

[54] **APPARATUS AND METHOD FOR CONTINUOUSLY SEPARATING SOLID PARTICLES IN A FLUID MEDIUM**

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[51] Int. Cl. **B03b 3/34**

[58] Field of Search **209/211, 144, 158-161, 209/155, 138-141**

[56] **References Cited**

UNITED STATES PATENTS

2,150,226	3/1939	Kennedy.....	209/160
654,647	7/1900	Koppelman.....	209/159 X
1,937,190	11/1933	Chance.....	209/161 X
982,583	1/1911	Flood.....	209/158
2,172,792	9/1939	Hall.....	209/158 X
2,967,617	1/1961	Evans et al.....	209/211 X

FOREIGN PATENTS OR APPLICATIONS

536,384	1/1957	Canada.....	209/211
348,958	5/1905	France.....	209/166

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[57] **ABSTRACT**

Classification apparatus for continuously separating solid particles in a fluid medium contained in a cylindrical vessel. Upwardly and downwardly spiraling vortices of turbulence are created in the fluid medium by injecting pressurized fluid streams through the sides of the vessel. A mixture of the particles and fluid medium are introduced downwardly through the top of the vessel to intercept the upwardly spiraling vortex and causing a first separation of heavy and light particles, the heavier particles falling down through the fluid medium and intercepting the downwardly spiraling vortex and effecting a second separation of heavy and light particles. The lighter particles are swept upwardly and discharged by the action of the fluid medium and the heavy particles are discharged through the bottom of the vessel.

