

Nov. 26, 1968

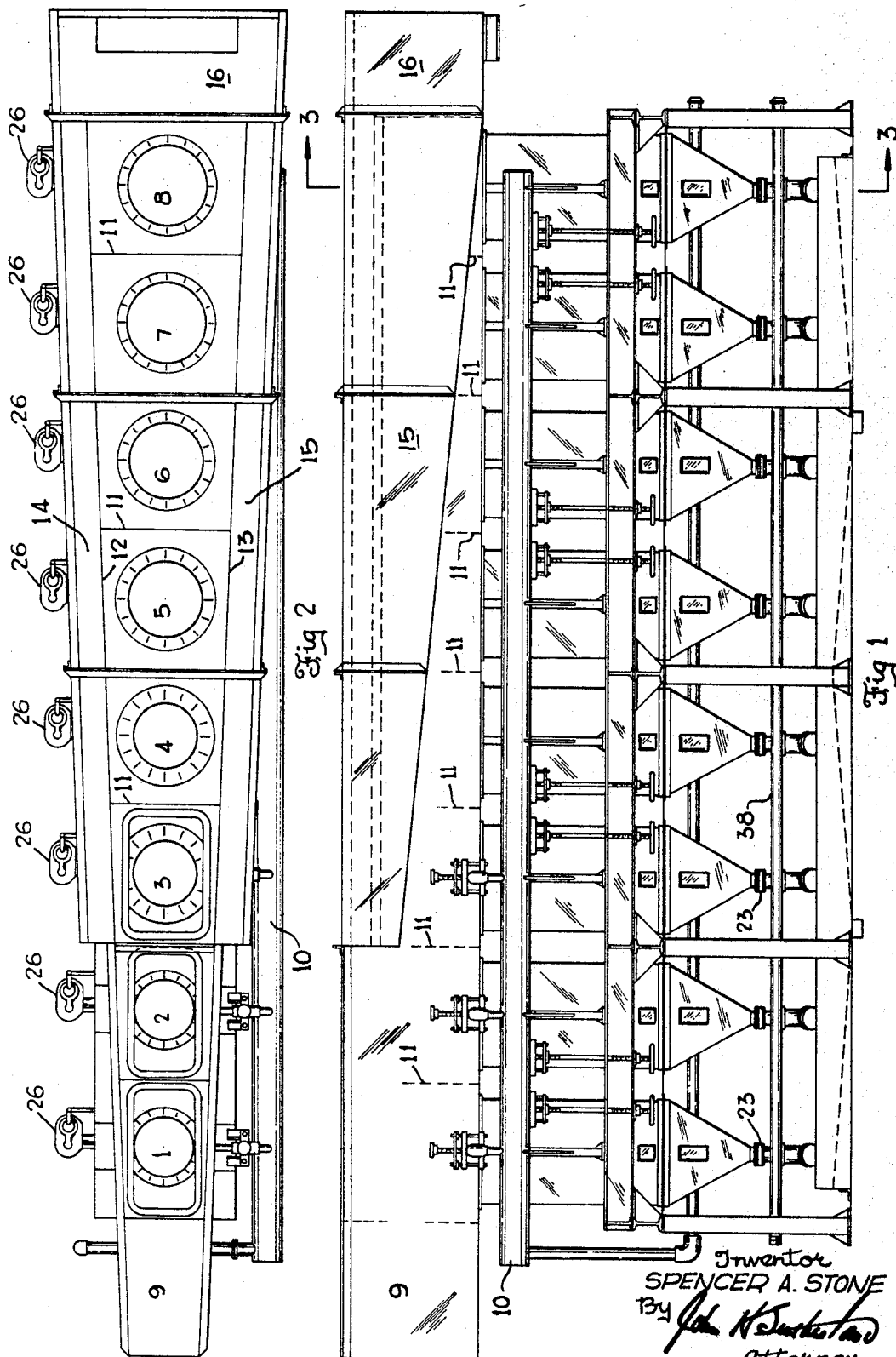
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3,412,858

HYDRAULIC CLASSIFIER HAVING AUTOMATIC UNDERFLOW DISCHARGE CONTROL

Filed June 16, 1965

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

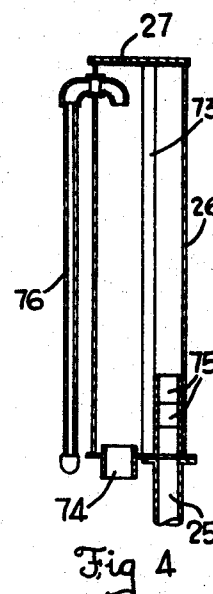
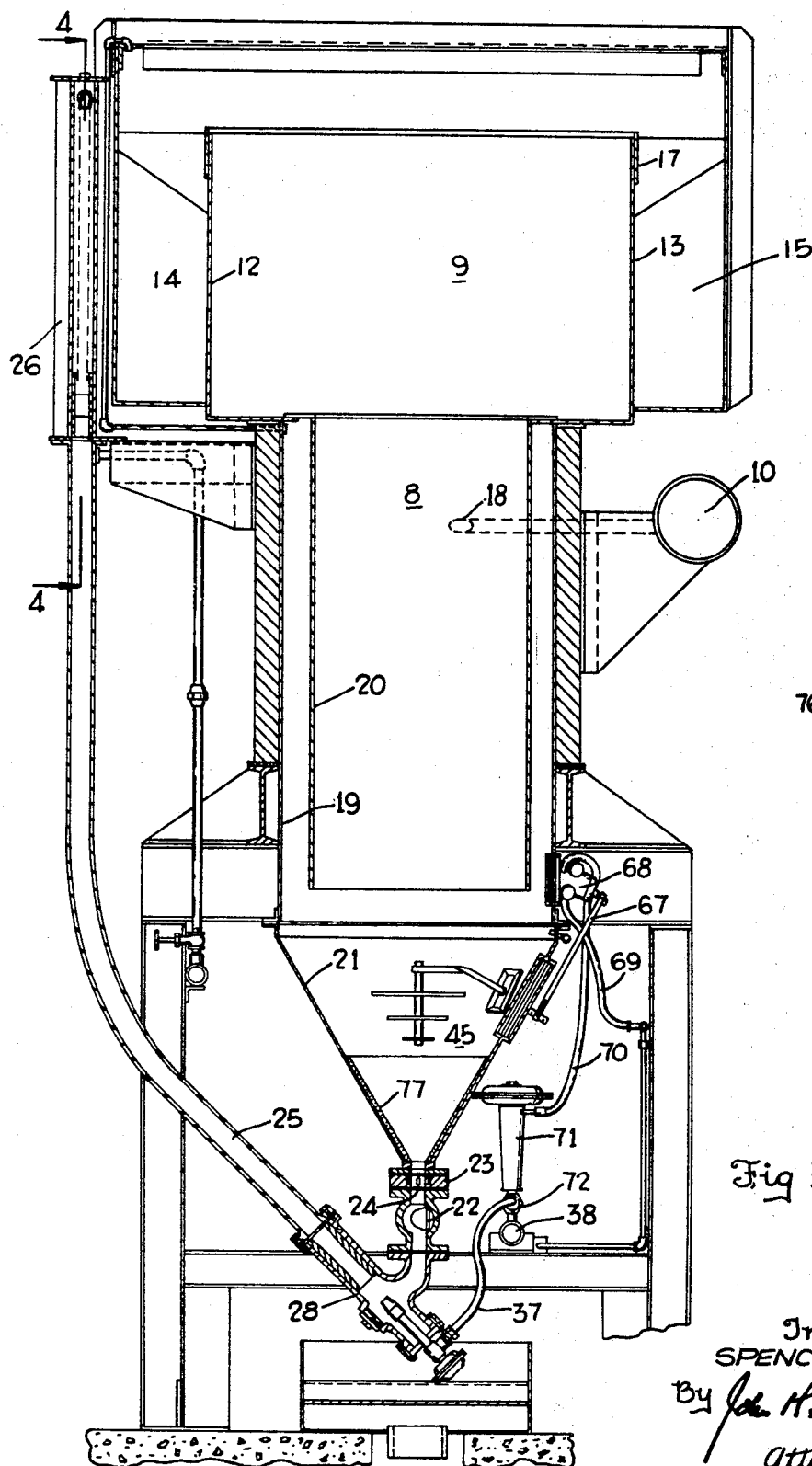


