Aug. 16, 1955 E. B. FITCH 2,715,463

HYDRAULIC CLASSIFIER

Filed Dec. 9, 1953 5 Sheets-Sheet 1

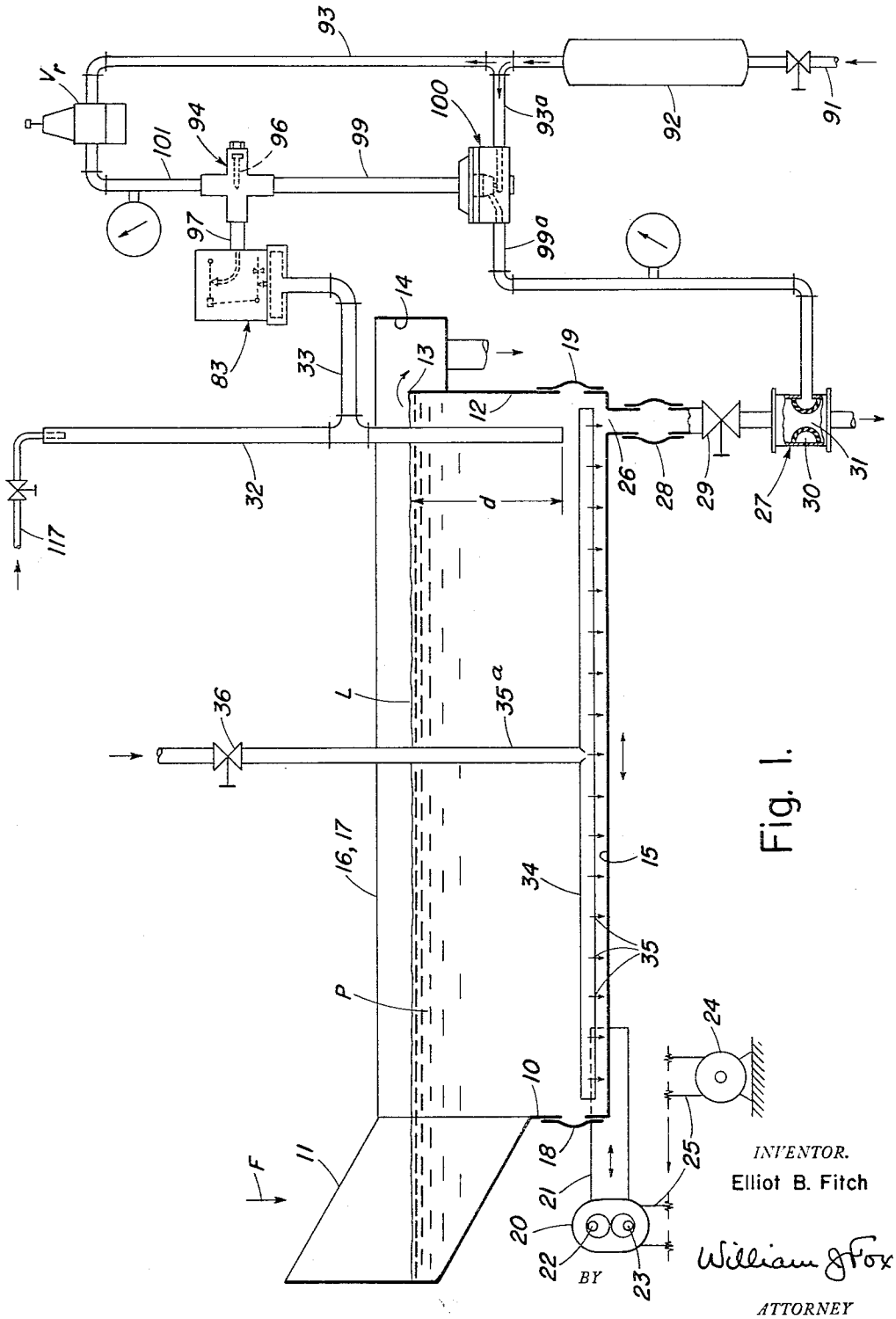


Fig. 1.

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HYDRAULIC CLASSIFIER

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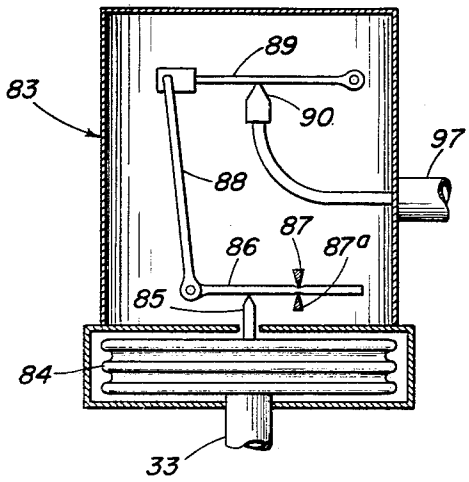


Fig. 1a.

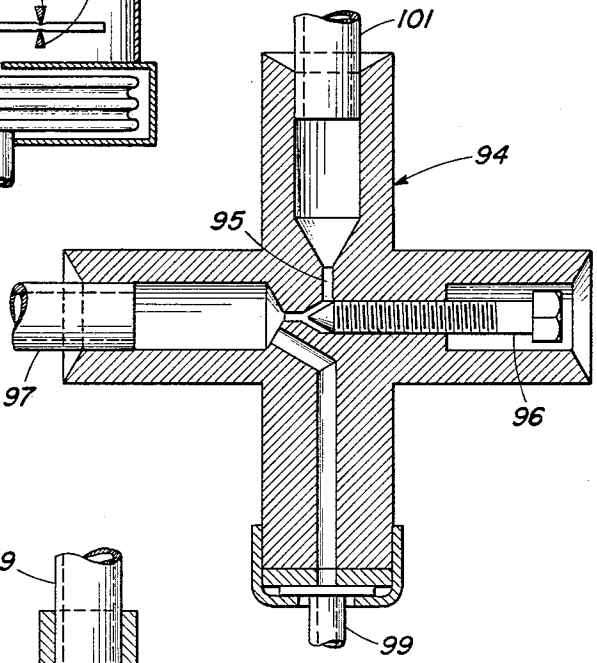


Fig. 1b.