7 Claims, 6 Drawing Figures

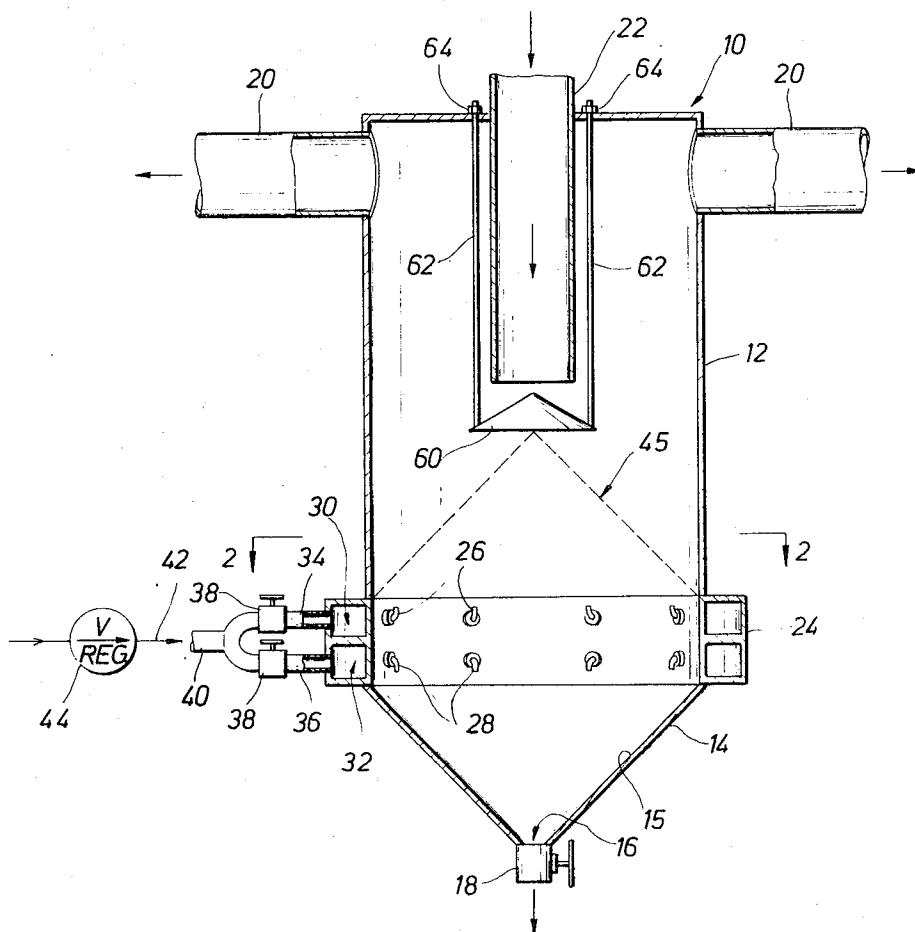


FIG. 2

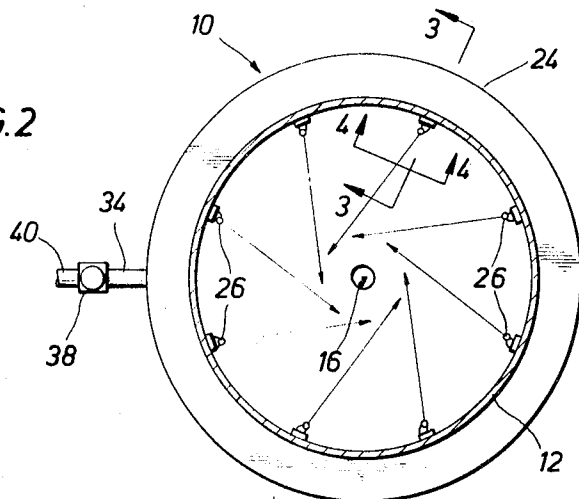


FIG. 3

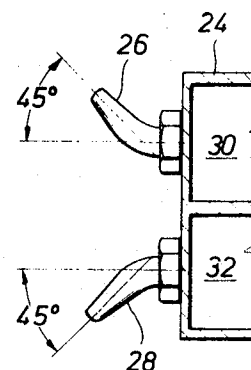


FIG. 1

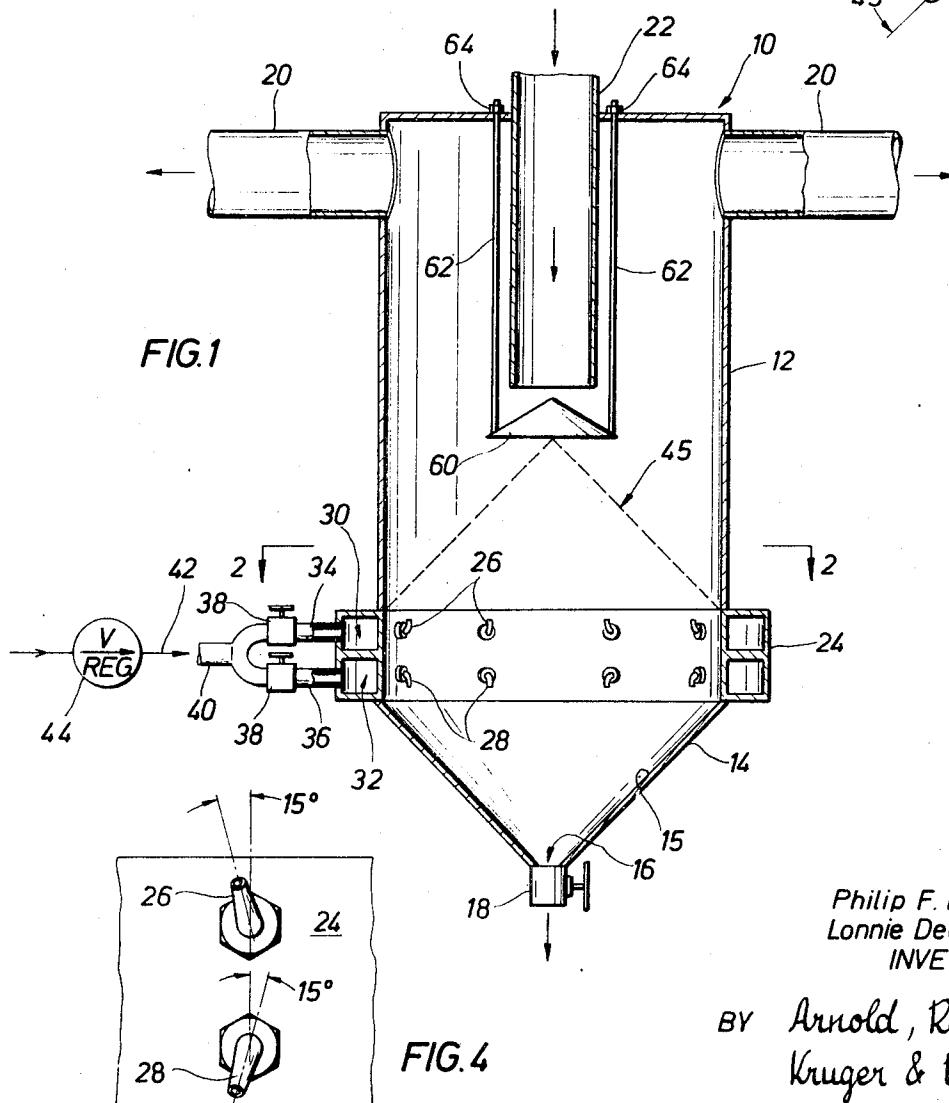
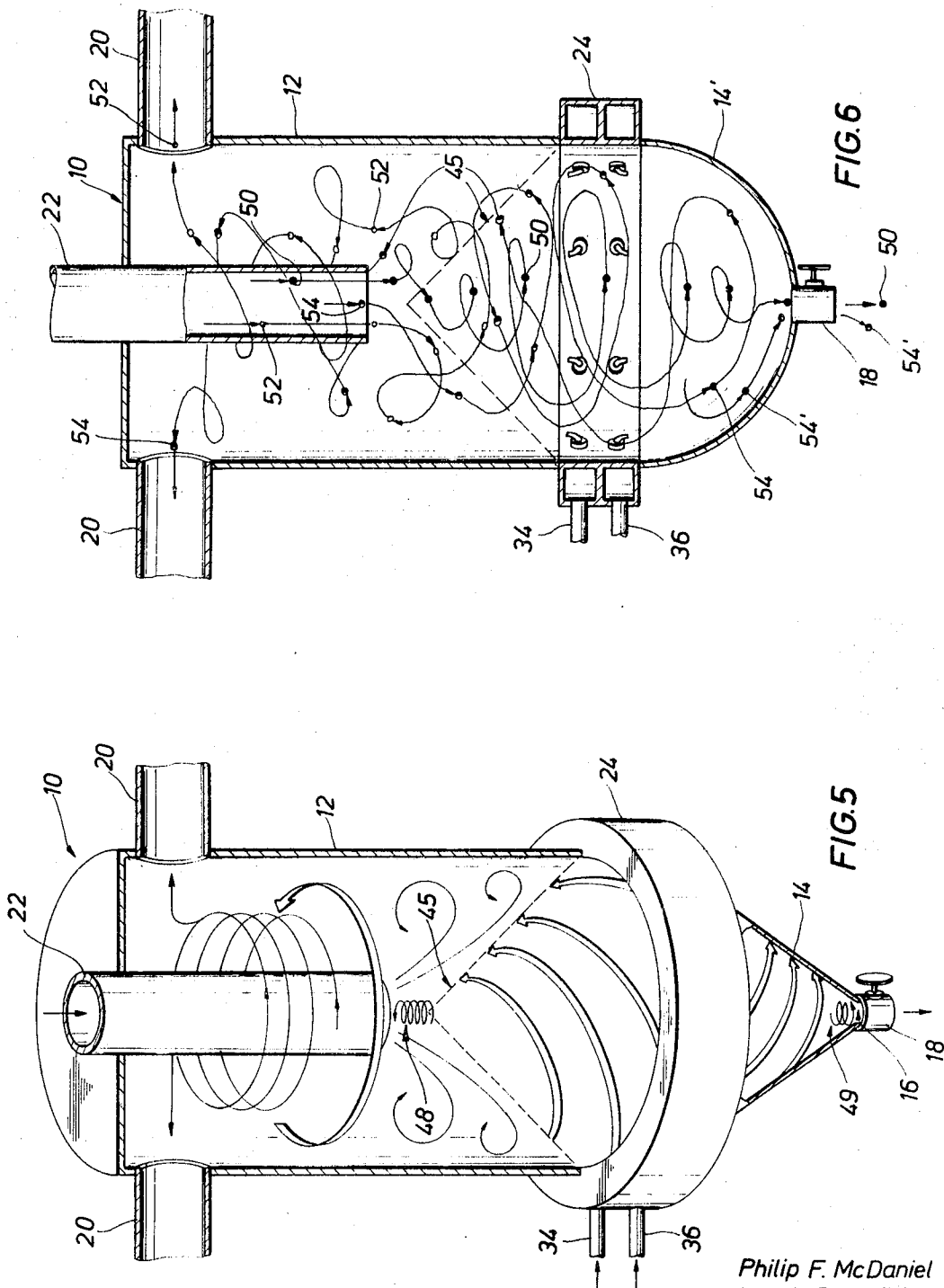