Fig 3

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4 Sheets-Sheet 3

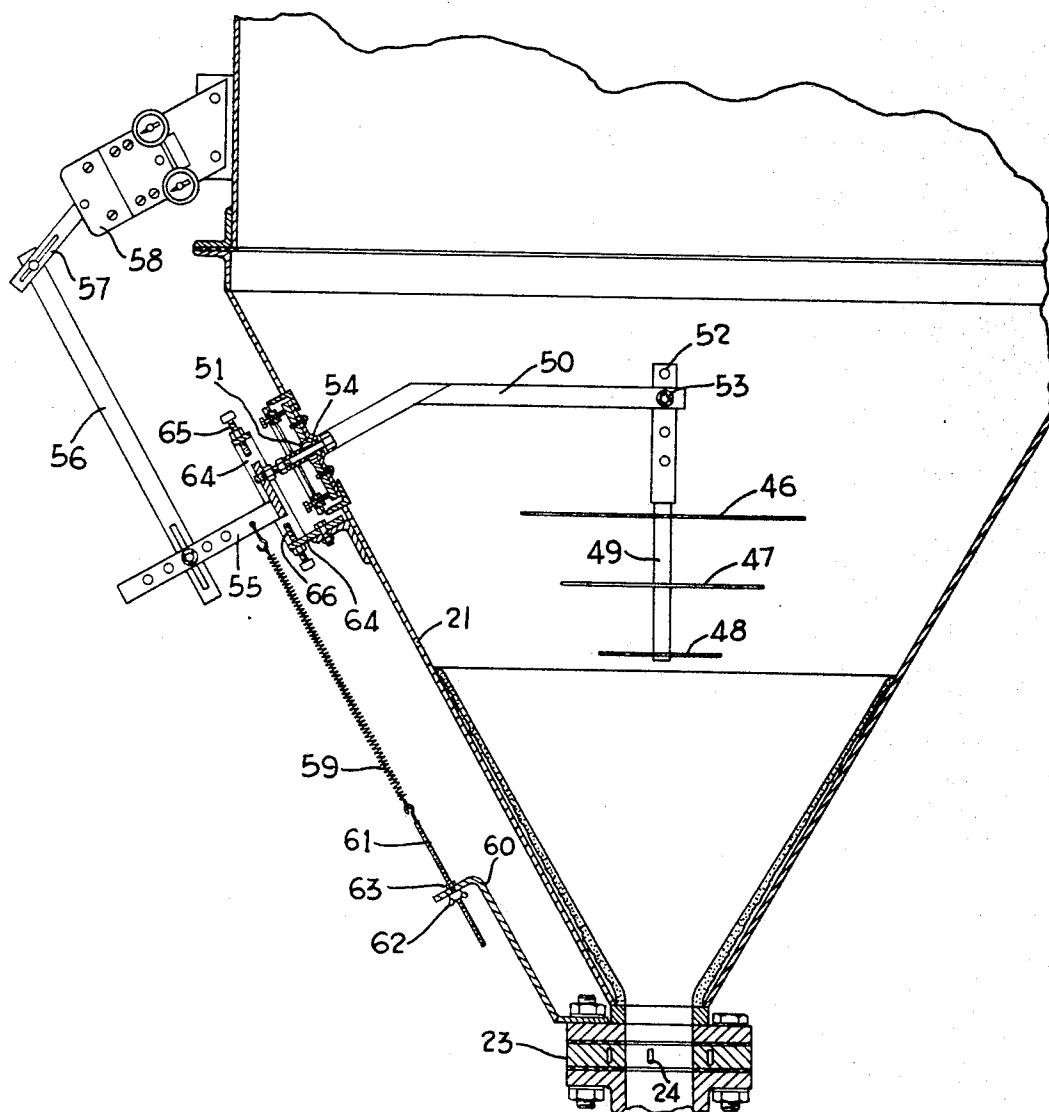


Fig 5

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4 Sheets-Sheet 4

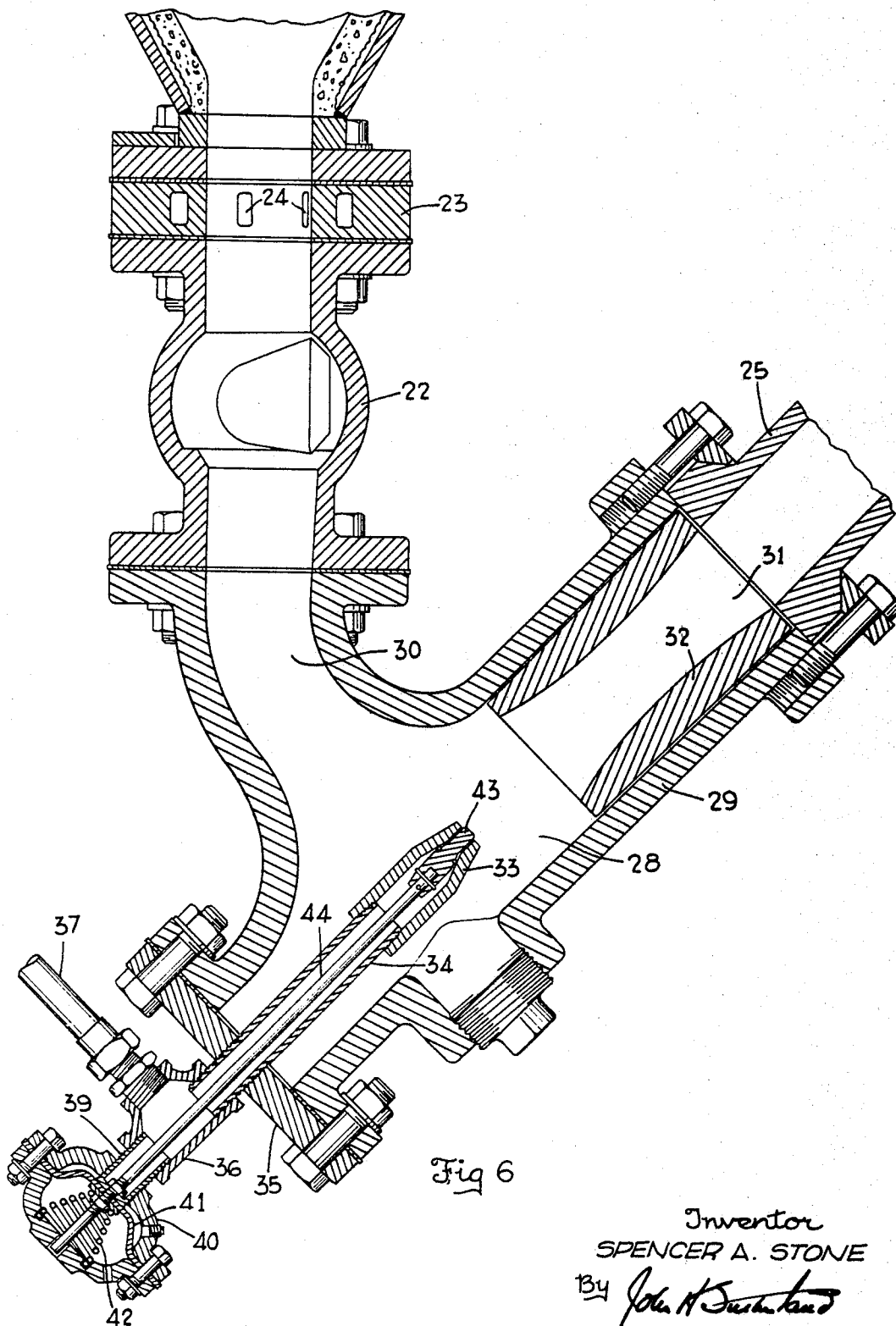


Fig 6

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## HYDRAULIC CLASSIFIER HAVING AUTOMATIC UNDERFLOW DISCHARGE CONTROL

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13 Claims. (Cl. 209—159)

### ABSTRACT OF THE DISCLOSURE

Hydraulic classifier of the teeter column type having, in the quiescent zone where the solid particles settle as a bed, a sensor which responds to changes in the depth of the bed to control discharge from the classifier. The discharge from the classifier is normally open, but flow through it is regulated by a hydrostatic head acting counter to that imposed by the contents of the classifier, and by a fluid ejector.

This invention relates generally to mineral separation, and particularly to the control and automation of hydraulic classifiers of the general type shown in U.S. Patent No. 2,696,298, and their use in a mineral separation system where the discharge from the hydraulic classifier is the feed to a coal washing or ore concentrating table.

Such hydraulic classifiers, equipped with constrictor valves of the type shown in U.S. Patent No. 2,681,751, have performed with excellent results, but, in the course of time, it was found that the flexible tube, which was repeatedly collapsed and extended to perform a valving function, was of unpredictable longevity, and would sometimes rupture unexpectedly, with the result that an entire plant would have to be shut down not only to replace the tube, but to clean up the "mess" resulting from such rupture.

Accordingly, it is one object of the present invention to provide such an hydraulic classifier with discharge controls of a character such that the aforesaid objections are avoided.

In the operation of hydraulic classifiers constructed as aforesaid, in situations where the feed was subject to frequent variations in rate or character or both, constant supervision has heretofore been required in order to avoid the possibility that one or more cells would either run empty or lose the required quiescent bed of solids, and discharge water at a considerably increased rate, or, if the solids were not drawn off fast enough, they would build up beyond a safe operating depth. Consequently, in some installations, it was mandatory to keep an operator or supervisor in constant attendance in order to manually regulate the cells' discharge as feed conditions varied.

Accordingly, it is another object of the present invention to provide an hydraulic classifier of the character aforesaid which is self-regulating.

