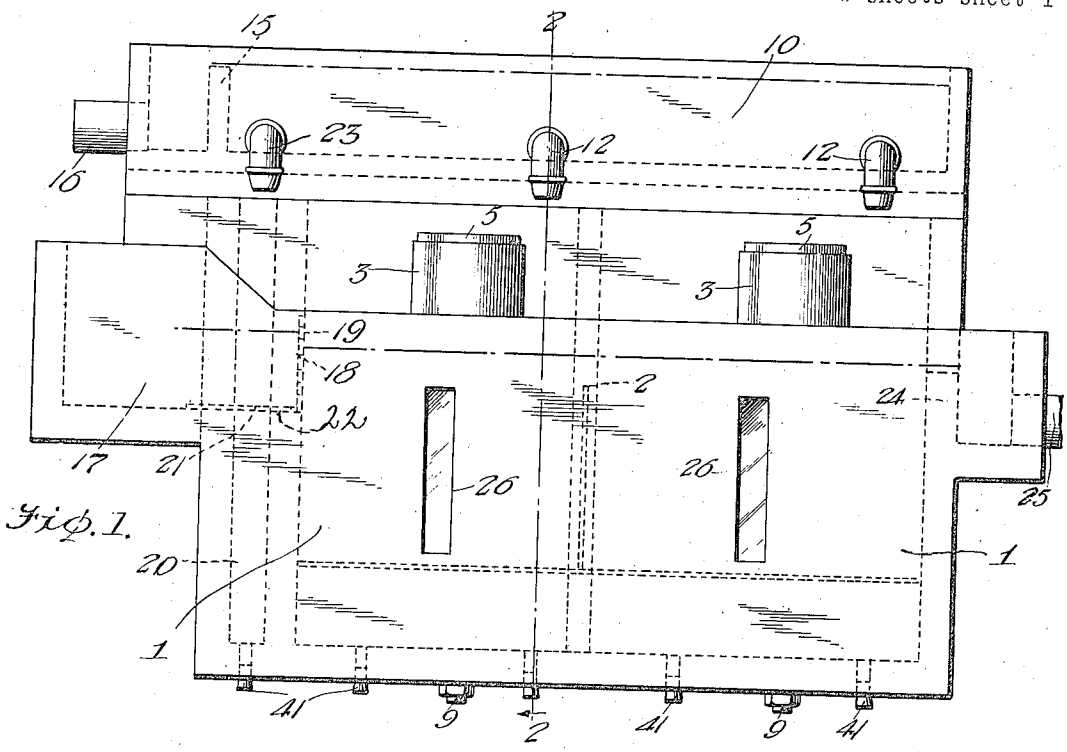
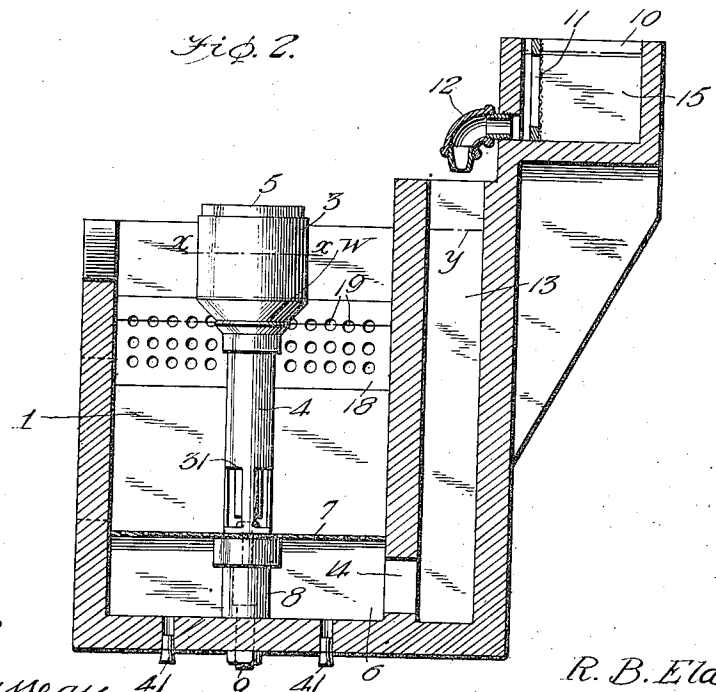


Fig. 1.

Fig. 2.



WITNESSES

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3 sheets-sheet 2

Fig. 3.

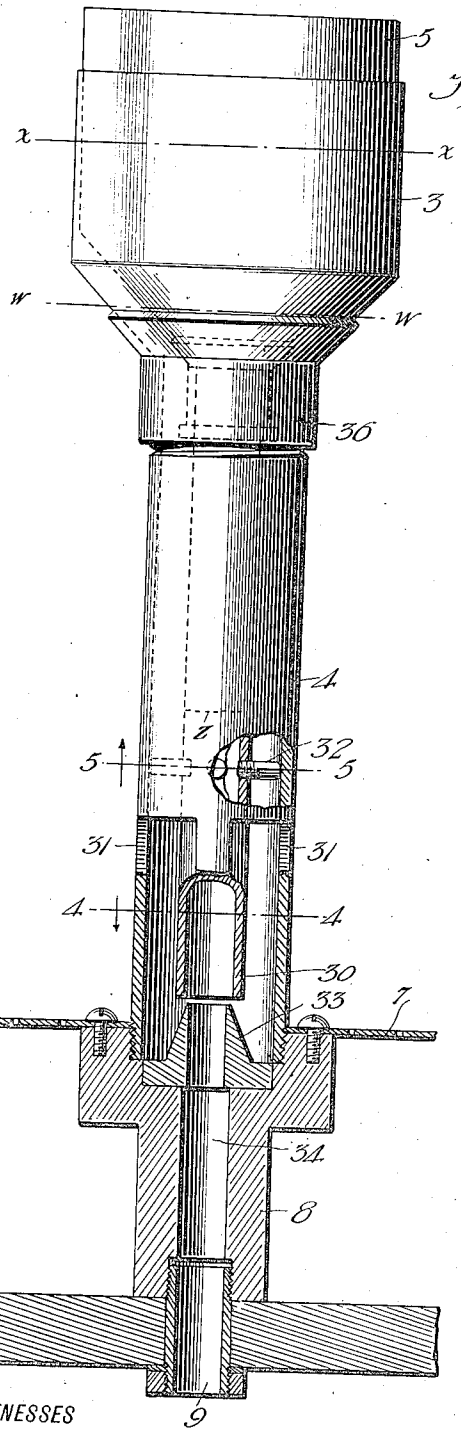


Fig. 4.