FIG. 4

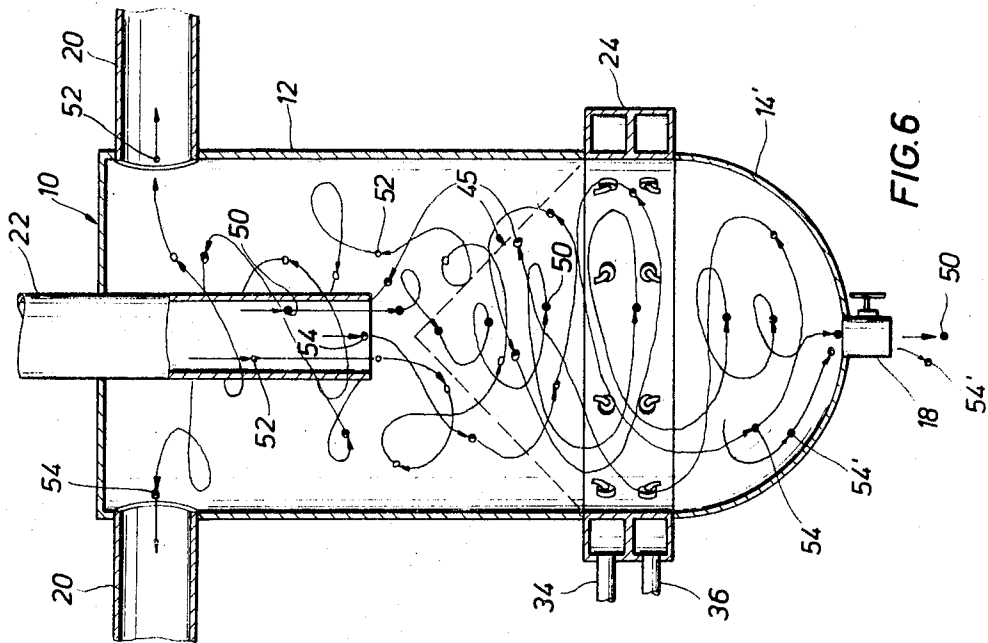
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APPARATUS AND METHOD FOR CONTINUOUSLY SEPARATING SOLID PARTICLES IN A FLUID MEDIUM

BACKGROUND OF THE INVENTION

In many industrial and mining applications, it is necessary to classify or separate solid particles of mixed sizes and often of different specific gravities. It is common to use a fluid acting on the solid particles to achieve the desired sorting.

The main objective of classification is to separate the particles according to size. Where sorting by size is most significant, sorting may most readily be accomplished by screening, but classification is applicable to smaller particles and is more economical than screening.

Materials may also be classified by specific gravity, a method that separates substances differing in chemical composition. Such classification may be accomplished by hydraulic separation. Classification by this method is based on the fact that, in a fluid, particles of the same specific gravity but of different sizes or shape, settle at different constant speeds. Large, heavy round particles settle faster than small, light, needlelike or flaky ones. If the particles also differ in specific gravity, the speed of settling is further effected. This is the basis for the separation of particles by kind rather than by size alone.