An additional object of the invention is to provide such an hydraulic classifier which is not only self-regulating, but so self-regulated as to maintain the liquid-to-solid content of its discharge as desired for feed to a coal washing or ore concentrating table forming a part of the same mineral separation system, and thus to coordinate the operation of the two mineral separation instrumentalities.

Generally stated, the aforesaid objects, and others which will hereinafter become apparent, are accomplished

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by imposing a reverse hydraulic head at the discharge of the hydraulic classifier, so that the quiescent bed of solids within the classifier is subjected to a differential head imposed, on the one hand, by the body of liquid above it within the classifier, and, on the other hand, by the column of liquid outside the classifier which is imposed on the discharge. Thus, the differential in such heads becomes the primary control on the rate of discharge of settled solids from the hydraulic classifier, and is subject to variations either manually or automatically, and may be supplemented, if desired, by other means to accelerate the rate of discharge and vary its fluid content when need be.

In order to effect the automatic control of the rate of discharge of settled solids from the hydraulic classifier, and to adjust the liquid content of such discharge, the invention contemplates the provision of a sensor within the quiescent zone, where the solids having specific gravity and size above predetermined values settle as a bed near the bottom of the hydraulic classifier. To achieve optimum operation with a given feed, it is desirable to maintain the bed of settled solids in the quiescent zone at a more or less constant depth, and accordingly the invention contemplates the provision of means for continuously sensing the level of the top of the bed of settled solids, and to translate changes of the bed level into corrective action. On the other hand, if such a sensor be provided so as to ride on top of the bed of settled solids, it is subject to the influence of swirling currents of liquids, and likely to give a false indication of the depth of the bed when buffeted by such swirling currents. Accordingly, the invention contemplates that the sensor be entrained within the bed of ambient material which consists of settled solids and interstitial water, so that it will be drawn down as the bed, en masse, moves downward in the process of being drawn off without replenishment. Such a sensor may operate like a scale or balance, so that it constantly measures the weight of settled solids sustained by it, but is counterbalanced so as to maintain it in a neutral position when the weight of settled solids sustained by the sensor is at the optimum value. On the other hand, as the depth of the bed of settled solids increases, the weight of solids sustained by the sensor increases, so that the sensor moves downwardly, and either signals the existence of imbalance, or actuates the instrumentalities necessary to bring the operating conditions back into balance.