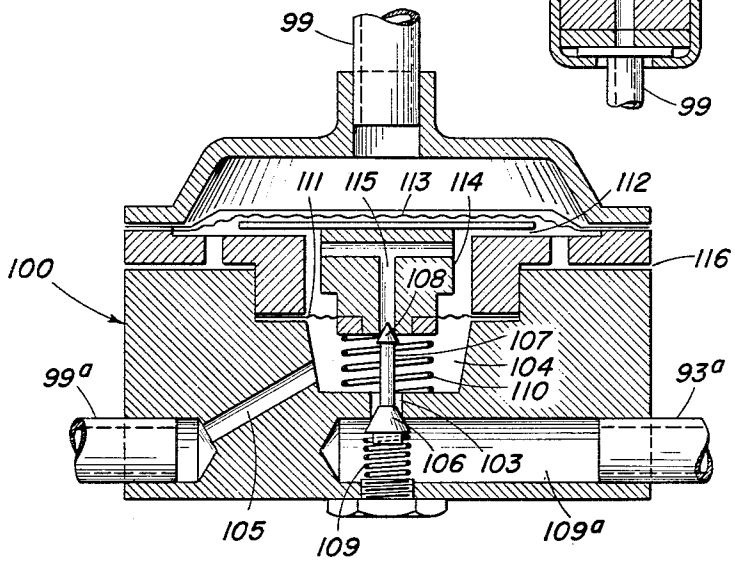


Fig. 1c.

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Aug. 16, 1955 E. B. FITCH 2,715,463

HYDRAULIC CLASSIFIER

Filed Dec. 9, 1953 5 Sheets-Sheet 3

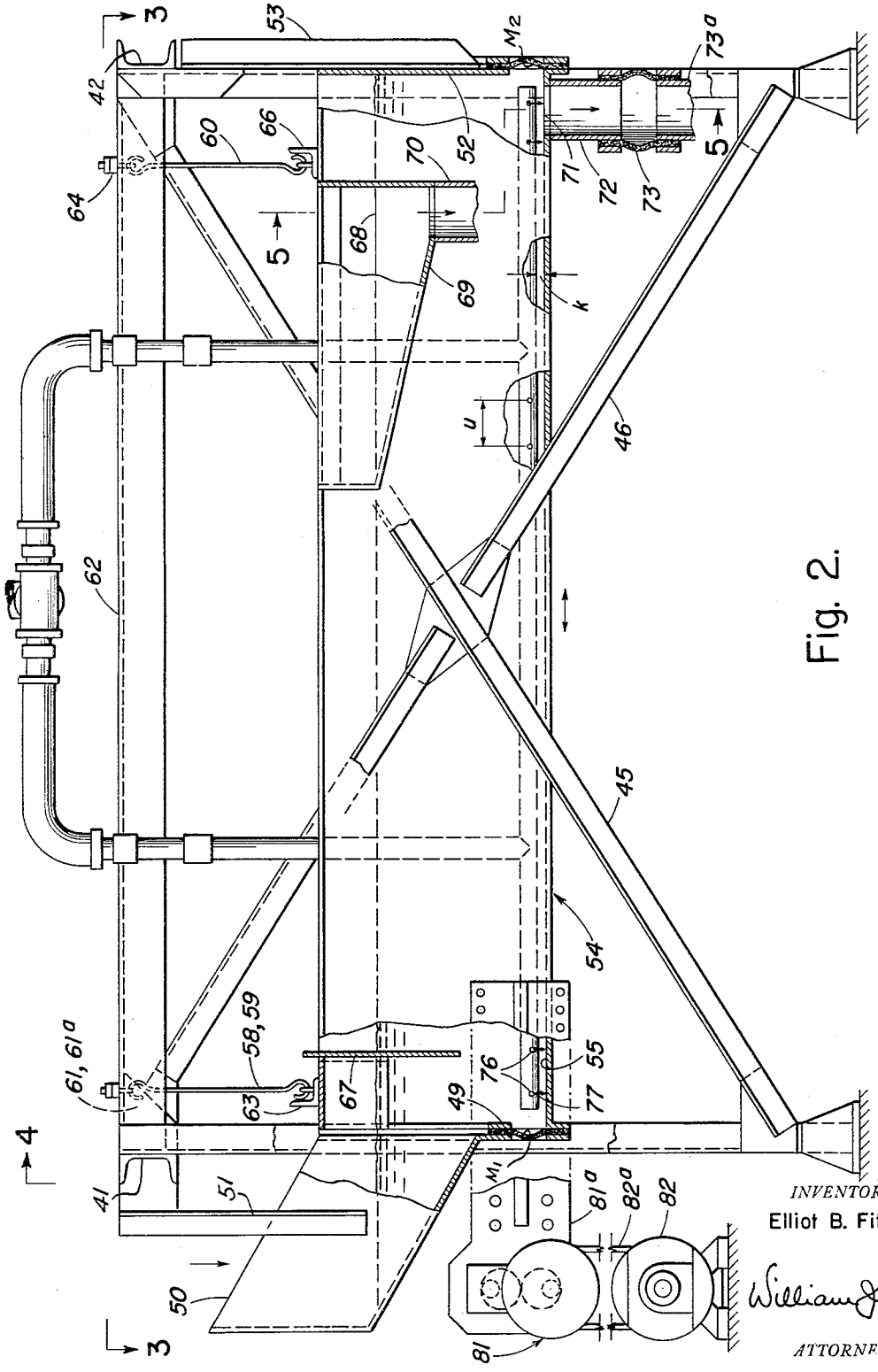


Fig. 2.