Mechanical classifiers utilize the differences in settling velocities by bringing the feed mixture containing the particles to be classified into contact with a continuous stream of fluid and allowing the particles to reach their settling velocities with respect to the fluid. Then, by adjusting the rate of flow of the fluid, the small particles, which have the lower settling speeds, are moved from the classifier with the fluid stream before they have had time to settle out of the fluid. The larger particles, which settle through the fluid more rapidly, are collected in the bottom of the apparatus for periodic or continuous removal.

Vertical-flow classifiers using water as a sorting fluid have been generally employed in industry when separation by specific gravity is critical. In such vertical-flow classifiers, where shape and specific gravity are very important, the solid particle classification is accomplished by the differential settling of the particles in a vertically flowing stream of water. The varying resistances to fall of the various solid particles through the flowing water accomplishes the separation of the fine and heavy particles.

In the surface mining of placer deposits of sand, gravel, and other alluvium and eluvium containing concentrates of metals or minerals of economic importance, separation of the placer deposits has long been accomplished by means of mechanically separating the heavier placer concentrates from the lighter sands which are of no value. The classification and separation of the placer concentrates, particularly when metals or minerals of economic importance are sought such as gold, platinum, tin, phosphate and others or various types of gems, from the alluvial sand and gravel deposits with which they are associated has long been accomplished by taking advantage of the differences in the specific gravities of the heavier metals and the lighter sands. This is particularly true when placer mining gold, an extremely heavy metal.

Many techniques have been used in classifying and separating placer concentrates of gold from the bulk of its associated placer material, such as the "gold rush" method of panning, and the use of flowing-water sluice boxes, where the heavier metal particles, having the greater specific gravity, settled out of the turbulent water while the lighter sands were washed away. Because the proportion of valuable placer concentrates is commonly low in relation to the total bulk of placer material, most placer mining methods have attempted to reduce the bulk handled for classification, and to refine recovery practices to increase efficiency.

In the past, the placer mining industry has commonly used various types of horizontal-flow wet classifiers using water as the sorting fluid. Again, typical horizontal-flow classifiers have

been variations of the flowing-water sluice box, which is inefficient and not well suited to portable dredging operations. Other horizontal-flow devices typically accomplish classification by allowing the sands carried by the flowing water to overflow a dam or weir at one end of an elongated settling tank where the heavier placer concentrates settle to the bottom. The concentrates are then carried along the upwardly sloping tank bottom by means of a reciprocating rake, or a slowly rotating spiral, or some other mechanical means. The placer concentrates will then be discharged over a weir or baffle at the other end of the settling tank. The greatest problem with this type of device is that the control of the classification of the placer concentrate is extremely limited, and too great a proportion of the bulk of unwanted placer material, i.e., sands, also settle out and move with the wanted placer concentrates.

Other techniques, utilizing vertical-flow classification of solid particles, have now heretofore been used in placer mining. The vertical-flow classifiers commonly used for industrial purposes are not suitable for use in placer mining, especially in the more common form of mining by dredge, because of their complexity, power requirements for driving mechanical agitators and beaters, their inability to effectively handle the huge volumes of bulk placer materials continuously over extended periods of time, their inability to efficiently classify heavy particles such as gold, and their inability to withstand hard and abrasive treatment during continuous operation. Most industrial applications of vertical-flow classifiers are directed to efficiently classifying very small solid particles, generally 25 mesh or smaller, while placer mining classifiers must be able to handle ¼- to ½-inch bulk placer materials.

SUMMARY THE INVENTION

The instant invention provides a novel vertical-flow classifier ideally suited for use in classifying and separating placer concentrates from bulk placer materials utilizing the principles of classification by specific gravity of the materials handled. This method is accomplished by continuously feeding preclassified bulk placer materials and water into a vertically disposed separating chamber having a conical or hemispherically shaped lower settling chamber provided with a downwardly directed opening for the discharge of the separated placer concentrates. Lateral discharge pipes communicating with the interior of the upper separating chamber allow for the overflow of water from the separating chamber to discharge the unwanted bulk placer materials or sands. The prescreened bulk placer materials and water are introduced into the settling chamber via a feed pipe where the placer materials are directed downwardly into the central portion of the settling chamber.

A spirally rotating and conically shaped vortex or curtain of water from an array of nozzles peripherally spaced about the lower walls of the separating chamber cause the water within the chamber to have an upwardly spiralling motion. The downwardly falling placer materials intercept the vortex or water curtain and the lighter particles are immediately swept upwardly and outwardly by the swirling water in the separating chamber and discharged through the lateral discharge pipes in the sides of the separating chamber. The heavier placer concentrates are agitated by the water curtain and lighter particles adhering thereto are loosened and swept away, but because the upward force of the vortex or water curtain does not overcome the downward gravitational force exerted by the placer concentrates because of their specific gravity, the placer concentrate particles fall through the water curtain.

Another array of peripherally spaced nozzles, located below the upper group of nozzles, directs a conically swirling spray of water downwardly onto the sloping surfaces of the settling chamber to form an inverted vortex of water in the chamber and further wash the placer concentrates, separating lighter particles that may be adhering to the heavier concentrates, and continually sweeping the downwardly sloping sides of the

settling chamber and causing the placer concentrates to be discharged through a downwardly directed opening in the settling tank. Varying the pressure of the upwardly and downwardly directed vortices or water curtains allows precise control of classification by size and weight of the placer concentrate within the separating chamber.