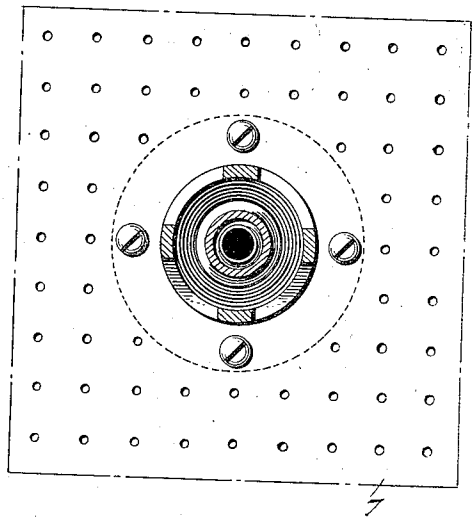
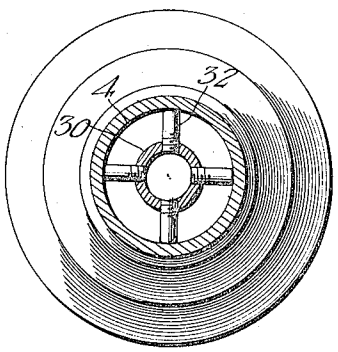


Fig. 5.



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3 sheets-sheet 3

Fig. 6.

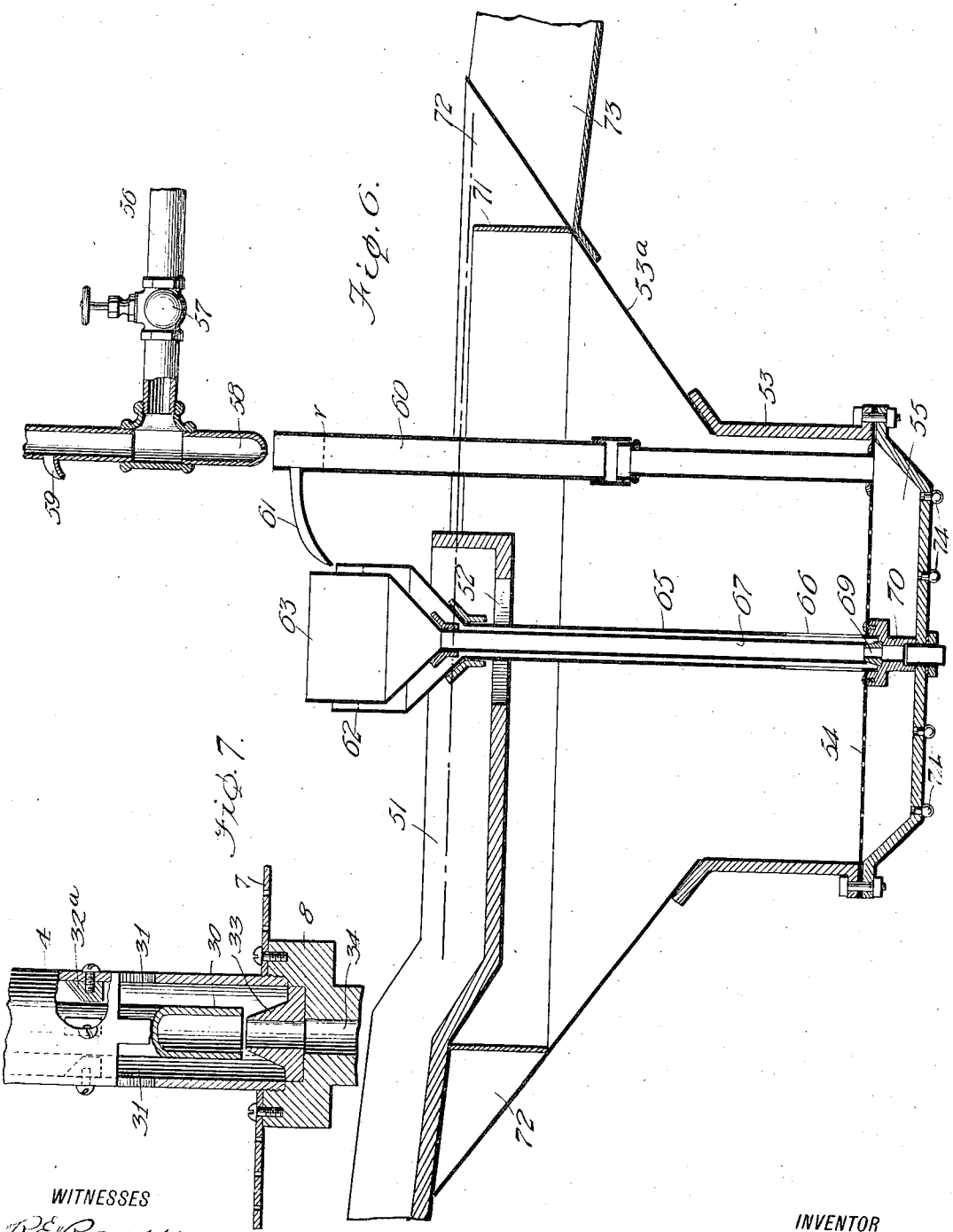

Fig. 7.