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HYDRAULIC CLASSIFIER

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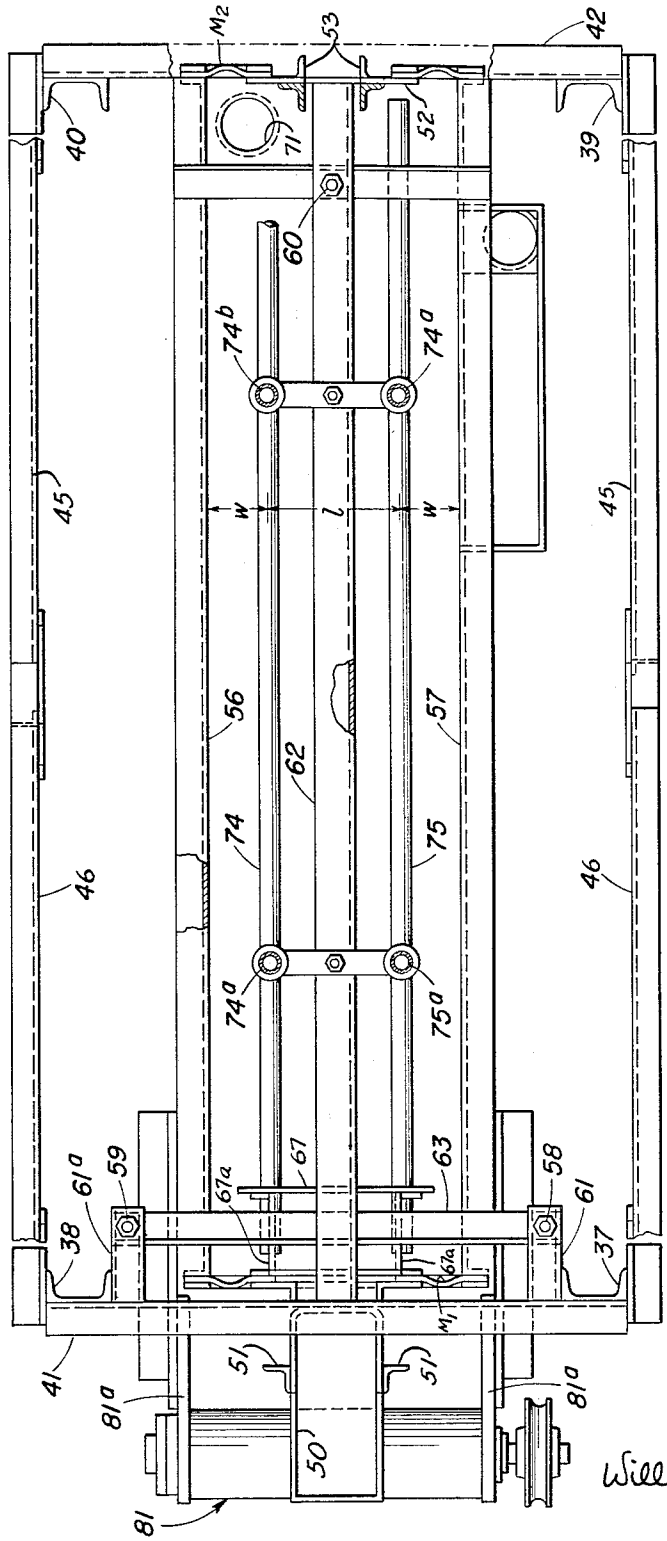


Fig. 3.

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HYDRAULIC CLASSIFIER

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Fig. 4.

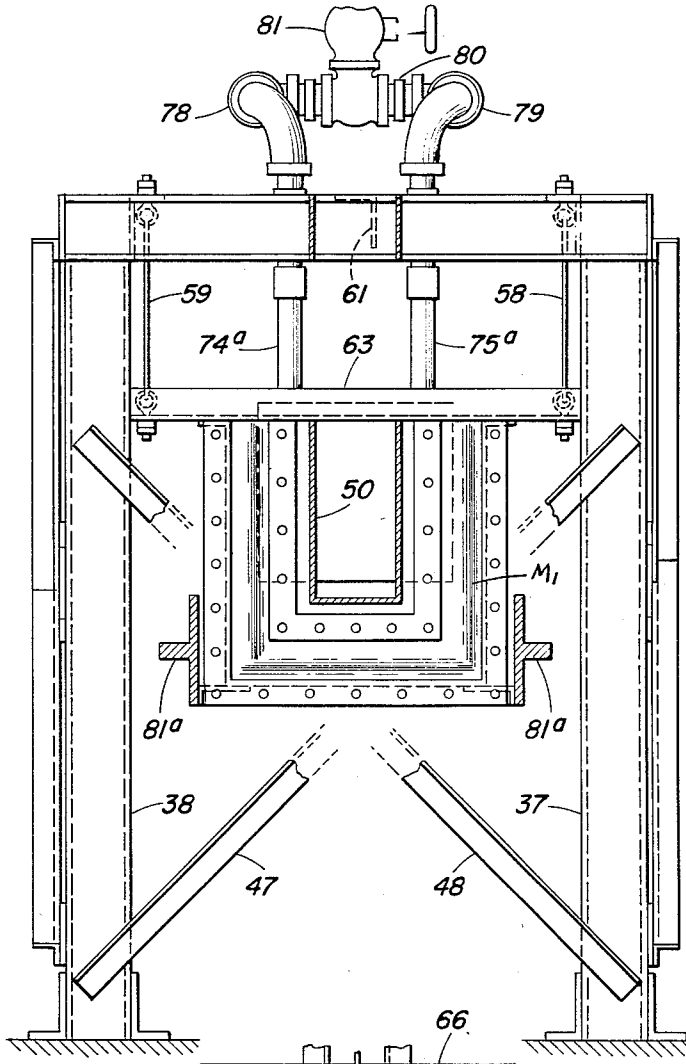
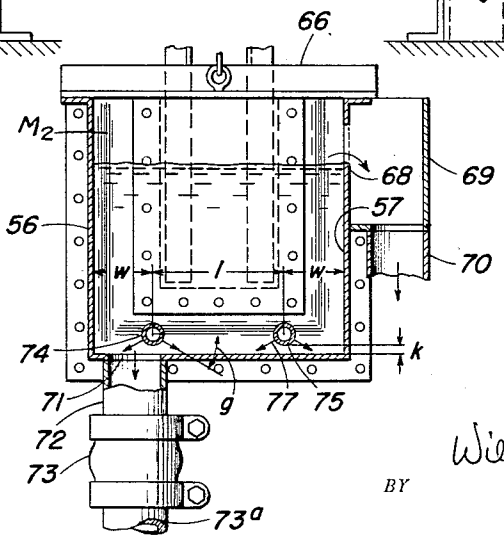


Fig. 5.