Accordingly, one primary feature of the present invention is to provide apparatus and method for continuously classifying placer concentrates from bulk placer materials using water as a separating medium.

Another feature of the present invention is to provide classifying means for effecting continuous separation of heavy placer concentrates from lighter placer materials utilizing a rapidly spiralling vortex of water as the separating medium.

Yet another feature of the present invention is to provide a continuous system of separating placer concentrates from bulk placer materials contained in a fluid medium more efficiently than heretofore possible.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the manner in which the above-recited advantages and features of the invention are attained, as well as others that will become apparent, can be understood in detail, a more particular description of the invention may be had by reference to specific embodiments thereof which are illustrated in the appended drawings, which drawings form a part of this specification. It is to be noted, however, that the appended drawings illustrate only typical embodiments of the invention and therefore are not to be considered limiting of its scope for the invention may admit to further equally effective embodiments.

In the drawings:

FIG. 1 is a detailed vertical cross-sectional view of one embodiment of the apparatus according to the present invention.

FIG. 2 is a horizontal cross-sectional view taken along the lines 2—2 of FIG. 1.

FIG. 3 is an enlarged fragmentary vertical cross-sectional view of the upwardly and downwardly directed nozzles as taken along lines 3—3 of FIG. 2.

FIG. 4 is an enlarged fragmentary detailed view of the nozzles taken along lines 4—4 of FIG. 2.

FIG. 5 is a perspective view, partly in cross section, of the apparatus according to the present invention showing water circulation within the separating apparatus.

FIG. 6 is a detailed vertical cross-sectional view of the separating apparatus according to the present invention schematically portraying the flow patterns of the placer concentrate particles and the bulk placer materials such as sands.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 1 and 2, an embodiment of the vertical-flow fluid separator utilizing water as a sorting fluid and constructed in accordance with the invention is depicted by reference number 10. The upper portion of separator 10 is comprised of a cylindrical separating chamber 12, the central axis of which is vertically oriented and supported by a frame structure (not shown). The lower portion of separator 10 comprises a substantially conical chamber 14 having a downwardly directed apex communicating with an opening 16 for the discharge of the sorted placer concentrates through valve 18 to an appropriate collecting tank or vat (not shown). Disposed between sections 12 and 14, and interconnecting the two sections, is a ring-shaped water manifold having separated upper and lower chambers, 30 and 32, respectively.

Nozzles 26, spaced regularly about the inner periphery of manifold 24, communicate with the upper chamber 30. Lower nozzles 28, spaced below the upper nozzles 26 and about the inner periphery of manifold 24 communicate with the lower chamber 32. Nozzles 26 are directed upwardly into the interior of separating chamber 12, while the lower nozzles 28 are directed downwardly into the settling chamber 14. The upper

and lower manifold chambers, 30 and 32, respectively, of water jacket 24 receive pressurized water via pipes 34 and 36, respectively, the flow of which may be regulated by a manual valve 38 disposed in each of the inlet water pipes. Pipes 34 and 36 branch from a main water pipe 40 which receives water from the fresh water distribution system line 42 under pressure from a pump (not shown). The pressure in the system is controlled by a pressure-regulating valve 44, to maintain a constant water pressure in pipe 40 regardless of the pump pressure fluctuations. The placer material feed pipe 22 passes through the top of section 12 and is disposed axially therein to discharge the placer materials centrally within the separating chamber.

Sections 12, 24 and 14 are preferably constructed of steel to withstand the pressures within the container and the abrasive actions of the bulk placer materials. However, other suitable materials may be employed under some circumstances and under certain conditions. For instance, it may be desirable to construct the separator chamber 12 of a thick glass or plastic in order to visually monitor the separating and classifying action. Or a window of glass or other suitable transparent material may be inserted in the side of section 12 for the same purpose.

As may be seen by referring to FIGS. 3 and 4, the upper or first group of nozzles 26 point upwardly for directing a jet of pressurized water into the separating chamber 12. Each of the nozzles 26 is also tilted from the vertical (see FIG. 4) to cause the water jet to be displaced radially from the axis of chamber 12, as may more readily be seen in FIG. 2. The upward and slightly laterally deviating jets of water create a swirling, conically shaped inverted vortex or curtain of water, the outline of which is generally shown at 45, and the function of which will be hereinafter more fully explains.

The downwardly projecting or second group of nozzles 28 direct jets of water downwardly into the interior of settling tank 14, and since each nozzle deviates from the vertical, as hereinbefore discussed with the upper nozzles 26, a similar spiraling flow of water or vortex is created about the inner surface 15 of settling chamber 14.

The settling chamber 14 is shown having a conical shape, the apex of which communicates through opening 16 to a discharge pipe via valve 18. However, the cross-sectional configuration of settling chamber 14 may vary from a conical to a nearly hemispherical configuration (see FIG. 6) without appreciably altering the flow and discharge characteristics of the placer concentrates as will be hereinafter more particularly explained.