WITNESSES

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Patented Apr. 10, 1923.

1,451,067

UNITED STATES PATENT OFFICE.

ROBERT BAXTER ELDER, OF DENVER, COLORADO, ASSIGNOR TO ANDREW DARWIN ELDER, OF DENVER, COLORADO.

HYDRAULIC CLASSIFIER.

Application filed December 6, 1918. Serial No. 265,614.

To all whom it may concern:

Be it known that I, ROBERT BAXTER ELDER, a citizen of the United States, and a resident of Denver, in the county of Denver and State of Colorado, have invented certain new and useful Improvements in Hydraulic Classifiers, of which the following is a specification.

My invention is an improvement in hydraulic classifiers, and has for its object to provide a new and novel form of throttle valve or gate especially designed for use with hindered settling ore classifiers, for controlling the discharge of pulp from the teeter chambers of such classifiers, wherein the discharge of the heavy classified pulp from the teeter chamber is regulated by a mechanical valve which opens and closes in response to the changing of the density of the pulp in the teeter chamber, to maintain the thickness and density of the pulp bed constant or nearly so.

A further object of the invention is to provide a throttle valve or gate of the character specified for giving accurate and delicate control of the outflow of liquid material from the container, controlled by the change of the density of the liquid.

A further object of the invention is to provide a means whereby unclassified pulp may be fed into a teeter chamber in such a manner as to avoid any violent agitation caused by the stream of pulp entering the teeter chamber.

In the drawings:

Figure 1 is a side view of a two chambered classifier provided with the improved valve;

Figure 2 is a section on the line 2—2 of Figure 1;

Figure 3 is an enlarged view of the valve, partly in section;

Figures 4 and 5 are sections on the lines 4—4 and 5—5, respectively, of Figure 3, each view looking in the direction of the arrow adjacent to the line;

Figure 6 is a vertical section of a cone classifier provided with the improved valve;

Figure 7 is a sectional view of a modified construction of valve.

In the embodiment of the invention shown in Figures 1 and 2, a casing is provided, having two teeter chambers 1, the said chambers being separated by a vertical partition 2 of thin material, and of lesser height than the height of the teeter chambers. Each teeter chamber is provided with a float chamber 3, supported by a vertical pipe 4, which is attached at its lower end to the bottom 7 of the teeter chamber, and each float chamber has therein a float 5, to which is attached the valve to be described.

Below each teeter chamber is a hydraulic chamber 6 communicating with the teeter chamber by restricted openings in the partition or plate 7 which separates the teeter chamber from the hydraulic chamber, forming the bottom of the teeter chamber and the top of the hydraulic chamber. A casing 8 within the hydraulic chamber forms a communication between the lower end of the pipe 4 and the spigot 9 which extends through the bottom of the hydraulic chamber.

Water is supplied to both teeter chambers from a feed water chamber 10 arranged above and at one side of the casing, by means of spigots 12 which deliver into chambers 13 arranged below the spigots and at one side of the teeter and hydraulic chambers. Before entering the spigots 12 the feed water flows through a screen 11, and from the chambers 13 the water flows into the hydraulic chambers through openings 14 in the partition wall between the hydraulic chambers and the chambers 13. From the hydraulic chambers the water flows through the restricted openings in the plates 7 into the teeter chambers, where it performs the work of classification. The openings through the partition 7 are so restricted that they form a resistance to the passage of the water such that its even distribution is maintained over the teeter chamber area. The feed water chamber 10 has an overflow above a partition 15 near one end, and a discharge or waste pipe 16 leads from the space formed between the partition 15 and the adjacent end of the casing.

In operation, water is supplied to the chamber 10 slightly in excess of that which will flow through the spigots 12, the excess overflowing at the point 15 and running to waste through the pipe 16. This maintains practically uniform the pressure on the spigots 12, and hence the flow of water through the spigots is uniform. The chambers 13 are of such height above the level

of the pulp in the teeter chambers that they can support a column of water of sufficient height to force the water to flow into the teeter chambers against any column of pulp which can form therein. This insures that each teeter chamber receives water at a uniform constant rate, which depends only on the size of the spigots 12 and on the head of water in the feed water chamber 10, and is not affected by the density of the bed in the teeter chamber.

The unclassified pulp is fed into the pulp feed chamber 17, and between this chamber 17 and the first teeter chamber is the partition 18 which is provided with numerous small perforations or openings 19 through which the pulp may pass from the feed chamber 17 into the first teeter chamber 1. A hydraulic chamber 20 is provided below that portion of the chamber 17 next to the partition 18, and the chamber 20 is separated from the chamber 17 by a partition 21 having openings or perforations 22 which provide a communication between the chambers 20 and 17. Water is admitted to the chamber 20 from a spigot 23, similar to the spigots 12 and leading from the chamber 10. The water flows into a chamber similar to the chamber 13, and through an opening similar to the opening 14 into the hydraulic chamber 20, and from this chamber through the openings 22 into the chamber 17. The openings 22 are so restricted that they form enough resistance to the passage of the water that this resistance maintains the distribution of the water to all of the openings 22. The water entering the chamber 17 maintains in a liquid condition that portion of the pulp adjacent to the partition 18 and thus prevents the orifices 19 from becoming blocked, maintaining so a constant flow of pulp from each of these orifices. This gives a feed of pulp to the first teeter chamber in many small streams, instead of in one large stream, and so prevents the agitation in the teeter chamber which a large stream would produce and which would interfere with the proper classifying action.