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United States Patent Office 2,715,463 Patented Aug. 16, 1955

2,715,463

HYDRAULIC CLASSIFIER

Elliot B. Fitch, Westport, Conn., assignor to The Dorr Company, Stamford, Conn., a corporation of Delaware

Application December 9, 1953, Serial No. 397,207

5 Claims. (Cl. 209—159)

This invention relates to the wet or hydraulic classification treatment of pulp containing a range of particle sizes from fine to coarse, as exemplified by metallurgical pulps or pulps of wet-ground ore, to effect the separation of the mixture of particles into a course and a fine fraction of sizes, these fractions herein to be simply termed the coarse fraction and the fines fraction, or else the oversize and the undersize. The coarse fraction then contains substantially all sizes above an intermediate size while the fines fraction contains substantially all those that are smaller than the intermediate size.

Hydraulic separation such as herein contemplated takes place in a classification pool into which the pulp is fed, while the coarse fraction is withdrawn from the bottom of the pool and the fines fraction overflows from the pool across a weir. In order to aid and control the separation, the mixture of particle sizes while in transit through this pool may be kept mobilized by being subjected to the effect of controlled mechanical agitation, or subjected to the effect of a stream of auxiliary so-called hydraulic operating water up-flowing through the pool at a controlled velocity; however, as contemplated by this invention, the mixture in the pool is subjected to the joint effects of both mechanical and hydraulic action, with the result that a desired coarse fraction above a certain mesh size will collect at the bottom of the pool to be withdrawn therefrom, while a corresponding fraction of fine sizes with its carrier water overflows from the pool, this to afford superior means of separation control presently to be set forth.

It is among the basic problems in such wet classification- or separation treatment that there be effected as sharp a separation as possible between the oversize and the undersize or else between the underflow sizes and the overflow sizes; thus the aim is to conduct the classification treatment in such a manner or with such type of apparatus that each of the two fractions be obtained as free as possible from stray sizes of the other fraction.

Another basic problem in such wet classification treatment or apparatus is that of providing control means whereby the point of separation or fractionation or "cut" between the two groups of sizes, the oversize and the undersize can be readily established and accurately adjusted. For example, if the feed be of a run containing particle sizes ranging, say, from 28 to 200 mesh, then it should be possible, for example, to make a clean split at say, 100 mesh, yet it should be possible to readily shift the "cut" to, say, 48 mesh. This calls for providing simple and effective means for so adjusting or shifting the "cut" while deriving the respective size fractions clean, that is with a minimum of stray sizes admixed thereto. For example, the importance of producing a clean coarse fraction is apparent where the classification apparatus operates in closed circuit with a wet grinding mill, the mill to receive coarse fraction particles for regrinding, and where the admixture of an appreciable amount of undersize or stray sizes would burden the circulating load through the mill and would accordingly

reduce its efficiency as well as that of the circuit as a whole.

Moreover, there is the general problem that such an apparatus should be capable of handling effectively a feed slurry containing a relatively wide range of particles of extreme sizes, that is, from relatively very fine to relatively very coarse.

Also there is to be considered in the operation of such classification treatment and apparatus the degree of dilution of the feed pulp, since it is desirable to produce a separation which remains substantially stable in spite of possible variations in the degree of feed dilution; another aspect lies in the fact that it may be desirable to derive the overflow of fines at the highest possible density, there being the difficulty that a high rate of hydraulic water required might run counter to the goal of attaining the desired degree of overflow density.

The invention provides improvements over the wet classification machine employing the joint or compound effect of mechanical and hydraulic classifying action shown in the patent to W. C. Weber, No. 2,302,588, which produces a sharp "cut" easily and accurately controllable, and which is operable with minimum of hydraulic operating water, capable of absorbing appreciable changes in the dilution of the feed pulp substantially without affecting the "cut" itself, even though capable of producing the overflowing undersize fraction at relatively great density, and of handling a feed pulp containing a wide range of particle sizes from fine to coarse.

It is among the objects of the present invention to produce a machine possessing at least the operational characteristics and capabilities of the machine in the aforementioned patent, yet to be simpler of construction, lighter in weight, cheaper to build, as well as simpler to maintain, simpler to overhaul and simpler to service, and last but not least, which is more compact and which lends itself to a variety of structural modifications whereby it is conveniently and compactly adaptable for structural integration in a treatment system such as closed-circuit grinding. The significance of these objects will appear more precisely from the following outline of the machine shown in that patent. In that machine, the pulp is fed to a significantly shallow pool the bottom of which is formed by a horizontal circular false bottom in the form of a perforated plate usually termed a constriction plate. A hydraulic supply chamber is associated with the under side of the constriction plate unitary therewith and has hydraulic operating water fed thereto continuously in order that such auxiliary water may continuously rise in the pool through and upwardly from the constriction plate at a controllable rate, thus helping to maintain the particles in the pool in a mobilized state. Moreover, this hydraulic chamber with its constriction plate is mounted for oscillatory movement about a vertical axis by means of a hollow vertical column rising from the center of the constriction plate and suspended from an overhead bearing structure which carries drive mechanism for imparting the oscillatory movement through the column to the constriction place and its associated hydraulic supply chamber. The slurry or pulp is fed to a central annular feed well surrounding the column, and under normal operating conditions the pulp in the pool is subjected to the joint effect of the oscillatory motion of the constriction plate and of the hydraulic water rising therethrough. A uniform distribution of hydraulic water over the entire bottom of the pool is thus obtained not only by reason of the fact that the water is being introduced by the great many holes in the constriction plate, but also because these holes are constantly being oscillated incident to the oscillatory motion of the constriction plate.

The classifier pool is furthermore defined by a cylin-

drical stationary boundary wall the top edge of which constitutes an overflow weir for discharging the undersize fraction of the pulp. This cylindrical boundary wall of the pool is concentric with the constriction plates although of a somewhat smaller diameter so that it is spaced slightly inwardly from the periphery of the constriction plate, yet also spaced upwardly from the marginal portion of the constriction plate. Thus, the constriction plate may oscillate beneath the stationary boundary wall, with the vertical distance between this wall and the constriction plate constituting an annular sands passage or solids transfer passageway leading outwardly from the pool bottom to allow for the outward migration and removal of the oversize fraction of the pulp from the pool. Importantly, along the periphery itself of the constriction plate there is provided what is herein termed a submerged sands discharge weir over which spill the sands or coarse fraction particles down into a receiving chamber which in turn surrounds the constriction plate. The sands discharge weir rises to a level at least somewhat higher than the sands passage, so that thereby there is maintained an annular sealing column of sands in transit between the passageway and the weir.