In operation, fresh water under pressure regulated by valve 44 and distributed via line 42 is applied through pipe 40 to the upper and lower chambers 30 and 32 of manifold 24, respectively, via pipes 34 and 36, respectively. The pressure and the volume of water applied to each of the chambers may be controlled by means of the manually operated valve 38 disposed in each pipe line. With valves 38 open, nozzles 26 and 28 inject multiple streams of high-pressure fresh water upwardly into the separating chamber 12, and downwardly against the interior walls 15 of the settling chamber 14. As hereinabove described, since nozzles 26 deviate laterally from the vertical, the injected streams of water deviate radially from the central axis of chamber 12, (see FIG. 2) creating a conically shaped, spiraling spray of water or inverted vortex 45, spiraling rapidly about an axis coincident with the central axis of the separating chamber and projecting upwardly therein (see FIG. 5). The downwardly directed and radially deviating spray of water from nozzles 28 strikes the inner surface 15 of settling chamber 14 or 14' (see FIG. 6) and creates a spiraling vortex of water over the inner surface, the vortex being axially aligned with the axes of inverted vortex 45 and chamber 12. The lower tip or cavity of the vortex 49 communicates with the downwardly directed opening 16.

With valves 18 and 38 properly adjusted, the swirling water entering separator 10 via nozzles 26 and 28 begin to fill the settling chamber 14 and rise above the level of the nozzles and

into the separating chamber 12, since the volume of water entering the separator via nozzles 26 and 28 is much greater than the volume of water discharged via opening 16 and valve 18. By referring to FIGS. 2, 4 and 5, it may be seen that the rotational motion of the water sprays generated by nozzles 26 and 28 are complimentary and create a rotating body of water having a general configuration of a "spinning top," or more properly, the configuration of two cones placed base to base and rotated about an axis passing through their respective vertices and coincident with the axis of chamber 12. As the water rises in chamber 12, it continues to rotate, only its spiral motion slows as it rises over the apex of water curtain 45. The water, spiraling more slowly as it rises, reaches the level of the laterally disposed overflow discharge pipes 20, and overflows into the pipes for distribution to another classifier or to waste (see FIGS. 1 and 5). This action continues until the volume of water injected by nozzles 26 and 28 is reduced or the discharge valve 18 is opened to allow a greater discharge. Accordingly, the level of the water within separator 10 and the overflow discharge rate may be controlled by adjustment of valves 18 and 38 taking into consideration the volume of water and bulk material entering via pipe 22 as will be hereinafter described in greater detail.

Referring now to FIGS. 1, 2, 5 and 6, prescreened bulk placer material is fed into the interior of separator 10, accompanied by a predetermined volume of water, and hereinafter to be called the "bulk placer mixture," via feed pipe 22. The bulk placer mixture introduced through feed pipe 22 may be injected under pressure, however, the injection pressure of the bulk placer mixture must always be below the upward pressure exerted by the inverted vortex 45 for reasons to be more fully described below. The bulk placer mixture strikes the rapidly rotating vortex or water curtain 45 causing the introduced placer concentrates and sands of the mixture to be vigorously and turbulently rotated in the spiraling flow of water within separating chamber 12. The heavy placer concentrate particles 50 and heavier placer materials 54, (see FIG. 6) having a high specific gravity, overcome the upward force exerted by the rotating conically shaped water curtain 45, falling through the water curtain and into the rotating and turbulent flow between the vortices created by nozzles 26 and 28. The placer concentrate particles 50 and heavier placer materials 54 are whirled and rotated about and spiraled downwardly into settling chamber 14. The swirling water within the interior of settling chamber 14 continuously sweeps surface 15 and directs particle 50 into the discharge opening 16 and through valve 18 to a suitable collecting vat or tank (not shown).

The lighter placer materials 52, such as sand, silt and other particles, having a specific gravity less than particles 50 and highly resistant to fall through the turbulent inverted water vortex 45, are directed outwardly from the axis of rotation of the vortex and are swirled outwardly and carried upwardly in a spiraling motion by the upward flow of water to be discharged through the overflow pipes 20.

The heavier placer materials 54, having a specific gravity less than particles 50 but heavier than particles 52, fall through water curtain 45 and are swept into the rapidly swirling area between the upper and lower vortices. The particles 54 will settle more slowly into the settling chamber 14 than particles 50, and will be swept and agitated by the lower vortex sweeping surface 15. Most of the particles 54 will be swept upwardly by the force of the lower vortex and carried up and out of the upper vortex and into the rapidly swirling water column in chamber 12. The particles 54, swept upwardly, will be carried into discharge pipes 20 with the overflow water.

However, some heavier placer particles 54' will resist the upward force of the lower vortex and will be swept downwardly into the discharge opening 16 along with the heavy placer concentrate particles.

The turbulent meeting of particles 50, 52 and 54, the water curtain 45, and the lower vortex agitates the particles and

helps separate particles that are compacted together, further insuring a greater accuracy of classification. Thus it may be seen that a primary classification is accomplished as to the placer concentrate and material particles meet water curtain 45 and as the particles fall within the area between the two vortices. Secondary classification occurs when the particles are swept by the lower vortex adjacent surface 15 and again violently agitated and washed.

In operation, bulk placer materials of various prescreened sizes may be applied to individual separators 10, to classify and recover various sizes of placer concentrates, generally in the range of ¼-inch to 1/16-inch particles. Smaller flakes and the like may be recovered from the overflow discharge of the separator handling the smallest prescreened bulk material by means of conventional jigs. If the overflow discharge is not reclassified, it would ordinarily be discharged to waste.