Those particles of ore which are able to sink into the pulp bed in the first teeter chamber settle into this chamber, crowding out the lighter particles. The heavy particles are discharged from the spigot of the first teeter chamber, and the particles which cannot sink into the first teeter chamber pass over the partition 2 into the second teeter chamber, where the heaviest of them are again sorted out and pass into the pulp bed and through the spigot, while the lightest particles, rejected by the second teeter chamber, pass over the partition 24 and through the pipe 25.

Each teeter chamber is provided with an opening 26, which is filled with some transparent material, as for instance, a sheet of glass, so that a section of the pulp bed may be observed. Each hydraulic chamber is provided with drain plugs 41 which may be removed to drain these chambers.

In Figures 3, 4 and 5 is shown the valve and its mounting. The said valve is a tube open at both ends and attached at its upper end to the float 5, so that the valve and float together form one integral structure. This structure is arranged inside of and concentric with the pipe 4 and the float chamber 3, the pipe 4 being secured to the bottom of the teeter chamber to stand vertically in the said chamber, and being of such length that the float chamber 3 will be above the level of the pulp in the teeter chamber. At its bottom the pipe 4 is provided with radial openings 31 which extend from near the plate 7 upwardly, and spacing pins 32 extend radially from the valve, engaging at their free ends the interior of the pipe 4, to properly space the valve 30 from the said pipe, the pins having threaded engagement with the valve. Thus the valve is always held accurately concentric with the pipe 4. The valve seat 33, which is seated loosely in a depression in the upper end of the casing 8, is a frustum of a cone, having a cylindrical bore. Its axis coincides with the axes of the valve and the pipe 4, and the upper or smaller end of the valve seat is smaller than the bore of the valve 30, so that when the valve 30 is lowered to contact with the conical periphery of the seat, the inner edge of the lower end of the valve will make such contact. The bore of the seat connects directly with the bore 34 of the casing 8, and a spigot 9 opens from the bore 34 through the bottom of the hydraulic chamber. The relation between the length of the valve 30 and the pipe 4 is such that when the pipe 30 is moved downward its lower end will touch the seat before the float 5 contacts with the float chamber 3, and the pins 32 are so placed that they will be slightly above the openings 31 when the valve is closed. It will be seen that when the valve 30 is raised any liquid in the teeter chamber will flow through the openings 31, between the lower end of the valve and the upper end of the seat, through the bore of the seat and that of the casing 8 and out through the spigot 9. When the valve is closed, that is, when the valve contacts with the seat, there will be an unobstructed passage through the classifier from the spigot 9 to the space above the float 5, since the float 5 has an open top.

The teeter chamber of a hindered settling classifier is occupied by pulp consisting of ore particles held in suspension by an upward moving current of water. This pulp reacts as if it were a liquid having a specific gravity greater than that of water. When the classifier is operating the pipe 4 is immersed in the pulp and the annular space

between the pipes 4 and 30 is open to the pulp at the top of the openings 31. The current of water moving upward through the teeter chamber maintains the pulp particles in suspension outside of the pipe 4, but in the annular space between the valve and the pipe 4 there is no upward current, so that any ore particles in this space will soon settle out, leaving clear water. The result is that the water rises in this space until its hydrostatic pressure at the upper end of the openings 31 is great enough to balance the hydrostatic pressure at this point caused by the column of pulp outside of the pipe 4, and since the water in the annular space is a lighter liquid than the pulp it will rise to a height above the level of the pulp in the teeter chamber.

When this column of water rises inside the pipe 4 into the float chamber 3, the float 5 becomes a partially submerged body and it is evident that, given the proper proportioning of the apparatus, a point will be reached where the weight of the water displaced by the float 5 will equal the weight of the said float and the valve. Any further rising of the column of water will then lift the float and valve, which will open the valve, and permit the pulp to flow from the teeter chamber out through the spigot 9. If the pulp is being fed steadily to the teeter chamber the float will rise until a point is reached at which the pulp is discharged through the spigot as fast as the pulp bed is formed, and there will be maintained in the teeter chamber a bed of pulp of sufficient thickness and density to balance the column of water which lifts the float far enough to discharge the pulp at this rate.

With the valve in closed position, the lower end of the valve 30 is exposed to the hydraulic pressure due to the column of pulp in the teeter chamber, and this pressure exerts a force on the lower end of the valve, tending to lift the valve. The vertical components of any pressure on the lower end of the valve are in no material degree altered by the valve being slightly open, as in the open position shown in Figure 3 the same horizontal area is exposed to the hydraulic pressure as when the valve is shut. This would not be true if the valve were a flat disk attached to the float by a solid rod instead of by a pipe. In such case, with the valve in the closed position, the center of the disk would be subject only to the atmospheric pressure communicated through the spigot 9, and when the valve were slightly open, the hydraulic pressure begin to be communicated to this center of the disk.

The pressure applied to this disk would be a vertical force tending to lift the valve, and its effect would be accelerated with the opening of the valve so that when the valve started to open it would open wide suddenly. On closing, the reverse of this action would take place, causing the valve to close suddenly and the result would be a periodic opening and closing of the valve, giving a periodic instead of a continuous discharge of the pulp. Also if the valve were not open to the atmosphere throughout the bore thereof a partial vacuum might be formed inside of the same under some conditions, because of the pulp catching bubbles of air and carrying them downwardly through the passage 34 and the spigot 9.

In order that the raising and lowering of the valve 30 may be perfectly controlled by the float 5 without this control being interfered with, by the pressure or flow of liquid at the lower end of the pipe 30 three conditions must obtain: first, at the lower end of the valve any surface of it except the vertical surface must be equally exposed to the hydraulic pressure with the valve opened or closed; second, the area of the surface not vertical and so exposed must be small, so that vertical forces caused by the inertia of the moving liquid impinging on this surface should not be great (that is, the walls of the valve 30 should not be too thick); and, third, the valve must be so constructed that no partial vacuum can form inside of it.

The openings 31 must be relatively large, so that the inertia of the moving mass of pulp approaching these openings to pass through the valve does not affect the pressure at the upper ends of these openings, since the pressure at this point controls the height of the column of water in the float chamber 3 and hence the discharge of the pulp. With the openings 31 too short or otherwise too constricted, the pressure at the bottom of the annular space between the pipe 4 and the valve 30 is increased by the inertia of the mass of pulp approaching the openings 31 when the flow is in progress, and this interferes with the proper control of the valve by affecting the height of the column of water in the chamber 3 and gives a periodic instead of a continuous discharge.

The bottoms of the float 5 and of the float chamber 3 are made conical, the slope of the cone being downward toward the center and at an angle of approximately forty-five degrees. This is to avoid corners in which loose particles of sand or other material may accumulate. The critical angle of a pile of sand is less than forty-five degrees, so that any particle of sand finding its way into either the float chamber 3 or the float 5 will not be able to lodge there, but will pass downward, either into the teeter chamber through the openings 31 or out through the spigot 9, as the case may be.

The valve 30 is threaded into the lower end of the float 5, and a lock nut 36 is provided for locking the valve to the float. The lower end of the pipe 4 has threaded en-

gagement with the enlarged upper end of the casing 8, the said pipe being threaded into the recess or depression for the seat 33. If the valve 30 is lowered with respect to the float 5, a higher column of water is required in the chamber 3 to open the valve. To support this higher column of water requires a heavier bed of pulp in the teeter chamber, so that the adjustment of the length of the valve 30 in its relation to the float 5 may be used to produce a lighter or heavier bed of pulp in the teeter chamber. This same adjustment could be made by using weights in the float 5, the weights to be of such a shape that they would not prevent the passage of air from the float to the interior of the valve 30. I believe that the plan of making the valve 30 adjustable in its relation to the float 5 is to be preferred, as this adjustment is less easily tampered with.

The wearing parts of the apparatus are the upper end of the cone shaped valve seat 33 and to a lesser extent the lower end of the pipe 30. The seat 33 fits close enough in the depression in the upper end of the casing 8 to be held properly centered, but to permit its removal when worn.

The relative elevation of the liquid surfaces when the classifier is operating are indicated by the dotted lines. The surface of the pulp in the teeter chamber is indicated at *w*, of the water in the float chamber 3 at *x*, of the water in the chamber 13 at *y* and of the pulp in the valve 30 at *z*. The level to which the pulp rises in the valve 30 will be determined by the size of the opening through the seat 33, in its relation to the amount of pulp to be discharged. This bore or opening must be large enough to discharge the required amount of pulp when the pulp is running under a pressure head less than that required to raise the pulp into the float 5.

In the embodiment of the invention shown in Figure 6 the unclassified pulp is supplied from the pulp launder 50 and flows first into the pulp feed chamber 51. This chamber 51 communicates with the main body of the classifier by an opening 52 in its bottom, and the said chamber is placed partly submerged in the liquid in the classifier so that it is partly filled with pulp at all times. The plunging current of pulp being fed to the classifier exhausts its force in producing agitation in the pulp chamber 51, and the pulp settles quietly through the opening 52 and forms no eddying current in the pulp in the classifier which might interfere with the proper action of the classifier.

The heavy ore particles settle into the casing 53 which forms the teeter chamber, and here they are held in a condition of hindered settling by water which comes into the teeter chamber through the restricted openings in the plate 54 arranged between the teeter chamber and forming the bottom thereof, and a hydraulic chamber 55 of which it forms the top. The water is supplied by the pipe 56 which is controlled by a valve 57. A chamber 58 corresponding to the chamber 10 of Figure 1 receives the water from the pipe 56 and supplies it to a pipe 60. From the pipe 60 the water passes into the hydraulic chamber 55, the pipe 60 having the same function as the chambers 13 of Figure 2. The chamber 58 is provided with an overflow 59 and the chamber 60 is provided with an overflow 61. From the overflow 59 will flow the slight excess of water supplied to it from the pipe 56 over and above that which will flow from the chamber 58 at the pressure head maintained thereon, and this maintains a constant uniform flow of water from the chamber 58. The overflow 61 of the pipe 60 is above the float chamber of the valve, and is arranged so that any water overflowing at the overflow 61 will be admitted into the float chamber outside of the float. The overflow 61 is at a height above that to which the water in the pipe 60 will rise to create pressure enough in the hydraulic chamber 55 to force the water into the teeter chamber against the regular bed of pulp which it is desired to maintain in the teeter chamber, so that under regular operating conditions the water in the pipe 60 does not overflow but stands at the level *v*. The float chamber 62 is similar to the chamber 3 of Figure 1, being supported on the vertical pipe 65 corresponding to the pipe 4 and having openings 66 similar to the openings 31. The valve 67 has connected at the upper end thereof the float 63 similar in all respects to the float 5 of Figure 1. The valve 67 has the centering lugs similar to the lugs 32 and co-operates at its lower end with a seat 69 similar to the seat 33. The construction and operation of this valve are precisely the same as of that shown in Figures 1 to 5, and the seat 69 is supported by a casing 70 corresponding to the casing 8 of Figure 1.

In operation, the water rises in the annular space between the valve 67 and the pipe 65, until it is high enough in the float chamber to raise the float and the valve, which permits the pulp to flow from the teeter chamber through the bore of the valve seat and out through the casing 70. With the exception of the arrangement of the overflow 61 of the pipe 60 and the arrangement of the box 51 for feeding the pulp to the classifier, the classifier of Figure 6 operates in a manner identical with that of Figure 1. The overflow 61 leading to the chamber 62 is provided as an aid in establishing the normal operating conditions when the classifier is first filled with pulp.

Suppose the classifier to be empty, and water through the valve 57 and pulp through

the launder 50 be simultaneously admitted. The pulp being the natural product of crushed ore, contains material as fine as the very finest slime, and as the pulp level rises and the classifier is filled with pulp, the annular space between the pipe 65 and the valve 67 is filled with water forced into it from the teeter chamber through the opening 66. The larger particles of ore will immediately settle out of this space or will not be carried up into it at all. Some smaller particles will be carried up into this space by the rising water and the result will be that the annular space between the pipes as well as the float chamber 62 will become filled with muddy water.

This is a light pulp, that is, a liquid whose specific gravity is somewhere between that of the pulp in the teeter chamber and that of clear water. Therefore, it rises to a less height in the float chamber than a column of clear water would rise, in order to balance a pulp bed of a given density. Hence results that the bed of pulp must accumulate to a density in excess of that which it is desired to maintain regularly, before the column of muddy water rises high enough to lift the float and permit the pulp to discharge.

The increase in density of the pulp bed forces the water to rise in the pipe 60 to a higher level than it rises when the pulp bed is of a normal thickness. By arranging the overflow 61 as shown, slightly above the level v at which the water normally stands, a slight increase in density of the pulp bed raises the level of the water in the pipe 60 until some of it overflows at 61 into the chamber 62. This furnishes clear water in the chamber 62 which displaces downwardly the muddy water and so substitutes a column of clear water for the column of muddy water. The column of clear water holds a level high enough to lift the float which permits the pulp to flow from the teeter chamber until the normal thickness of the pulp bed is reached and the water in the pipe 60 will then return to its normal level at v. Without this arrangement some time would elapse before the very fine ore particles settled from the chamber 62 and the annular space between the pipe 65 and the valve and normal operating conditions were established.

The overflow from the cone classifier takes place at the top of the ring 71 which is arranged within the hopper shaped upper portion 53^a of the casing. The space 72 outside of the ring constitutes a launder about the top of the classifier which conducts the overflow to the discharge launder 73. Plugs 74 are provided in the bottom of the hydraulic chamber for draining the said chamber. It is obvious that although but one use of this form of valve is indicated, namely, to regulate the discharge of classified pulp from an ore classifier, its usefulness is not restricted to this specific application.

In the design of both Figures 1 and 6 the float which controls the movement of the throttle valve is supported on a column of water balanced hydraulically against a portion of the column of pulp in the teeter chamber. It is theoretically possible to obtain the same control of the movement of the valve by the use of a float immersed directly in the pulp. When the pulp becomes dense the force tending to lift the float will be correspondingly increased, since the float is buoyed up by a force equal to the weight of the liquid it displaces. A construction depending on a float immersed directly in the pulp would not be a departure from the spirit of my invention.

Figure 7 shows a construction wherein the spacing pins 32^a are attached to the pipe 4 instead of to the valve. The advantage of the construction shown in Figure 7 is that with this construction the pipes 4 and 30 may be kept more accurately centered than with the construction indicated in Figure 3, that is, less lateral play is necessary in the moving parts in order to insure that the valve 30 will at all times be free to move vertically without binding of the guides. The advantage of the construction shown in Figure 3 is that with this construction it is not necessary to remove the pipe 4 from its position in the teeter chamber in order to remove the valve seat 33 when it becomes worn, and replace with a new valve seat.

I claim:

1. In a classifier having an outlet for the discharge of pulp, means for varying the capacity of the outlet controlled by the density of the pulp, said means comprising a gate or valve, a float for operating the gate or valve and balanced between a column of water and a column of pulp in the container, said valve being a hollow cylindrical body vertical or nearly so, open at top and bottom, integrally connected with the float and of smaller cross section than the float.

2. In a classifier, having an outlet for the discharge of pulp, means for varying the capacity of the outlet controlled by the density of the pulp, said means comprising a gate or valve, a float for operating the gate or valve and balanced between a column of water and a column of pulp in the container, said float and valve being hollow bodies open at top and bottom, the float being of greater diameter than the valve and having its under surface tapering toward the valve.

3. In a classifier having an outlet for the discharge of pulp, means for varying the capacity of the outlet controlled by the density of the pulp, said means comprising a gate or valve, a float for operating the gate or valve and balanced between a column of

water and a column of pulp in the container, said valve being a tubular body with thin walls, open at top and bottom, its closure being effected by contact of the inside edge of its lower end with a valve seat.

4. A valve of the character specified, in the shape of a tube, vertical or nearly so, having at its upper end a float of larger cross section than the valve, the bore of the valve communicating with the atmosphere at its upper end, a seat with which the valve cooperates at its lower end, said seat having its peripheral surface tapering toward the valve, and a casing arranged outside of and concentrically with the valve and having at its upper end a float chamber and having openings at its lower end.

5. A valve of the character specified in the shape of a tube connecting at its upper end with a float, the bore of the valve being open through the float, a valve seat with which the valve co-operates at its lower end, the valve seat being of such a shape that the lower end of the walls of the tube are exposed to the hydraulic pressure with the valve either open or closed.

6. Means depending on the density of ore pulp in a container for regulating the discharge of the pulp therefrom, said means consisting of a throttle valve or gate suspended from a float which is supported on a column of water balanced hydraulically against all or part of the column of pulp in the container.

7. Means depending on the density of ore pulp in a container for regulating the discharge of the pulp therefrom, said means consisting of a throttle valve or gate suspended from and integral with a float which is supported on a column of water balanced hydraulically against all or part of the column of pulp in the container.

8. Means depending on the density of ore pulp in a container for regulating the discharge of pulp therefrom, said means consisting of a throttle valve or gate made in the form of a hollow cylinder with thin walls, open at both ends and suspended from and integral with a float, the valve being attached to the float with free communication between the inside of the valve and the space above the pulp, the float being supported on a column of water balanced hydraulically against all or part of the column of pulp in the container.