The annular space between the constriction plate and the surrounding receiving chamber is covered and closed by a top portion of the receiving chamber, which top portion in fact supports the cylindrical boundary wall of the poll by being rigidly connected therewith.

A body or column of clear water maintained in the sands receiving chamber defined by a clear water overflow weir of adjustable height balances the column of pulp or mobilized particles in the pool, and this balance represents a hydraulic equilibrium condition in the machine, whereby the separation or "cut" is readily controllable, namely, as by adjustment of the height of the clear water overflow weir.

The coarse fraction particles upon the oscillatory constriction plate will move or migrate outwardly, radially in all directions towards and through the sands discharge passage and over the submerged sands discharge weir which surrounds the passage, and into the surrounding sands receiving chamber whence they can be removed into emergence from a body of clear water as by any suitable conventional elevating means or by controlled spigot discharge.

Thus, it is among the more specific objects of this invention to provide a machine which, while possessing at least the operating features and advantages of a machine such as above outlined, is simpler, lighter and cheaper of construction, with a substantial reduction of the oscillatory, or moving, masses which is more compact and which is more readily and more compactly adaptable to environmental structural conditions, for example, in what are known in metallurgical apparatus as closed-circuit grinding systems.

The objects of this invention are attained by a machine which is functionally similar to the one disclosed in the patent application of Harold B. Coulter, Serial No. 397,205 filed December 9, 1953 concurrently herewith, in that it provides a classifying pool where the feed pulp enters at a point spaced from the point of fines overflow discharge and from the point of sands underflow discharge. For example, the pulp may pass in a longitudinal direction from end to end through the pool undergoing classification, the underflow discharge being by way of a sands passage at the bottom of the pool and through a connecting sands column outside this passage. The desired kind of classification of the pulp in the pool is effected by the conjoint action of hydraulic water being introduced in substantially uniform distribution at the bottom of the pool and of horizontal longitudinal back-and-forth or vibratory movement of the bottom face of the pool. This movement is such as to provide sufficient acceleration and deceleration within its vibratory cycle, to continuously induce and maintain an intensified degree

of relative movement between the bottom and the strata of oversize particles supported thereby. The "cut" between the two fractions is controllable by way of adjusting a static hydraulic counter-pressure effective at the sands discharge passage. One mode of so controlling the hydraulic counter-pressure is by way of a water column superimposed upon the sands column and defined by an adjustable clear water overflow at the super-elevation level. That is to say, the oversize particles from the sands column may be allowed to spill into a clear water chamber thence to be removed upwardly by suitable elevating mechanism, or to be removed downwardly by a suitably controlled spigot discharge valve. The fines fraction discharges by overflowing from the classifier pool.

In distinction from the apparatus of the above mentioned Coulter application, this invention provides a machine having controllable spigot discharge devices for discharging the coarse solids or sands fraction material substantially directly from the bottom strata of the classifier pool; and thus without the use of a special clear water chamber with clear water balancing column disclosed in the Coulter application. According to this invention, such direct discharge means are combined with automatic devices whereby the rate of coarse solids discharge is controllable in such a manner as to automatically maintain a desired size separation or "cut." The automatic control devices adjust the discharge means in response to density changes in the pool so as to correspondingly increase the sands discharge rate in response to a rise in pool density, while decreasing the sands discharge rate in response to a drop in pool density, the control effects being such as to maintain a desired separation of sand size fractions.

According to one feature, the automatic density controlling devices comprise a density responsive probe associated with the pool, and relay devices functionally interposed between said probe and said discharge means for automatically translating density changes indicated by said probe into corresponding changes of the discharge rate.

According to one embodiment, the tank structure containing the pool comprises an intermediate tank portion having a bottom portion and longitudinal sidewalls, a stationary feed end portion and a stationary discharge end portion, each end portion having a flexible or diaphragm connection with the intermediate body portion. A vibrating device connected with the bottom portion imparts thereto repetitive back-and-forth movements of a suitable frequency and suitable length of stroke. The automatic spigot valve discharges coarse fraction material directly from the pool bottom, and with the valve stationary a flexible connection is provided between the valve and the pool bottom.

The probe, for example, is in the form of a hydraulic clear water balancing column communicating with the pool, which column being responsive to density changes in the pool by variation height, influences relay devices to control the discharge valve to increase or decrease its discharge opening in a manner to substantially maintain a desired pool density and thereby to maintain a desired size separation or "cut."

As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive since the scope of the invention is defined by the appended claims rather than by the description preceding them, and all changes that fall within the metes and bounds of the claims, or of forms that are their functional as well as conjointly cooperative equivalents, are therefore intended to be embraced by those claims.

In the drawings:

Figure 1 is a diagrammatic longitudinal sectional view of one form of the classifying apparatus equipped with

the underflow discharge control system according to this invention.

Figure 1a, Figure 1b, Figure 1c are enlarged vertical sectional detail views of component devices of the control system.

Figures 2 to 5 represent the classifier apparatus of Figure 1 in a form that is structurally more fully implemented; Figure 2 showing a part-sectional side view of the apparatus; Figure 3 showing a plan view of the apparatus, taken on line 3—3 of Figure 2; Figure 4 showing a cross-sectional view of the apparatus, taken on line 4—4 of Figure 2; Figure 5 showing a cross section of the apparatus taken on line 5—5 of Figure 2.

The diagrammatic view of Figure 1 shows one form of the classifier apparatus proper in which the tank structure comprises a pair of stationary end wall portions, namely a feed end portion and an overflow discharge end portion, and a body portion which comprises the bottom as well as the side walls of the tank structure and which is horizontally reciprocatable or vibratable. A flexible or diaphragm connection is provided between each stationary end and the adjoining end of the vibratable body portion of the tank. Coarse fraction material discharges directly through the tank bottom from the bottom strata of the pool, through a controlled spigot valve. Corrective control of this spigot valve is effected automatically by adjusting the valve opening in response to density changes in the pool, so that thereby a desired size separation as between overflow and underflow may be attained. Automatic control means for the spigot valve comprise a clear water balancing column communicating with the bottom strata of the pool, and a relay system operatively interconnects the balancing column with the spigot valve, so that variations in the height of the balancing column, reflecting variations in pulp density, will correctively adjust the opening of the spigot valve. Thus, the classifier apparatus in Figure 1 comprises a stationary feed end portion 10 having a feed chute 11 or the like, and a stationary discharge end portion 12 having an overflow weir 13 for the fines fraction of the pool to pass into a discharge launder 14.

The vibratable portion of the tank structure comprises a horizontal flat bottom 15 proper, and a pair of side walls 16 and 17 unitary with the bottom 15. The stationary feed end portion 10 of the tank is connected with the adjacent end of the vibratable tank portion by a suitable flexible connection or diaphragm indicated at 18. Similarly, the stationary discharge end of the tank is connected with the adjacent end of the vibratable tank portion by a suitable flexible connection or diaphragm indicated at 19. A manner of imparting horizontal reciprocatory or vibratory motion to the bottom 15 is here indicated by a vibrating device 20 which is rigidly connected to the bottom as by bracket members 21. The vibrating device 20 comprises a pair of eccentrically weighted shafts 22 and 23 geared up with one another and thus rotatably in geared relationship with respect to one another so as to impart to the bottom horizontal vibratory motion indicated by the double headed arrow A. The vibrating device is actuated by a motor 24 which through an endless drive element 25 rotates the eccentrically weighted shafts 22 and 23. Slurry feed indicated at "F" enters the pool P in the tank, the pulp level of the pool being indicated at L.

At the discharge end of the tank bottom there is provided a discharge passage 26 connected to a controllable spigot valve 27 by way of a flexible tube connection 28. A hand-operated shutoff valve 29 is interposed between the flexible connection 28 and the spigot valve 27. The spigot valve 27 is here shown to be of a type in which the through-flow area is controllable by way of inflating or deflating a rubber annulus 30 which is part of this spigot valve, providing a variable passage 31 through this annulus. That is to say, variations in the pulp density of the pool are translated through a relay system to inflate or deflate and thereby correctively vary the diameter of the passage through the rubber annulus in such a manner as to maintain the desired pulp density in the pool.

Variations in pulp density are indicated by way of a clear water column shown in the form of a vertical open ended pipe 32 the lower end of which is immersed into the pool a suitable distance *d*. As the clear water super-elevation in the pipe varies with changes in pulp density, such changes or pressure variations are imparted through a branch pipe 33 to the relay system which in turn correctively controls the throughflow passage of the spigot valve. Details and function of the relay system will be described further below in conjunction with detail Figures 1a, 1b and 1c.

Auxiliary water is introduced distributively into the bottom strata of the pool as is here indicated by a horizontal pipe 34 extending near the tank bottom and having orifices for emitting water jets 35 towards the bottom of the tank. A vertical pipe 35a with control valve 36 provides the supply of auxiliary pressure water to the pipe 34.

Structural details of the classifier itself appear more clearly from Figures 2, 3, 4, 5. The classifier tank proper is mounted upon and operatively supported by a stationary frame structure comprising four corner posts 37, 38, 39, 40 interconnected at the top as by a pair of transverse members 41 and 42. This frame also comprises a pair of diagonal bracing members 45 and 46 at each side and a pair of bracing members 47 and 48 at each end.

The tank structure itself comprises a stationary wall 49 at one end, provided with a feed chute 50 and fixedly mounted upon the supporting frame as indicated by bracket members 51, and a stationary wall 52 at the opposite end and fixedly mounted upon the supporting frame as indicated by bracket member 53. The stationary end walls 49 and 52 are operatively connected to the respective ends of the vibratable tank portion 54 by means of membranes M_1 and M_2 consisting of suitable flexible sheet material such as rubber.

The intermediate or vibratable body portion of the tank is designated by the numeral 54 and comprises a flat bottom 55, and a pair of longitudinal side walls 56 and 57.

The vibratable tank portion is suspended from the top end portion of the framework by means of three swingable hanger rods 58, 59, 60 disposed in a three-point supporting arrangement. The upper ends of hangers 58 and 59 at the feed end of the tank are anchored upon a pair of brackets 61 and 61a mounted above the supporting frame whereas the third hanger rod 60 has its upper end anchored upon a horizontal structural member 62 extending longitudinally and medially of the frame structure at the top thereof. That is to say, the hangers 58 and 59 have their lower ends operatively connected to a cross piece or angle iron 63 which in turn is fixed to and extends crosswise of the top ends of the side walls 56 and 57 of the vibratable tank portion 54. Thus, the hanger rods 58 and 59 support the feed end of the vibratable tank portion 54, while the third hanger rod 60 having its upper end anchored at 64 upon the structural member 62 supports the discharge end of the vibratable tank portion 54 by way of being connected to a cross piece 66 fixed to the top of the side walls 56 and 57 of the tank portion 54. At the feed end this vibratable tank portion is provided with a transverse feed baffle 67 rigidly connected and supported by the end plate 49 as by means of bracket plates 67a. At the discharge end, this tank portion is provided with overflow means for the fines fraction, provided upon the wall 57 and comprising an overflow weir 68 provided at its discharge side with an overflow receiving box 69 having a discharge conduit 70. The bottom 55 has a coarse fraction discharge opening 71 disposed opposite to the fines overflow, namely in the tank bottom near the opposite tank wall 56 and

near the stationary end wall **52**. This discharge opening **71** has a discharge neck **72** (corresponding to the neck **26** in Figure 1). A flexible tube or conduit portion **73** connects this neck **72** of the vibratable tank portion with a stationary conduit portion **73a** leading to the stationary controllable spigot valve **27** of Figure 1.

Auxiliary water is introduced distributively at the tank bottom by means of a stationary pipe system shown to comprise a pair of horizontal pipes **74** and **75** close to although spaced from the bottom, each pipe having along each side thereof a row of orifices **76** for emitting jets **77** of hydraulic operating water under an angle *g* towards the tank bottom. The horizontal pipe **74** has a pair of vertical supply pipes **74a** and **74b** interconnected by a sub-header **78**, and the horizontal pipe **75** similarly has a pair of vertical supply pipes **75a** and **75b** interconnected by a sub-header **79**. The sub-headers **78** and **79** are interconnected by a main header **80** provided with a control valve **81**.

Provision may be made for the jet-emitting pipes or pipe system to be adjustable relative to the bottom of the classifier pool whereby the clear distance between the jet-emitting pipes and the tank bottom may be adjusted.

Reciprocatory or vibratory movement is imparted to the vibratable tank portion by means of a vibrator device **81** bodily connected to the tank portion as by bracket **81a** and driven by a motor **82** through an endless drive transmitting element **82a** substantially in the manner already indicated in connection with Figure 1.

Referring to Figures 2, 3, 4, the horizontal jet-emitting pipes **74** and **75** extend substantially the entire length of the tank and are spaced a distance *k* from the tank bottom. These horizontal pipes are spaced a distance *l* from one another and a distance *w* from the respective side walls of the tank. The jet orifices being provided in rows along each side of each pipe are spaced from one another a distance *u*, the jets being directed towards the tank bottom under an angle *g* below the horizontal.

A more detailed showing of the component devices of the automatic spigot control system is presented in Figures 1a, 1b, and 1c, and their structural details and their function are as follows:

The automatic spigot discharge or underflow control system is connected to and derives its primary control impulse from a clear water super-elevation column maintained in the stationary open-ended pipe **32** the lower end of which extends a suitable distance into the pool of pulp being classified in the tank. If the super-elevation in pipe **32** should rise, the spigot valve **27** will open and allow an increased volume of pulp to discharge until the super-elevation has been restored to its pre-set level, at which time the spigot valve will constrict to the proper diameter to maintain the level at that point. Conversely, if the super-elevation in pipe **32** should decrease, the spigot valve will constrict, reducing the volume of underflow pulp leaving the machine, which in turn results in an increase in the height of water in the super-elevation column until it has been restored to the desired level.

To bring about the control of underflow volume there is provided a primary or master control device capable of sensing and responding to changes in the height of water column in pipe **32**. Such a primary or sensing device is here shown in the form of a Minneapolis-Honeywell pressure control type PO97A designated by numeral **83**, the position of which in the system is indicated in Figure 1. An enlarged view illustrating the basic working mechanism of that device or unit is shown in detail in Figure 1a. A bellows **84** at the base of the pressure control unit **83** is directly connected to the transparent super-elevation pipe **32** which in turn communicates with the sand bed of the classification pool. Any change in the height of the water column in the super-elevation pipe **32** is manifested by an expansion or contraction of the bellows **84** of the pressure control unit **83**. The expansion or contraction of the bellows actuates the bellows rod **85** which in turn causes the main lever **86** to rotate about the fixed knife edges **87** and **87a**. This motion of lever **86** is transmitted through the linkage **88** to the flapper valve **89** which by raising or lowering regulates the amount of air allowed to escape from the nozzle **90**.

A supply of high pressure air **91** enters the system through the lamb's wool filter **92**. After leaving the filter **92** one leg **93** of the high pressure line leads to a reducing valve V_r which provides a constant 15 lbs. per square inch supply of air to the T-restriction device **94**. By reference to the detail view of the T-restriction shown in Figure 1b a better idea of its internal construction and operation may be had. Air under a constant pressure of 15 lbs. per square inch enters the T from the top and passes through a constricted passage **95** the opening of which may be adjusted by means of a threaded needle **96**. The purpose of the constriction **95** is to allow the escape of only a very small volume of the 15 lbs. pressure air into the leg **97** leading to the nozzle **90**. Since the cross sectional area of the constriction **95** is small as compared to the area of the opening of nozzle **90**, the pressure of the air which has passed through the constriction may be readily controlled by regulating the volume allowed to escape to the atmosphere through the flapper controlled nozzle **90**. The leg **97** of the T going to the nozzle **90** and the leg **99** going to a booster relay device **100** have a common connection from the T device, so the air pressure in these two legs must be the same. Thus, any increase or decrease in the amount of air allowed to escape through the nozzle **90** by the flapper valve **89** is reflected by a corresponding respective decrease or increase in the pressure in the leg **99** of the T device, which leads to and controls the booster relay device **100**, a leg **99a** leading from the booster relay **100** to the spigot valve, whereby air is either admitted to, or released from the spigot valve by the relay device **100**.

The booster relay device **100** is a device which regulates the pressure controlling the diameter or effective opening of the rubber spigot valve **27**, with Figure 1c illustrating its internal working mechanism. The control of air pressure to the spigot valve is effected by regulation of the flow of high pressure air through the high pressure port **103** into the controlled air chamber **104** and thence through port **105** to the spigot valve. Flow of air through the high pressure port **103** is controlled by the high pressure valve **106** which is attached through the valve rod **107** to the unloading valve **108**. A small spring **109** in the high pressure chamber **109a** exerts a force which tends to keep the high pressure valve **106** in a closed position. A larger spring **110** in the controlled air chamber **104** exerts an upward force against the small diaphragm **111** tending to hold the unloading port **112** open. Controlled pressure from the T device **94** acting upon the large diaphragm **113** forces it downward, which downward motion is transmitted through the unloader assembly **114** to the unloading valve **108** which closes as it engages its seat in the unloader assembly **114**. As air pressure from the T device **94** increases, additional motion is imparted to the valve rod **107** forcing the high pressure valve **106** to open admitting high pressure air to the controlled air chamber **104**. As the pressure in this chamber builds up it acts upon the small diaphragm **111** forcing it upward. When the force against the large diaphragm **113** is exactly equal and opposite to that against the small diaphragm **111**, the high pressure valve **106** will close. The pressure in the controlled air chamber **104** will then remain constant until the pressure upon the large diaphragm **113** either increases or decreases to admit air to or release air from the controlled air chamber **104**. If the pressure upon the large diaphragm **113** decreases the unloader assembly **114** will be forced upward by the unbalanced force acting upward on the small diaphragm **111**. This opens the unloader port **115** which allows air from the controlled air chamber **104** to bleed to the atmosphere through the unloader discharge passage

116 until the forces against the diaphragms 111 and 113 are again in balance. When this occurs the unloader port 115 will close and the pressure within the controlled air chamber 104 will assume a new value as dictated by the pressure acting upon the larger diaphragm 113.

In its simplest form this control system may be regarded as comprising a pressure control which senses and responds to changes in the height of the super-elevation. The pressure control then varies the air pressure actuating the booster relay system, which in turn regulates the air pressure controlling the diameter of the rubber spigot valve 27.

Flushing water 117 introduced into the top of the super-elevation tube 82 does not enter into operation of the automatic control in any way, but is added solely to prevent any solid particles from entering the pressure control bellows.

A tentative example of the classification apparatus presents a combination of structural and operational data as follows:

The machine operates a longitudinal classifying pool about 4' long, about 1' wide, and about 9" deep, with the sands discharge passage at the bottom being about ½" high and the sands discharge weir about ¾" high, the pool area being 4 square feet.

As for the vibrating motion imparted to the bottom of the classifier pool, a practical or suitable operating range for the vibrating stroke under conditions in this example lies in a range of about ⅛" to about ¼", while the stroke frequency covers a practical range of 600 to 1000 reciprocations per minute.

This operating example provides for a stroke length about 3/16" at a stroke frequency on the order of 700 reciprocations per minute. In this example the hydraulic water is supplied by a pair of longitudinally extending horizontal pipes having a clearance from the bottom of the pool of about ½" with center-to-center spacing between the pipes of about 6", and the center of each pipe in turn spaced a distance of about 3" from the respective side walls of the pool.

In this example two jet-emitting pipes are provided parallel to one another, each 4 feet long, of ½" standard pipe having .622 inside diameter and .840 outside diameter, with a spacing between the jet holes of 1 5/16" center-to-center, the jet holes themselves being drill holes produced with No. 37 drill, and having an area each of .00849 square inch, the nominal diameter of the drill hole being .1040 inch, and the total open area of the holes being 1.22 square inches for a total number of 144 holes. In this example the hydraulic water is emitted from the pipes by jets provided by a double row of jet orifices in each pipe so disposed that a row of jet openings at each side of each pipe would emit jets at an angle of about 20° below the horizontal. Head loss through the holes was 1 foot water column for a flow rate of 18 gallons per minute. The jet emitting pipes extend in the direction of vibration or reciprocation imparted to the bottom of the classifier pool.

With a feed to the classifier pool consisting of a deslimed sands mixture having a range of sizes of —20 to —200 Tyler mesh and feeding 79.5 tons per day (dry weight) it is considered that there be obtainable 59.0 tons per day (dry weight) in the underflow and 20.5 tons per day (dry weight) in the overflow; the separation in terms of the size of the "cut" was 250 microns with a "super-elevation" being maintained at 3¼" and a supply hydraulic operating water at the rate of 18 gallons per minute.

I claim:

1. Apparatus for the hydraulic classification treatment of a pulp containing a mixture of particle sizes ranging from fine to coarse, to effect the separation of the mixture into a fraction of fines and a fraction of sands, such fractions being defined as undersize and oversize particles respectively, which apparatus comprises a classifying pool having said mixture supplied thereto in a portion thereof and said fractions discharged from another portion thereof, said pool being confined within a tank structure comprising a horizontal bottom element adapted to be moved in the horizontal plane, with driving means provided and operatively associated with said bottom element for continuously reversing the direction of movement in that plane, and with water supply means provided for emitting at the bottom hydraulic auxiliary water at a controllable rate distributively in a manner whereby the water in effect rises in substantially uniform distribution from the bottom and whereby there are adapted to be formed and maintained in said pool horizontal classification zones comprising substantially a coarse sands zone of oversize particles at the bottom, a fines zone of undersize particles at the top, and an intermediate zone containing a mixture of undersize and oversize particles in teeter condition, there being provided an overflow weir for overflow discharge of undersize particles from said top zone of the pool, underflow sands outlet means leading from the bottom of the pool, throttling means so associated with said outlet means as to operate directly under the influence of gravity of the pulp column in the pool above, said throttling means being adapted to vary the through flow area of the outlet means for thereby adjusting the pulp density in the pool, and a control system comprising a density responsive probe device functionally associated with the pool, and automatic relay devices functionally interconnecting said probe device and said throttling means to automatically adjust the throughflow area thereof in a manner to maintain a predetermined pulp density in the pool and thereby a desired size separation as between the overflow and the underflow fractions.

2. Apparatus according to claim 1, in which the throttling means comprise an inflatable annular member the opening of which represents said throughflow area, and in which relay devices comprise auxiliary pressure air supply means for inflating said annular member and means for controlling the inflated condition of said annular member in response to said pulp density changes in the pool for correctively varying said throughflow area.

3. Apparatus according to claim 1, in which said tank structure comprises said bottom element, a pair of side walls rising from the lateral edges of said bottom element and unitary therewith, said bottom element with said side walls being horizontally movable in a direction coextensive with said lateral edge portions, said tank structure further comprising a stationary inlet end wall at the feed end of said tank structure, a stationary discharge end wall at the opposite end of said bottom element, and deformable means for sealingly interconnecting each of said end walls with the adjoining edge portions of said bottom element and said side walls of the tank structure.

4. Apparatus according to claim 1, in which the water supply means comprise a jet emitting conduit means disposed adjacent to that space upwardly from the tank bottom, and controllable supply means extending from above for supplying water controllable to said jet emitting conduit means.

5. Apparatus for the hydraulic classification treatment of a pulp containing a mixture of particle sizes ranging from fine to coarse, to effect the separation of the mixture into a fraction of fines and a fraction of sands, such fractions being defined as undersize and oversize particles respectively, which apparatus comprises a classifying pool having said mixture supplied thereto in a portion thereof and said fractions discharged from another portion thereof, said pool being confined within a tank structure comprising a horizontal bottom element adapted to be moved in the horizontal plane, with driving means provided and operatively associated with said bottom element for continuously reversing the direction of movement in that plane, and with water supply means comprising a jet-emitting conduit element provided for emitting at the

bottom hydraulic auxiliary water at a controllable rate distributively in a manner whereby the water in effect rises in substantially uniform distribution from the bottom and whereby there are adapted to be formed and maintained in said pool horizontal classification zones comprising substantially a coarse sands zone of oversize particles at the bottom, a fines zone of undersize particles at the top, and an intermediate zone containing a mixture of undersize and oversize particles in teeter condition, there being provided an overflow weir for overflow discharge of undersize particles from said top zone of the pool, underflow sands outlet means leading from the bottom of the pool, throttling means so associated with said outlet means as to operate directly under the influence of gravity of the pulp column in the pool above,

said throttling means being operable to vary the through flow area of the outlet means for thereby adjusting the pulp density in the pool and maintaining a predetermined pulp density in the pool and thereby a desired size separation as between the overflow and the underflow fractions.

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