The desirable ratio by volume of water to screened bulk material for optimum performance of the separator is approximately 5:1. In order to achieve this ratio, the input volume of water injected via nozzles 26 and 28 may be adjusted within certain limits. To achieve a greater volume of water ratio the volume may be increased by increasing the nozzle pressure, however, too great a pressure may lessen the classification efficiency since some placer concentrates or heavy particles may not overcome the upward lift of the increased vortex or water curtain pressure. If there is a need for greater water volume without the corresponding increase in pressure, nozzles having larger apertures may be substituted.

The preferred technique is to add water to the screened bulk materials prior to injection into chamber 12 via feed tube 22 for achieving the approximate 5:1 ratio of water by volume to screened bulk materials within chamber 12 as mentioned above. Generally, the ratios are not critical except that the ratio of water to screened bulk materials cannot be less than 8:1 (or 14 percent bulk materials) or the input mixture becomes such a heavy slurry that the particles are in suspension and the heavier particles may be trapped by the suspended lighter particles and carried away for discharge, lessening the separation efficiency.

the orientation of nozzles 26 and 28 are The FIGS. 3 and 4 as hereinbefore described. The angles of horizontal and vertical deviation are not critical, however, it has been found that optimum results for the broad range of prescreened materials are achieved with the nozzles angled 45° with respect to a horizontal plane perpendicular to the inner surface of manifold 24, and deviating from a vertical plane passing through the center of the horizontal extending portion of the nozzle by 15°. Of course, under special conditions of heavier particles of greater specific gravity or larger prescreened materials to be handled, it may be necessary to change the angular deviation of the nozzles for more efficient classification.

Under certain conditions of high water spray pressure from nozzles 26, the inverted vortex of water 45 causes a cavity or vacuum whirlpool 48 to extend from its apex end (a phenomenon well known in the art of fluid mechanics) into feed pipe 22 and literally "draw" placer materials, including both placer concentrates and sands, through the cavity, without separation, and into the interior of the rotating mass of water below water curtain 45. Once the lighter and heavier sands have penetrated the water curtain or the inverted vortex 45, efficient separation and classification from the placer concentrates is reduced. A larger percentage of the sands may be swept into settling chamber 14 and discharged with the placer concentrates through opening 16 as undesirable contaminants.

In order to eliminate this problem, a conically shaped vortex cavity eliminator 60 may be inserted just below the lower end of feed pipe 22 and spaced between the end of pipe 22 and the apex of the water curtain 45. Eliminator 60 may be adjustably mounted by means of rods 62 passing through the top of chamber 12 and adjustably secured by means of nuts 64 or any other conventional attaching means. Eliminator 60 then acts to break up and prevent the formation of a vortex cavity 48

and prevents the extension of such a cavity up into the feed pipe 22. Further, the downward sloping top surfaces of plate 60 also help to equally distribute the flow of the injected bulk placer mixture in the interior of settling chamber 12.

It should be noted that the separator may be operated utilizing compressed air pumped into manifold 24 and chambers 30 and 32 for forming an "air curtain" 45. The ratio of the volume of water to bulk material to be classified, injected via feed pipe 22, would have to increase, or a separate source of water utilized to inject additional water into separation chamber 12. In classifying fine particles, the bubbles generated by the air sprays from nozzles 26 and 28 would assist in breaking up concentrates from finer particles and floating the particles upwardly in chamber 12.

The apparatus above discussed has been described in the context of an application in the surface mining of placer metals and minerals. However, it would be obvious to one skilled in the art of vertical-flow classifiers that the apparatus and method herein described may be utilized in other mining and industrial applications without deviating from the scope of the invention herein described.

Accordingly, numerous variations and modifications may obviously be made in the structure herein described without departing from the present invention. Accordingly, it should be clearly understood that forms of the invention herein described and shown in the figures of the accompanying drawings are illustrative only and are not intended to limit the scope of the invention.

What we claim is:

1. Apparatus for continuously classifying discrete particles having varying specific gravities and resistances to fall in a fluid medium, comprising

a vessel defined about a vertical axis for receiving the particles and fluid medium and forming a separation chamber for the particles, said vessel being closed at the lower end by downwardly and inwardly depending walls for forming a particle settling chamber, said chamber having a downwardly directed aperture coincident with said vertical axis of said vessel,

overflow means peripherally disposed adjacent the topmost portion of said separation chamber and communicating interiorly therewith,

a feed pipe coaxially disposed within said vessel and extending downwardly therein for continuously introducing a mixture of the fluid medium and the discrete particles downwardly within said separation chamber adjacent said vertical axis of said vessel,

a manifold encircling the outer periphery of said vessel and attached thereto adjacent the lower end of said separation chamber, said manifold containing a pair of chambers for carrying the pressurized preselected fluid,

a first group of horizontally disposed, spaced nozzles fixed to the interior periphery of said vessel opposite one of said encircling manifold chambers and communicating therewith, said first group of nozzles each angled inwardly at an angle with respect to the radial direction and upwardly for directing the pressurized fluid upwardly, inwardly and rotationally into said separation chamber for forming an upwardly spiraling water curtain to effect a first separation of the particles having a lesser specific gravity and a greater resistance to fall from the particles having a greater specific gravity and a lesser resistance to fall, the lighter particles being swept upwardly and circularly in said separation chamber for discharge through said overflow means, the heavier particles falling downwardly through said water curtain into said settling chamber, and

a second group of horizontally disposed, spaced nozzles fixed to the interior periphery of said vessel below said first group opposite the other one of said encircling manifold chambers and communicating therewith, said second group of nozzles each angled inwardly at an angle with respect to the radial direction and downwardly for

directing the pressurized fluid downwardly and inwardly into said settling chamber in a conically shaped rotating spray to sweep the inner surface of said settling chamber and effecting a second separation of the particles having a lesser specific gravity and a greater resistance to fall from the particles having a greater specific gravity and a lesser resistance to fall and carrying the heavier particles into said settling chamber aperture for discharge.