9. Means depending on the density of ore pulp in a container for regulating the discharge of the pulp therefrom, said means consisting of a throttle valve or gate made in the form of a cylindrical pipe with thin walls and open at both ends, suspended vertically from a float supported on a column of water balanced hydraulically against all or part of the column of pulp in the container, the inside of the valve having free communication with the space above the pulp, a valve seat for the valve of such shape that when the valve is closed only the inside edge of its lower end touches the valve seat.

10. Means depending on the level of a liquid in a container for regulating the outflow of the liquid therefrom through an orifice at or near the bottom thereof, said means consisting of a throttle valve in the form of a cylindrical pipe open at both ends, suspended vertically from and integral with a float which derives its support from being partially submerged in the liquid, the inside of the valve having free communication with the space above the surface of the liquid, the lower end of the valve coming into contact with a valve seat in the form of a frustum of a cone with a hole through its axis, the valve seat being of such a size and position that contact between the valve and valve seat takes place between the inside edge of the lower end of the valve and a circle of the conical surface.

11. A valve for regulating the discharge of liquid from a container, the valve or moving portion being a straight cylindrical pipe in a vertical or approximately vertical position, open at both ends, with its upper end open to the space above the surface of the liquid in the container and its lower end immersed in the liquid, a valve seat in the form of a frustum of a rectangular cone with a hole through its axis, the axis of the cone being coincident with the extension of the center line of the cylinder forming the valve, the motion of the valve being confined to a direction parallel with its center line, the small end of the frustum being upward next the valve and smaller than the inside of the valve, so that contact between the valve and valve seat takes place when the valve is closed between the inner edge of the lower end of the valve and a circle of the conical surface.

12. A valve for regulating the discharge of liquid from a containing vessel, the valve or moving part being a straight cylindrical pipe in a vertical or approximately vertical position, open at both ends with its upper end open to the space above the surface of the liquid in the container and its lower end immersed in the liquid, a valve seat in the form of the frustum of a rectangular cone with a hole through its axis, the axis of the cone being coincident with the extension of the center line of the cylinder forming the valve, the motion of the valve being confined to a direction parallel with its center line, the small end of the frustum being upward next the valve and smaller than the inside of the valve so that contact between the valve and valve seat takes place when

the valve is closed between the inner edge of the lower end of the valve and a circle of the conical surface, the relative position of the valve and valve seat depending on the buoyant force exerted on a body in the nature of a float either wholly or partially immersed in the liquid of the containing vessel.

13. In a hydraulic classifier, a teeter or pulp chamber wherein hindered settling conditions are maintained, means for supplying unclassified pulp to the teeter chamber and for conducting away the lighter portion of the pulp unable to sink into the chamber, means for regulating the discharge of the heavy classified pulp from teeter chamber by a mechanical throttling valve in the form of a hollow cylinder open at both ends, and the operation of which is controlled by the changing of the density of the pulp in the teeter chamber, the valve seat of the throttling valve being in the shape of a frustum of a cone hollow through its axis.

14. In a hydraulic classifier, a pulp or teeter chamber wherein hindered settling conditions are maintained, means for supplying unclassified pulp to the chamber and for conducting away the lighter portion of the pulp unable to sink into the chamber, means for regulating the discharge of the heavy classified pulp from the teeter chamber by the use of a mechanical throttling valve which is a hollow cylinder open at both ends and attached at its upper end to a float resting on a column of water balanced hydraulically against all or part of the column of pulp in the teeter chamber, the valve seat for the valve being in the shape of a frustum of a cone hollow through its axis.

15. In a hydraulic classifier, a pulp or teeter chamber wherein hindered settling conditions are maintained, means for supplying unclassified pulp to the chamber and for conducting away the lighter portion of the pulp unable to sink into the chamber, means for regulating the discharge of the heavy classified pulp from the teeter chamber by the use of a mechanical throttling valve in the shape of a hollow cylinder open at both ends, its action depending on the use of a column of water balanced hydraulically against all or part of the column of pulp in the teeter chamber, and its seat being in the shape of a frustum of a cone hollow through its axis.

16. In a hydraulic classifier, a pulp or teeter chamber, means for supplying hydraulic water to produce hindered settling classification therein, means for maintaining the even distribution of the hydraulic water over the teeter chamber area by forcing it to enter the teeter chamber through numerous small openings distributed over the bottom of the teeter chamber, the said openings being so restricted that they form enough resistance to the passage of the water that the distribution of the water is thereby maintained regardless of slight inequalities in the weight of the pulp bed at different points in the teeter chamber, means for supplying unclassified pulp to the teeter chamber and for carrying away the overflow pulp made up of the particles of ore too light to sink into the teeter chamber, means for discharging the heavy classified portion of the pulp through a restricted orifice at or near the bottom of the teeter chamber, with means for restricting the flow of the pulp at the point where it leaves the teeter chamber by the use of a mechanical valve or gate, the operation of which is accomplished by the use of a column of water balanced hydraulically against all or part of the column of pulp in the teeter chamber.

17. In a hydraulic classifier, a pulp or teeter chamber, means for supplying hydraulic water to produce hindered settling classification therein, means for maintaining the even distribution of the hydraulic water over the teeter chamber area by forcing it to enter the teeter chamber through numerous small openings distributed over the bottom of the the teeter chamber, the said openings being so restricted that they form enough resistance to the passage of the water that the distribution of the water is thereby maintained regardless of slight inequalities in the weight of the pulp bed at different points in the teeter chamber, means for supplying unclassified pulp to the teeter chamber and for carrying away the overflow pulp made up of the particles of ore too light to sink into the teeter chamber, means for discharging the heavy classified portion of the pulp through a restricted orifice at or near the bottom of the teeter chamber, means for regulating the outflow of the heavy classified pulp from the teeter chamber by the use of a throttling valve, the action of which is controlled by a float supported on a column of water balanced hydraulically against all or part of the column of pulp in the teeter chamber.

18. In a hydraulic classifier, a pulp or teeter chamber, means for supplying water to produce hindered settling classification therein, means for maintaining the even distribution of the water over the teeter chamber area by forcing it to enter the teeter chamber through numerous small openings distributed over the bottom of the teeter chamber, the said openings being so restricted that they form enough resistance to the passage of the water that the distribution of the water is thereby maintained regardless of slight inequalities in the weight of the pulp bed at different points in the teeter chamber, means for supplying un-

classified pulp to the teeter chamber and for carrying away the overflow pulp made up of the particles of ore too light to sink into the teeter chamber, means for discharging the heavy classified portion of the pulp and for regulating its rate of discharge by a throttling valve in the shape of a hollow cylinder open at both ends and suspended from and integral with a float which is supported on a column of water balanced hydraulically against all or part of the column of pulp in the teeter chamber, the valve seat for the valve having an orifice through it for the passage of the pulp and being of such a shape and size that when the valve is closed the valve seat touches the valve only at the inner edge of the lower end of the valve.

19. In a hydraulic classifier, a pulp or teeter chamber, a hydraulic chamber beneath the teeter chamber and communicating therewith by restricted openings, means for supplying water to the hydraulic chamber, a float chamber inside the classifier and supporting a column of water balanced hydraulically against all or part of the column of pulp in the teeter chamber, a stand pipe connecting with the hydraulic chamber and having an overflow above the float chamber and leading thereto, a throttling valve or gate for controlling the outflow of the heavy classified pulp from the teeter chamber, the said valve being operated by a float in the float chamber.

20. In a hydraulic classifier, a pulp or teeter chamber, a hydraulic chamber beneath the teeter chamber and separated therefrom by a partition having highly restricted openings, means for supplying water to the teeter chamber through the hydraulic chamber and the restricted openings in such quantity that the pressure head maintained across the partition will give even distribution of the water to the restricted openings and hence to all parts of the teeter chamber, a float chamber inside of the classifier and containing a column of water balanced hydraulically against all or part of the column of pulp in the teeter chamber, a stand pipe in connection with the hydraulic chamber and having an overflow above the float chamber and leading into the float chamber, a float in the float chamber connected with and operating a mechanical device which regulates the outflow of the heavy classified pulp from the teeter chamber.

21. In a hydraulic classifier, a pulp or teeter chamber, in all parts of which a uniform hindered settling bed of pulp is maintained by hydraulic water entering the teeter chamber through numerous small openings in the bottom thereof and under sufficient pressure to overcome slight inequalities at different points in the pulp bed, a float chamber supporting a column of water balanced hydraulically against all or part of the column of pulp in the teeter chamber, means controlled by the density of the pulp in the pulp bed for supplying water to the top of the float chamber, a float in the float chamber, and a mechanical device operated by the float for regulating the outflow of the heavy classified pulp from the teeter chamber.

22. In a device of the character specified, the combination of a teeter chamber, a feed water chamber located above the teeter chamber, means for maintaining a constant depth of water in the feed water chamber, and a valve or gate controlled by the density of the pulp bed and balanced hydraulically against the pulp for regulating the discharge of the heavy classified pulp from the teeter chamber.

23. In a device of the character described, a teeter chamber in all parts of which a uniform hindered settling bed of pulp is maintained by water entering the teeter chamber through numerous restricted openings in the bottom thereof and under sufficient pressure to overcome the tendency of the pulp to form a bank or solid mass upon the bottom of the teeter chamber, and means depending on the use of a column of water balanced hydraulically against a column of the liquid ore pulp in the teeter chamber for regulating the discharge of the pulp from the teeter chamber.

24. In a device of the character described, a teeter chamber, a hydraulic chamber there beneath and separated therefrom by a partition through which highly restricted openings are formed, means for supplying water through the partition to the teeter chamber in such a quantity that a predetermined pressure head may be maintained across the partition to effect even distribution of the water to all parts of the teeter chamber, and means depending on the use of a column of water balanced hydraulically against a column of the liquid ore pulp in the teeter chamber for regulating the discharge of the pulp from the teeter chamber.

25. In a device of the character specified, a teeter chamber, means for supplying water to the teeter chamber and means for restricting the flow of the water as it enters the teeter chamber in such a manner as to maintain its even distribution over the teeter chamber area, and means depending on the use of a column of water balanced hydraulically against a column of the liquid ore pulp in the teeter chamber for regulating the discharge of the pulp from the teeter chamber.

26. In a device of the character specified, a teeter chamber, means for supplying water to produce hindered settling classification therein, means for maintaining the even distribution of the water over the teeter chamber area by forcing it to enter the teeter

chamber through numerous small openings distributed over the bottom of the teeter chamber, the said openings being so restricted that they form enough resistance to the passage of the water that the distribution of the water is thereby maintained regardless of slight inequalities in the weight of the pulp bed at different points in the teeter chamber, and means depending on the use of a column of water balanced hydraulically against a column of the liquid ore pulp in the teeter chamber for regulating the discharge of the pulp from the teeter chamber.

27. In a hydraulic classifier, a pulp or teeter chamber wherein hindered settling conditions are maintained, means for supplying unclassified pulp to the chamber and for conducting away the lighter portion of the pulp unable to sink into the teeter chamber, means for regulating the discharge of the heavy classified portion of the pulp from the teeter chamber by a throttling valve in the shape of a hollow cylinder with thin walls, the operation of which depends on the use of a column of water balanced hydraulically against all or part of the column of pulp in the teeter chamber.

28. As a means of regulating the discharge ore pulp from a containing vessel, the use, in combination, of a valve in the shape of a hollow cylinder with thin walls and a column of water balanced hydraulically against a column of the ore pulp in the containing vessel.

ROBERT BAXTER ELDER.

Witnesses:
ALGERNON S. LONG,
MARTHA E. WALTON.