As indicated hereinbefore, the conditions of imbalance may be rectified either by varying the differential head on the discharge, or by accelerating the rate of flow through the discharge by other means, such, for example, as a fluid ejector located in the discharge line. Where such an ejector is employed in the discharge line, however, its nozzle is likely to become plugged by the settling thereabout of solids from the passing stream while the ejector is not operating. Accordingly, the invention contemplates the provision of such an ejector with means for preventing such plugging. Such a means may take the form of a cap or stopper for the nozzle of the ejector, and may be moved into and out of protective relationship with the nozzle by instrumentalities actuated by the aforesaid sensor.

Where the hydraulic classifier is to be used in a system in which the discharge from the hydraulic classifier constitutes the feed to a coal washing or ore dressing table, it is preferable to employ both the differential head and

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some such means as a fluid ejector for controlling the rate of discharge from the hydraulic classifier, and hence the rate of feed to the table. By merely increasing the differential head, the rate of discharge from the hydraulic classifier increases, but if the rate of discharge of solids is greater than the rate at which the solids are settling, no bed of solids would build up in the hydraulic classifier. Under the postulated conditions, the discharge would have too low a liquid content to constitute a satisfactory feed to the table. Conversely, if the differential head is too little, the rate of discharge would be too little, and the depth of the bed within the hydraulic classifier would build up to excessive height, and the discharge might become so overly thick that it would not flow through the discharge. Accordingly, the supplementation of the differential head with other flow-inducing means, which introduces liquid into the discharge stream, is desirable, not only for controlling the rate of discharge, but the ratio of water to solids in it, so that when there is need to increase the rate at which solids are removed from the hydraulic classifier, such is done, in part at least, by adding more liquid, and thus the water-to-solids ratio in the cell discharge remains satisfactorily uniform for good table operation. Modulation of the amount of water introduced into the discharge stream from the classifier may be automatically regulated by the response or signal generated by the sensor.

One embodiment of the invention is illustrated in the accompanying drawings, in which:

FIGURE 1 is a view in side elevation of a battery of hydraulic classifier cells constructed and equipped in accordance with the present invention;

FIGURE 2 is a top plan view of the cell battery shown in FIGURE 1;

FIGURE 3 is a sectional view taken along line 3-3 of FIGURE 1;

FIGURE 4 is a sectional view taken along line 4-4 of FIGURE 3;

FIGURE 5 is an enlarged sectional view of the quiescent zone in a cell, showing the sensor and appurtenances; and

FIGURE 6 is an enlarged sectional view showing the discharge end of the hydraulic classifier and its discharge outlet, equipped with a fluid ejector of the character contemplated by the invention.

In FIGURES 1 and 2 of the drawings, there is shown a battery of hydraulic classifier cells 1, 2, 3, 4, 5, 6, 7 and 8, of the general type disclosed in the aforesaid Patent No. 2,696,298. As will be observed from FIGURE 2, the teeter columns of the respective cells progressively increase in diameter from cell 1 to cell 8, as is conventional. A feed launder 9 interconnects the upper ends of the several cells in the usual manner, it being understood that the feed inlet is at the left end of launder 9 (as seen in FIGURES 1 and 2), and that between the respective cells, there are weirs 11 of gradually diminishing height from left to right, as seen in FIGURE 1. The weirs 11 separate the zones of activity of the respective cells, as more fully described in the aforesaid Patent No. 2,696,298. The overflow level in all cells is controlled by the elevation of the top edges of walls 12 and 13 that separate the feed launder from the gathering launders 14 and 15, which latter, in the form shown, extend alongside all cells from 3 to 8 to receive overflow and discharge the same into discharge box 16. In keeping with the conventional practice, the top edges of walls 12 and 13 are preferably provided with vertically adjustable weirs 17 (see FIGURE 3) in order to vary the elevation of overflow from all cells and thereby adjust the positive hydrostatic head on them.

A water header 10 extends along the battery of cells, and is provided adjacent each cell with a tangential water inlet 18, discharging between the external cylinder 19 and internal cylinder 20 of the respective cells as shown in FIGURE 3, and for the usual purpose to create a swirl of water or water solution, or other liquid medium,

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within the cells, whereby to stabilize the teeter column within cylinder 20. Below cylinder 20, the device is provided with a conical section 21, defining a "quiescent zone" within which the solids above a predetermined specific gravity, and above a predetermined size magnitude, settle, while those of lesser specific gravity and lesser size magnitude float to the top and spill over the weir which separates one cell from the next, moving in the left to right direction (or 1 toward 8) as seen in FIGURES 1 and 2.

As thus far described, the construction and operation of the battery of cells is consistent with prior practice, and constitutes only the background for the present invention.

Below the conical section 21, the present invention contemplates that there be provided a spigot including a valve 22, which latter is not for the purpose of controlling the discharge flow from the cell during normal operation, but for use in unusual situations to prevent such flow. Accordingly, such valve may be an ordinary ball valve or stop cock which has a closed and an open position, and is not intended to be operated at any intermediate position. Ordinarily, the valve 22 is operable manually, but its automatic operation, as hereinafter described, is contemplated by the invention.

Since there are periods of inoperation, as, for example, when valve 22 is in its closed position under some emergency condition, the bed of solids which has settled in the quiescent zone may become tight, so that it does not move when valve 22 is opened. In order to disintegrate and dislodge any such compaction of solids, an injection fitting 23 is provided between valve 22 and conical section 21. The fitting 23 is a collar provided with a plurality of openings 24, semitangentially opening into the interior of the collar, and connected on the exterior of the cell to a source of high pressure water, such as header 10, and appropriately controlled by a valve not shown.

Valve 22 is connected at its lower end to a discharge line 25, which rises to a level well above the quiescent zone, and terminates in a cell discharge box 26 which is vented to the atmosphere by a hole 27. The discharge line 25 is preferably formed of a nonmetallic conduit made, for example, of rubber, or other abrasion-resistant plastic material. The upper terminus of conduit 25 within discharge box 26 is, in accordance with the present invention, made of variable height, so as to regulate the vertical length of the column of liquid therein, and thereby to provide a substantial, but variable, hydrostatic head acting upwardly through valve 22 to resist downward flow through said valve under the influence of the hydrostatic head imposed in the opposite direction (i.e., tending to induce such flow) by the column of liquid within the cell. Accordingly, the maximum elevation of conduit 25, or its extensions, within cell discharge box 26 is below the top of the cell with which it is associated, so that the difference in elevation determines the degree of differential hydrostatic head tending to cause discharge flow through valve 22, and thereby regulates the rate of such flow. Various means may be employed for varying the elevation of the end of conduit 22 within the discharge box 26, as will be hereinafter described.

In the embodiment shown in the drawings, a liquid ejector 28 is provided at or near the bottom of the hydrostatic column in conduit 25. The ejector 28 is not essential in all applications of the apparatus, but in situations where it is desired to increase the rate of discharge flow through valve 22 either temporarily or constantly, the ejector 28 supplements the aforesaid differential head, and induces flow at a higher rate than would be accomplishable by gravity alone as regulated through the differential head.

The ejector 28 is shown in detail in FIGURE 6, and consists essentially of a housing 29 secured directly to the discharge outlet of valve 22 at opening 30, and having another opening 31 secured directly to discharge conduit 25. Adjacent opening 31, there is preferably provided

a venturi tube 32. Addressed toward the venturi is a nozzle 33, connected to a tube 34, which extends through a plate 35 to the exterior of housing 29, where the tube 34 is connected through a T 36, one leg of which is connected to a conduit 37 leading to a source of water, such as 38 (see FIGURE 1), under higher pressure than the water in header 10. The third leg of T 36 is connected through a nipple 39 to a diaphragm housing 40, within which is contained a movable diaphragm 41 biased in the direction toward T 36 by adjustable spiral spring 42. Thus, the arrangement is such that the hydrostatic pressure of liquid within T 36 is imposed upon diaphragm 41 tending to move the latter against the bias of spring 42, but when the hydrostatic pressure within T 36 is reduced, spring 42 tends to move the diaphragm to the position shown in FIGURE 6.

The purpose of the diaphragm and its adjunct parts is to maintain the orifice in the outer end of nozzle 33 closed at all times, save when the water under high pressure is desired to be ejected through said nozzle toward venturi 32. To accomplish this, there is provided a stopper 43, shaped and proportioned to snugly fit the orifice of nozzle 33, and preferably project a mite beyond the end thereof. The stopper 43 is connected by a rod 44 to diaphragm 41. Consequently, when the hydraulic pressure within T 36 is less than sufficient to overcome the bias of spring 42, the thrust of the spring is communicated through rod 44 to stopper 43, and thereby urges the stopper into the position shown in FIGURE 6, which prevents the ingress of solids at nozzle 33. On the other hand, when it is desired to eject water from nozzle 33 into the discharge line, the hydraulic pressure within T 36 must first build up to a value sufficient to move diaphragm 41 against the bias of spring 42 and dislodge stopper 43 from the end of nozzle 33. It will be understood, however, that in lieu of spring 42 and diaphragm 41, the stopper 43 may be manipulated to and from its nozzle-closing position by equivalent means, such as manually or by differential pressure devices. In any event, the ejection of high pressure liquid through nozzle 33 tends to increase the rate of discharge flow through valve 22, and conduit 25, the degree of such increase being proportional to the fluid pressure within the ejector, which in turn is subject to either manual or automatic control, as hereinafter described.

Within the conical section 21, sufficiently below the inner cylinder 20 so as to be unaffected by the swirling currents generated between the cylinders 19 and 20, there is a bed-depth sensor. The sensor may take a variety of forms in which its active parts are disposed so as to be entrained within the normal bed of settled solids, and to respond to variations in the depth of it, and to maintain a neutral position when the bed is normal. It may be in essence a weighing device which detects changes in the specific gravity of the mixture of solids and water surrounding it. Any hollow vessel, which acts as a float, may be used, but since the specific gravity of the bed will be higher at cell 1 than at cell 8, floats of different volume, or floats otherwise provided with means for varying their specific gravity, will be required in the respective cells; or a truncated cone mounted base-up with an imperforate base, a downwardly facing open truncation, and sides that are approximately parallel with the walls 21, may be used with advantage. In any event, when the bed of settled solids is drawn down abnormally low, which is a slow process, the active elements of such a sensor respond to the departure of the bed, and move upwardly from their neutral position. Conversely, if, for some reason, the bed of settled solids becomes abnormally deep, the active elements of the sensor respond by moving deeper into the bed as the solids below it are discharged. In the embodiment shown in the drawings, the active elements of the sensor may be regarded as floating in the bed of solids of normal depth, so that as the depth of the bed of solids increases above normal, additional load of sol-

ids is imposed on the active elements of the sensor, and its buoyance thereby diminished so that it sinks; or, conversely, as the depth of the bed of settled solids diminishes below normal, the load of solids sustained by the active elements of the sensor is reduced, thereby increasing its buoyancy, with the result that the sensor moves upwardly. The invention contemplates the utilization of these movements of a suitable sensor in response to variations in the depth of the bed of settled solids for automatically controlling the operation of the associated cell, or to signal the existence of an abnormal condition so that manual controls may be exercised.

Referring now to FIGURE 5, the preferred form of sensor 45 shown has a plurality of flights 46, 47 and 48 in the form of flat disks of diminishing area from top to bottom, mounted concentrically upon a stem 49 which is pendently supported at one end of a lever 50, whose fulcrum is provided by a ball and socket joint 51 in the wall of conical section 21. Provision is preferably made for varying the distance between the uppermost flight 46 of the sensor and its connection with the end of lever 50, in order to coordinate the sensor with the character of the material being settled. Such means may take the form of a series of holes 52 in stem 49, so that pivot pin 53 may be selectively disposed in the one of holes 52 which is most appropriate to the material being settled, or, in other words, most truly representative of the ideal position of the several flights 46, 47 and 48 within the bed of settled solids which is normal for the operation being carried out.

An appropriate seal, such as gasket 54, is disposed about the end of lever 50, on the inside of its fulcrum 51, so as to prevent leakage at that point, and, at the same time, permit some amplitude of movement of the level relative to the wall of conical section 21.

Beyond the fulcrum 51, lever 50 is connected to a bracket 55, which transmits the motion of lever 50 through a link 56 to another lever 57 which actuates a suitable control or signaling device 58.

For calibrating the sensor 45 to normal conditions, i.e., to balance it at the location within conical section 21 where a normal bed of settled solids will impose a normal magnitude of dead weight of settled solids on the several flights 46, 47 and 48, any suitable calibrating means may be provided, such as a spring 59 connected at one end to bracket 55, and at the other end to a fixed bracket 60. Any suitable means may be employed for varying the tension of spring 59, and in the embodiment shown, such means consists of a threaded hook shank 61, provided with a wing nut 62 on one side, and a lock nut 63 on the other side, of bracket 60.

As wide amplitude of movement of the sensor is unnecessary to signal the existence of, and the direction of, an abnormal condition in the bed of settled solids, it is frequently desirable to limit such amplitude in order to prevent wild swings of the sensor which would produce equally wild and objectionable changes in the discharge rate. In the form shown in the drawings, such amplitude limiting means is provided by a bracket 64 mounted on the side of conical section 21, and provided at one end with a set screw 65, and at the other end with a set screw 66, arranged respectively to be engaged by the portion of bracket 55 between them when the latter moves to either extreme. Thus, the sensor is semilocked within the bed. In any event, the sensor of the present invention does not ride on the top of the bed where it would be buffeted by the swirling current of water without the stabilizing influence of the settled solids, but rather is entrained within the bed where it is responsive only, and then but slowly as the bed moves upward or downward, to the weight of settled solids resting on the flights 46, 47 and 48. As the bed of settled solids becomes deeper (i.e., the top level rises), the weight of solids above the flights becomes greater and the assembly moves downward as

the solids below it are discharged. As the portion of arm 50 on the interior of the cell tilts downward the exterior portion thereof tilts upward until such movement is arrested by set screw 65. Such movement can be employed either to signal the existence of a condition, or to automatically actuate instrumentalities which tend to change that condition. For example, as the bed sensor moves downwardly within the cell to the limit of its movement, it may close an appropriate limit switch to complete an electrical circuit or actuate a fluid pressure system which opens or increases the degree of opening in a valve controlling the flow of water through pipe 37 to ejector nozzle 33, thereby increasing the rate of drawoff of pulp from the cell. Conversely, as the depth of bed of solids in conical section 21 decreases (as, for example, when the ejector is put into operation), the sensor will move upward, thereby decreasing the rate of, or interrupting, the flow of water through the ejector. Where automatic control is employed, it is preferable that the various instrumentalities be actuated and deactuated by sensor movement which maintains the top level of the bed of solids substantially constant within limits of two to four inches.

In the embodiment shown in FIGURE 3 of the drawings, the outside extremity of the sensor arm 50 is connected by a link 67 to a fluid control valve 68, which is connected through a conduit 69 to a source of fluid pressure and connected through a conduit 70 to a diaphragm valve 71, so that when the sensor 45 moves downwardly from normal position, control valve 68 opens to admit pressure to the diaphragm valve 71 in a direction which opens valve 72 controlling flow of water from header 38 to pipe 37 and ejector nozzle 33. The flow of water to the ejector continues as long as sensor 45 remains in position until the dead weight of solids on the flights of the sensor is reduced sufficiently that the sensor has moved upwardly to its normal position. In the meantime, the rate of flow of water through valve 72 to the ejector may, if desired, be regulated so as to diminish gradually. The fluid pressure system illustrated has the advantage over an electric limit switch type of control in that the latter responds only at the extremes of sensor movement, while the former effectively modulates between the extremes.

In like manner, valve 22 may be automatically operated to its closed position when, as in the case of failure of the instrumentalities which control valve 72 or in the case of other abnormality signaled by the position of sensor 45, interruption of discharge from the cell is indicated.

As clearly shown in FIGURE 4, the cell discharge box 26 is provided with an internal divider 73 extending vertically. The divider 73 does not, however, constitute an imperforate wall, but, on the contrary, permits free flow at every elevation of pulp from the side thereof to which discharge conduit 25 is connected toward the side thereof to which outlet 74 is connected. The dividers 73 serve merely as guides to control the position and direct the vertical movement of short sections of pipe 75, of which two are shown, but any desired number may be employed depending upon the differential head preferred under each given set of operating conditions. The greater the number of short sections of pipe 75 which are stacked over the mouth of discharge conduit 25 within cell discharge box 26, the lesser the differential head imposed on the settled solids within conical section 21. Thus the addition and subtraction of short sections of pipe 75 constitute a means for regulating the height of a weir over which the discharge through conduit 25 must flow, thereby to vary the magnitude of the differential head. Other weir height-controlling means may, of course, be utilized in the place and stead of the short sections of pipe 75, as for example, electrically-operated, fluid-operated, or similar mechanical means may be employed to raise or lower a weir for modulating the rate of discharge through conduit 25 of each cell by varying the differential

head on that cell. Indeed, such means can, if desired, be automatically controlled by the position of sensor 45 in a manner comparable to that above described in connection with the opening and closing of valve 72 for the admission of water to ejector 28. Furthermore, the same result may be accomplished by moving the mouth (within cell box 26) of discharge conduit 25 upwardly or downwardly, thereby, in effect, to change the elevation of a weir over which the discharge must flow. In practical operation, it is desirable that the weir within cell discharge box 26, regardless of the form it takes, be variable in elevation so that the differential head can be varied from a maximum of approximately forty inches to a minimum of zero inches to create a rate of discharge from the bottom of the cell which is adequate, but without high velocity at the top of the weir.

It is usually desirable that the cell discharge box 26 be so organized that a siphoning action does not occur. Such siphoning action is avoided by the provision of a hold 27 in the lid of cell discharge box 26. It is sometimes desirable to dilute the pulp after it is discharged from the cell, particularly when no water is being admitted through the ejector 28. This may be conveniently done by providing the cell discharge box with a water inlet 76. The flow of water through inlet 76 may be coordinated with the flow of water through ejector nozzle 33, so as to accomplish the desired dilution of the pulp prior to the time it is discharged through outlet 74 for delivery to tables or other processing instrumentalities.

Under some circumstances, it may be desired to apply enough fluid pressure through ejector nozzle 33 that it is possible to lift the discharge pulp to a level higher than launder 9, and in such cases, the top of cell discharge box 26 will extend above the level of launder 9.

In the construction illustrated in the drawings, the parts of the apparatus which are subject to greatest abrasion during operation are made readily replaceable. These include a liner 77 within at least the lower portion of conical section 21, the stopper 43 in the ejector, and the venturi tube 32. The liner 77 is preferably ceramic material of hardness greater than the material being treated; the stopper 43 is preferably of nylon; and the venturi tube 32 is preferably of cast iron. These parts can be easily and inexpensively replaced.

From the foregoing description, those skilled in the art will understand that when the cell of the invention is fed in the normal manner, the classified or hydraulically sized solid particles will settle through the teeter column and into the conical section 21, where they collect in a settled bed from which they can be drawn off as pulp of high solids-to-water ratio. The rate of discharge is controlled by (1) the differential head between overflow level of the launder for the given cell and the overflow level in the cell discharge box for that cell, and (2) the amount of ejector action produced by the high pressure water from nozzle 33. By increasing the differential head, the drawoff can be at a rate greater than that at which the solids are settling into the cone section 21, and no bed would build up in the cone. Under such conditions, the pulp discharge would be too dilute to constitute a satisfactory feed to the table. Conversely, if the differential head is too slight, the rate of flow would also be too little, and the depth of settled bed would build up to excessive height. Furthermore, the pulp would become overly thick to the point that it would not flow through the exit pipe, and would be too thick for proper table feed. However, the addition of water at the ejector corrects the last-mentioned conditions, and increases the rate of discharge so that, by proper modulation of ejector water, the rate of pulp discharge can be controlled so as to keep the cell in balance. Hence, by judicious selection of the differential head on each cell, it is readily possible to arrive at a setting where the cell is discharging at a rate slightly less than the rate at which the solids are settling, so that with a moderate amount of ejector water, the discharge rate can be brought

into balance with the feed rate and, with little modulation of ejector water, the cell can easily be kept in balance.

Where the pulp discharged from the cell is fed to a concentrating or coal washing table, it is important that a fairly uniform water-to-solids ratio be maintained in the table feed. The invention enables such ratio to be controlled automatically by coordination of the differential head with the volume of water discharged by the ejector. The greater the rate of water discharged from the ejector, the greater the rate of drawoff from the cell. When there is need to draw off more solids from the cell, the discharge of more water by the ejector accomplishes this, and, at the same time, the water-to-solids ratio in the pulp passing through conduit 25 remains satisfactorily uniform for good table operation.

A further advantage of the ejector control discharge as disclosed lies in the saving of head room in an operating plant. Because the actual release of the pulp from each cell is near the top level of the cell instead of at the bottom of the cell as heretofore, it enables the building or plant in which the machine is housed to be of less height than heretofore required, and correspondingly reduces building costs.

Other advantages of the invention will be immediately apparent to those skilled in the art. While one specific embodiment of the invention has been disclosed in detail, and various modifications and alterations of the several instrumentalities suggested, it is to be distinctly understood that the invention is not limited to the specific details of the foregoing disclosure, save as indicated in the appended claims.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. An hydraulic classifier cell comprising in combination,
  - (a) a vertically disposed exterior cylindrical wall;
  - (b) means for circumscribing a sorting column of greater vertical length than of transverse dimension, said means including an open-ended vertically axised tubular wall substantially concentric with said exterior wall, said tubular wall being of lesser outside dimension than the inside dimension of said exterior wall to provide therebetween an annular interspace which is open at its lower end;
  - (c) means for introducing water into said interspace in a direction such as to create a descending swirling current in the interspace and an ascending swirling current within said sorting column;
  - (d) means closing said interspace at the upper end thereof to confine the water therein against upward flow out of the interspace;
  - (e) means for directing solid material to be classified into the upper end of said sorting column in counter-current relationship to the ascending swirling current of water therein, said means having a part defining the level of overflow from the cell;
  - (f) means, below the lower extremity of said tubular wall, connected in fluid sealing relationship with said exterior wall (a), and in open communication with both said interspace and the sorting column inside of said tubular wall, for confining a body of liquid of depth such that at least a substantial zone of said body of liquid is sufficiently below the path of swirling currents to be quiescent to the extent that water-suspended solids settle into a bed therein;
  - (g) a spigot having an inlet in fluid-transmitting communication with said means (f) adjacent the bottom of the latter, and a normally open outlet below said inlet; and
  - (h) a discharge conduit extending from said spigot outlet to an elevation substantially above the lower end of said tubular wall to create a differential hydrostatic head on the settled bed of solids in said means (f), said discharge conduit having an outlet below the overflow level of said means (e).

2. The improvement of claim 1 having means for adjusting the differential head to vary the rate of flow through the spigot.

3. An hydraulic classifier cell comprising in combination,
  - (a) a vertically disposed exterior cylindrical wall;
  - (b) means for circumscribing a sorting column of greater vertical length than of transverse dimension, said dimension including an open-ended vertically axised tubular wall substantially concentric with said exterior wall, said tubular wall being of lesser outside dimension than the inside dimension of said exterior wall to provide therebetween an annular interspace which is open at its lower end;
  - (c) means for introducing water into said interspace in a direction such as to create a descending swirling current in the interspace and an ascending swirling current within said sorting column;
  - (d) means closing said interspace at the upper end thereof to confine the water therein against upward flow out of the interspace;
  - (e) means for directing solid material to be classified into the upper end of said sorting column in counter-current relationship to the ascending swirling current of water therein, said means having a part defining the level of overflow from the cell;
  - (f) means, below the lower extremity of said tubular wall, connected in fluid sealing relationship with said exterior wall (a), and in open communication with both said interspace and the sorting column inside of said tubular wall, for confining a body of liquid of depth such that at least a substantial zone of said body of liquid is sufficiently below the path of swirling currents to be quiescent to the extent that water-suspended solids settle into a bed therein;
  - (g) a spigot having an inlet in fluid-transmitting communication with said means (f) adjacent the bottom of the latter, and a normally open outlet below said inlet;
  - (h) a discharge conduit extending from said spigot outlet to an elevation substantially above the lower end of said tubular wall to create a differential head on the bed of settled solids in said means (f); and
  - (i) liquid ejector means located in said conduit between said spigot outlet and said elevation for addressing a forced stream of liquid into said conduit toward said elevation.

4. The improvement of claim 3 having means entrained within said quiescent zone and responsive to the density of the ambient material for controlling said fluid ejector.

5. The combination with an hydraulic classifier having a discharge conduit, of a source of pressure, a fluid ejector selectively connectable to receive fluid from said source located within said conduit and arranged, when active, to accelerate the rate of flow out of said classifier and through said conduit, said ejector having a discharge nozzle, a plug movable into and out of sealing relationship with said nozzle, and means responsive to declining fluid pressure within said ejector for moving said plug into sealing relationship with said nozzle.

6. The combination of claim 5 wherein said means is responsive to increasing fluid pressure within said ejector to move said plug out of sealing relationship with said nozzle.

7. An hydraulic classifier cell comprising in combination,

- (a) a vertically disposed exterior cylindrical wall;
- (b) means for circumscribing a sorting column of greater vertical length than of transverse dimension, said means including an open-ended vertically axised tubular wall substantially concentric with said exterior wall, said tubular wall being of lesser outside dimension than the inside dimension of said exterior wall to provide therebetween an annular interspace which is open at its lower end;

- (c) means for introducing water into said interspace in a direction such as to create a descending swirling current in the interspace and an ascending swirling current within said sorting column;
- (d) means closing said interspace at the upper end thereof to confine the water therein against upward flow out of the interspace;
- (e) means for directing solid material to be classified into the upper end of said sorting column in counter-current relationship to the ascending swirling current of water therein, said means having a part defining the level of overflow from the cell;
- (f) means, below the lower extremity of said tubular wall, connected in fluid sealing relationship with said exterior wall (a), and in open communication with both said interspace and the sorting column inside of said tubular wall, for confining a body of liquid of depth such that at least a substantial zone of said body of liquid is sufficiently below the path of swirling currents to be quiescent to the extent that water-suspended solids settle into a bed therein;
- (g) a sensor in said quiescent zone, said sensor having means for intercepting and retaining settling solids settled thereon; and
- (h) means mounting said sensor in said quiescent zone in a manner both:
  - (1) to make said sensor free for vertical movement in response to changes in the weight of solids settled thereon, and
  - (2) to make said sensor immune to changes in hydrostatic pressure thereon.

8. The combination of claim 7 in which the sensor has a plurality of spaced flights extending substantially horizontally, said flights being of different areas, and the larger area flight being closer to said interior wall than the smaller area flight.

9. The combination of claim 7 in which the sensor has means on the outside of said classifier for counterbalancing said flights and a predetermined burden of solids thereon.

10. In a minerals separation apparatus having an hydraulic classifier having a quiescent zone in which solids of predetermined specific gravity and granulation settle, a sensor in said quiescent zone, said sensor being movable in response to the weight of solids thereon, a conduit connected to receive discharge from said quiescent zone, a liquid ejector in said conduit, and means responsive to movement of said sensor for controlling said ejector.

11. In a minerals separation apparatus having an hydraulic classifier having an exterior wall, an open bottom sorting column located within the exterior wall, means for inducing a swirl of hydraulic medium in the sorting column, said exterior wall providing a quiescent zone below the bottom of the sorting column, and a spigot connected to said quiescent zone, the improvement which comprises: a discharge conduit extending from the said spigot to an elevation substantially above the bottom of the sorting column but below the top of said exterior wall to create a differential head on the quiescent zone; means for adjusting said differential head to vary the rate of flow through said spigot; a liquid ejector located in said conduit and addressed toward said elevation and arranged, when active, to accelerate the rate of flow through said conduit, said ejector having a discharge nozzle, a plug movable into and out of sealing relationship with said nozzle, means responsive to declining fluid pressure within said ejector for moving said plug into sealing relationship with said nozzle and responsive to increasing fluid pressure within said ejector for moving said plug out of sealing relationship with said nozzle; sensor means entrained within said quiescent zone and responsive to the density of the ambient material for controlling said liquid ejector; said sensor having a plurality of flights extending athwart the direction of flow between said zone and said outlet, and means on the outside of said classifier for

counterbalancing said flights and a predetermined burden of solids thereon, said flights being of different areas, and the smaller area flight being closer to said outlet than the larger area flight; a valve below said quiescent zone; and sensor responsive means for controlling the fluid pressure within said ejector.

12. In a minerals separation apparatus having an hydraulic classifier having an exterior wall, an open bottom sorting column located within the exterior wall, means for inducing a swirl of hydraulic medium in the sorting column, said exterior wall providing a quiescent zone below the bottom of the sorting column, and a spigot connected to said quiescent zone, the improvement which comprises: a discharge conduit extending from the said spigot to an elevation substantially above the bottom of the sorting column but below the top of said exterior wall to create a differential head on the quiescent zone; means for adjusting said differential head to vary the rate of flow through said spigot; a liquid ejector located in said conduit and addressed toward said elevation and arranged, when active, to accelerate the rate of flow through said conduit, said ejector having a discharge nozzle, a plug movable into and out of sealing relationship with said nozzle, means responsive to declining fluid pressure within said ejector for moving said plug into sealing relationship with said nozzle and responsive to increasing fluid pressure within said ejector for moving said plug out of sealing relationship with said nozzle; a sensor in said quiescent zone, said sensor having a plurality of flights extending athwart the direction of flow between said zone and said outlet, and means on the outside of said classifier for counterbalancing said flights and a predetermined burden of solids thereon, said flights being of different areas, and the smaller area flight being closer to said outlet than the larger area flight; and a valve below said quiescent zone.

13. An hydraulic classifier cell comprising in combination,

- (a) a vertically disposed exterior cylindrical wall;
- (b) means for circumscribing a sorting column of greater vertical length than of transverse dimension, said means including an open-ended vertically axised tubular wall substantially concentric with said exterior wall, said tubular wall being of lesser outside dimension than the inside dimension of said exterior wall to provide therebetween an annular interspace which is open at its lower end;
- (c) means for introducing water into said interspace in a direction such as to create a descending swirling current in the interspace and an ascending swirling current within said sorting column;
- (d) means closing said interspace at the upper end thereof to confine the water therein against upward flow out of the interspace;
- (e) means for directing solid material to be classified into the upper end of said sorting column in counter-current relationship to the ascending swirling current of water therein, said means having a part defining the level of overflow from the cell;
- (f) means, below the lower extremity of said tubular wall, connected in fluid sealing relationship with said exterior wall (a), and in open communication with both said interspace and the sorting column inside of said tubular wall, for confining a body of liquid of depth such that at least a substantial zone of said body of liquid is sufficiently below the path of swirling currents to be quiescent to the extent that solids suspended in said body of liquid settle, said means (f) having a discharge outlet at the bottom of said quiescent zone which is open continuously during normal operation;
- (g) sensor means in said quiescent zone and responsive only to changes in weight of solids settled thereon;
- (h) means mounting said sensor in a manner both:
  - (1) to make said sensor free for vertical move-

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ment in response to changes in the weight of  
solids settled thereon, and  
(2) to make said sensor immune to changes in  
hydrostatic pressure thereon;  
(i) and means responsive to movement of said sensor 5  
means to modulate conditions inducing such move-  
ment.

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FRANK W. LUTTER, *Primary Examiner.*

**Dedication**

3,412,858.—*Spencer A. Stone*, Fort Wayne, Ind. HYDRAULIC CLASSIFIER HAVING AUTOMATIC UNDERFLOW DISCHARGE CONTROL. Patent dated Nov. 26, 1968. Dedication filed June 16, 1977, by the assignee, *The Desiter Concentrator Company, Inc.*

Hereby dedicates to the Public the remaining term of said patent.

[*Official Gazette August 23, 1977.*]