2. The nozzles of said first group of nozzles as described in claim 1 are positioned upwardly at a 45° angle from the horizontal and at a 15° angle from the vertical for accomplishing the creation of an upwardly, inwardly and circularly swirling area of turbulence.

3. The nozzles of said second group of nozzles as described in claim 1 are positioned downwardly at a 45° angle from the horizontal and at a 15° angle from the vertical for accomplishing the creation of a downwardly, inwardly and circularly swirling area of turbulence.

4. Apparatus for continuously separating discrete particles having varying specific gravities and resistances to fall in water as a separating medium, comprising

an elongated cylindrical vessel vertically oriented for receiving the water and particles and forming a separation chamber for the particles, said vessel being closed at the lower end by downwardly and inwardly depending walls for forming a particle settling chamber having a downwardly directed aperture coaxial with the vertical axis of said vessel,

overflow means peripherally disposed adjacent the topmost portion of said separation chamber and communicating interiorly therewith,

a conduit fixed to the closed top of said vessel and concentrically projecting downward into said separating chamber for continuously introducing a mixture of the water and discrete particles downwardly into said separation chamber,

a manifold encircling the outer periphery of said vessel and attached thereto adjacent the lower end of said separation chamber, said manifold having first and second chambers for carrying water under pressure,

a first group of horizontally disposed, spaced nozzles fixed to the interior periphery of said vessel opposite one of said encircling manifold chambers, and communicating with said chamber carrying the water under pressure,

said first group of nozzles angled with respect to the radial direction for directing the pressured water upwardly, inwardly and circularly into said separation chamber for forming an upwardly spiraling area of turbulence and imparting an upward rotational motion to the water within said separating chamber, the axis of rotation of the water being substantially coincident with the vertical axis of said vessel,

said upwardly spiraling area of turbulence in the water effecting a first separation of the particles having a lesser specific gravity and a greater resistance to fall from the particles having a greater specific gravity and a lesser resistance to fall, the lighter particles being swept upwardly for discharge through said overflow means and the heavier particles settling down into said settling chamber,

a second group of horizontally disposed, spaced nozzles fixed to the interior periphery of said vessel below said first group opposite said encircling second manifold chamber and communicating with said second chamber carrying the water under pressure,

said second group of nozzles angled with respect to the radial direction for directing the pressurized water downwardly, inwardly and circularly into said settling chamber for forming a downwardly spiraling area of turbulence to sweep the inner surface of said settling chamber and effecting a second separation of the particles having a lesser specific gravity and a greater resistance to fall from the particles having a greater specific gravity and a lesser resistance to fall and carry-

ing the heavier particles into said settling chamber aperture for discharge.

5. The nozzles of said first group of nozzles as defined in claim 4 are angled inwardly and upwardly at preselected angles to the horizontal and vertical.

6. The nozzles of said second group of nozzles as defined in claim 4 are angled inwardly and downwardly at preselected angles to the horizontal and vertical.

7. A method for continuously separating discrete particles within a vessel having varying specific gravities and resistances to fall in water as a separating medium, comprising the steps of creating an upwardly spiraling conical area of turbulence in the water within the vessel for imparting rotational motion to the fluid medium, simultaneously creating a downwardly spiraling conical area of turbulence in the water within the vessel below said upwardly spiraling conical area of turbulence for imparting rotational motion to the water complementary to the rotational motion caused by said upwardly spiraling area of turbulence, and

introducing a mixture of the particles and water into the vessel along the rotational axis of said upwardly and downwardly spiraling areas of turbulence and above the apex of said upwardly spiraling area of turbulence to intercept said rotating water and said upwardly spiraling area of turbulence for effecting a first separation of the particles having a lesser specific gravity and a greater resistance to fall from the particles having a greater specific gravity and a lesser resistance to fall, the lighter particles being swept upwardly for discharge from the vessel and the heavier particles settling down through said upwardly spiraling area of turbulence in the rotating column of water for interception by said downwardly spiraling area of turbulence for effecting a second separation of the particles having a lesser specific gravity and a greater resistance to fall from the particles having a greater specific gravity and a lesser resistance to fall and carrying the heavier particles downward for discharge from the vessel.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,642,129 Dated February 15, 1972

Inventor(s) Philip F. McDaniel et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 18, "sizes" should read -- size --.
Column 4, line 34, "explains" should read -- explained --;
line 44, "form" should read -- from --.
Column 6, line 3, "to" should be deleted;
line 41, "the" should read -- The --; after "are"
insert -- shown in --; before "FIGS." delete "The".
Column 7, line 16, "on" should read -- an --.

Signed and sealed this 1st day of August 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents