

Oct. 10, 1944.

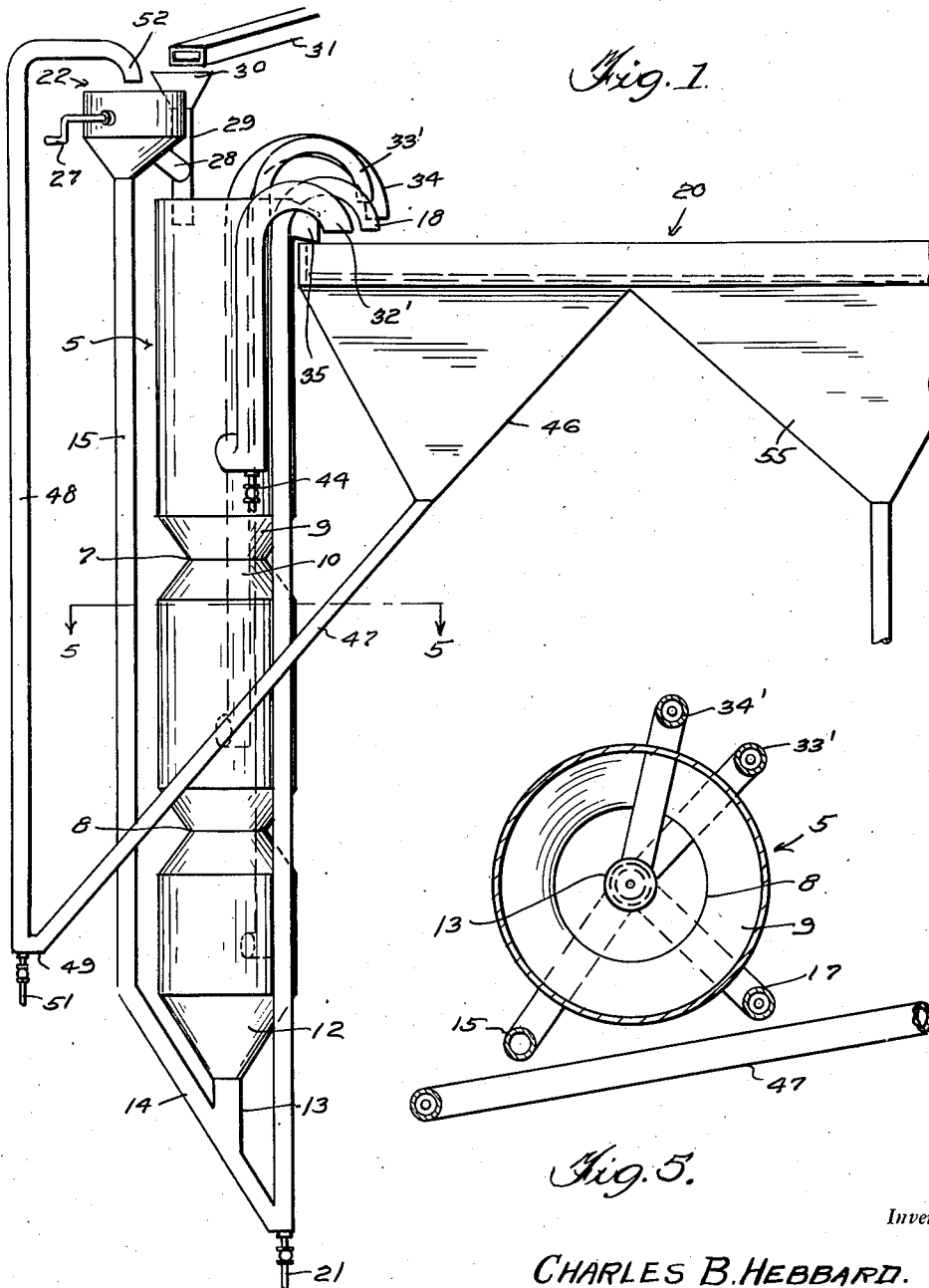
C. B. HEBBARD

2,360,129

MULTIPLE SEPARATION APPARATUS

Filed Feb. 14, 1942

3 Sheets-Sheet 1



Inventor

CHARLES B. HEBBARD.

By

Clarence A. O'Brien
and Harvey B. Jacobson
Attorneys

Oct. 10, 1944.

C. B. HEBBARD

2,360,129

MULTIPLE SEPARATION APPARATUS

Filed Feb. 14, 1942

3 Sheets-Sheet 2

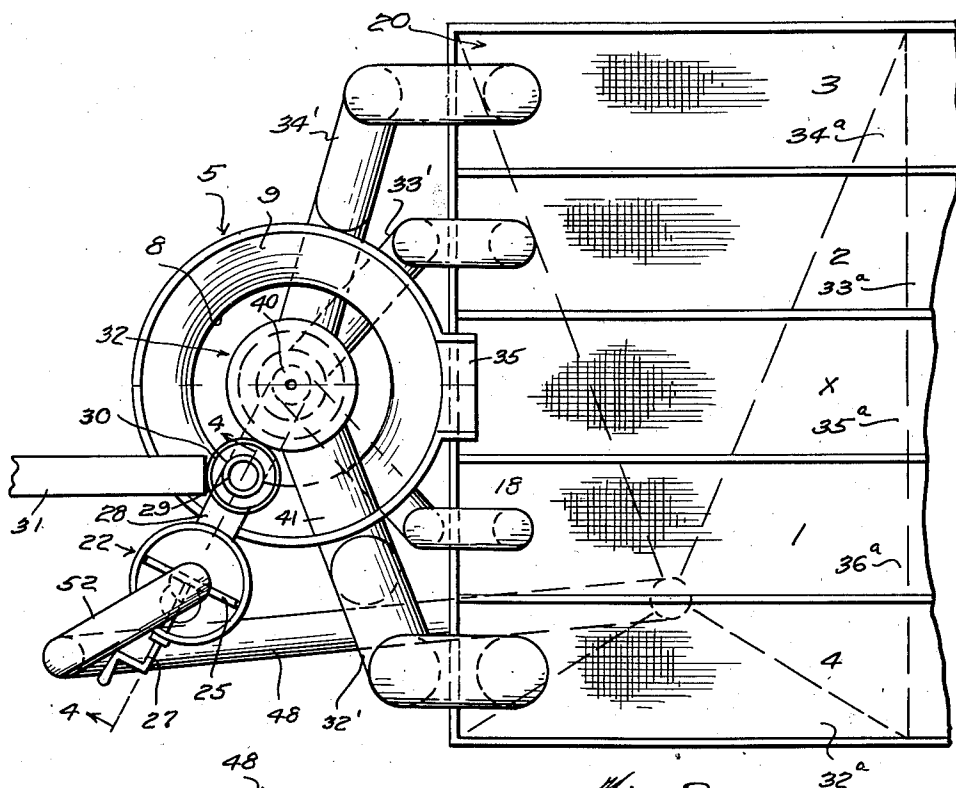


Fig. 2.

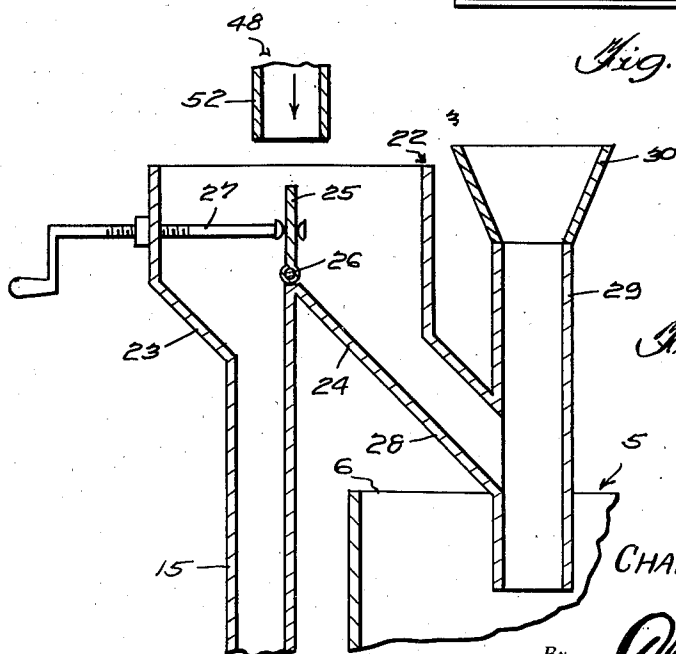


Fig. 4.

Inventor

CHARLES B. HEBBARD

By

Clarence A. O'Brien
and Harvey B. Jacobson
Attorneys

Oct. 10, 1944.

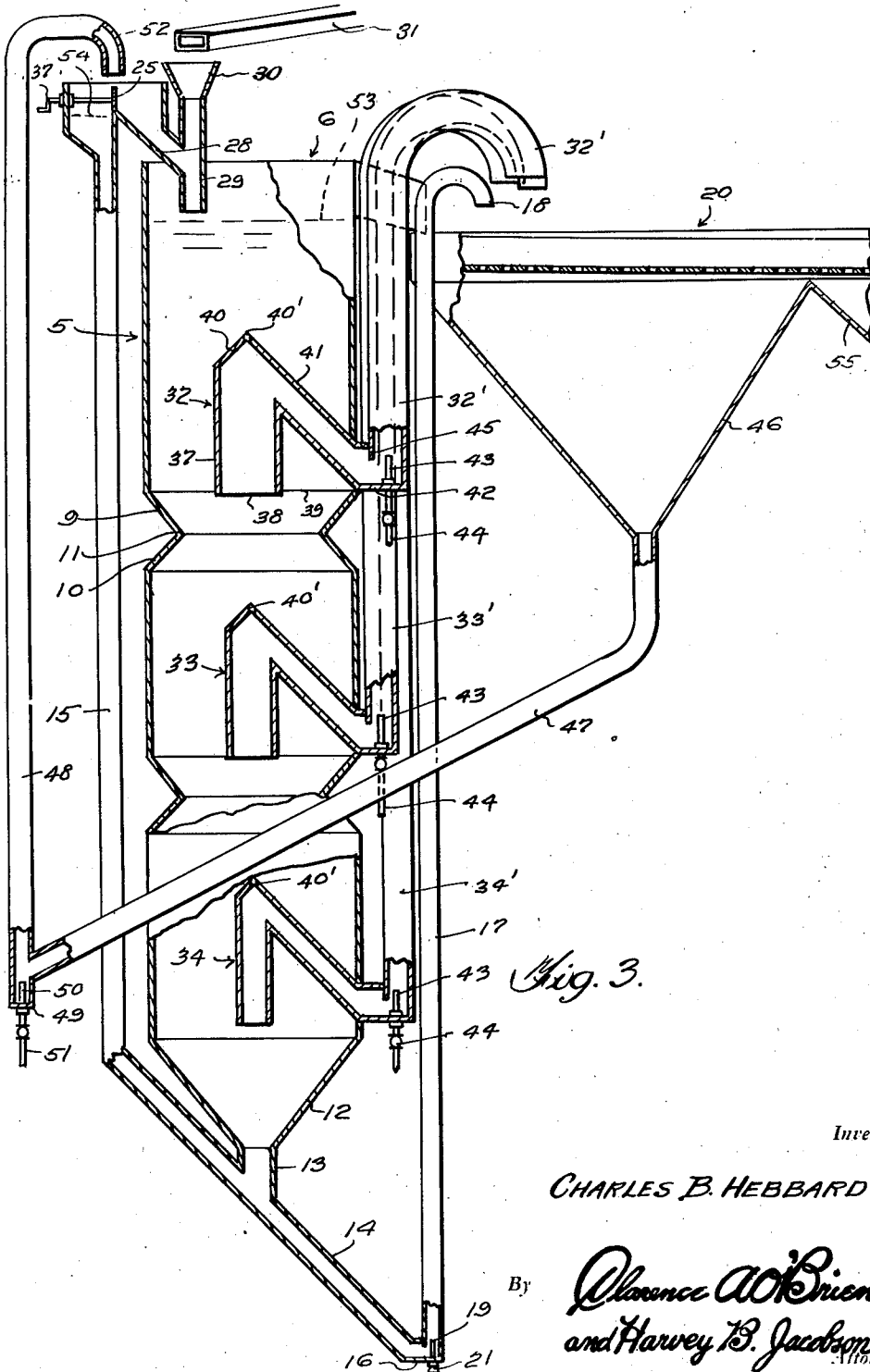
C. B. HEBBARD

2,360,129

MULTIPLE SEPARATION APPARATUS

Filed Feb. 14, 1942

3 Sheets-Sheet 3



Inventor

CHARLES B. HEBBARD

By

Clarence A. O'Brien
and Harvey B. Jacobson
Attorneys

UNITED STATES PATENT OFFICE

2,360,129

MULTIPLE SEPARATION APPARATUS

Charles B. Hebbard, Joplin, Mo., assignor of one-half to Kelsey Norman, Henry Warten, and Helen E. Redding, all of Joplin, Mo.

Application February 14, 1942, Serial No. 430,976

3 Claims. (Cl. 209—158)

The invention relates generally to improved means of producing multiple separation of components of fragmentary material, the said components having different specific gravities, and more particularly to process and apparatus producing such separation by means of the combined agencies of flotation and rising fluid currents of a heavy density medium, whereby fluid circuits are established which automatically operate to congregate and draw off particles of predetermined specific gravity at corresponding predetermined levels in the medium, whereby an indefinite number of components of progressively different specific gravities may be efficiently separated from the other components of the fragmentary material originally charged into the medium simply by providing and proportioning the necessary number of stages.

Important objects and advantages of the invention will be apparent from a reading of the following description and the appended drawings wherein preferred embodiments of the invention are set forth for illustrative purposes.

In the drawings:

Figure 1 is a general side elevational view of the apparatus in accordance with the present invention.

Figure 2 is a top plan view of Figure 1.

Figure 3 is a schematic sectional and elevational view of the apparatus with portions of the casing broken away to disclose the interior structure.

Figure 4 is an enlarged fragmentary vertical sectional view taken through Figure 2 along the line 4—4.

Figure 5 is an enlarged horizontal sectional view taken through Figure 1 along the line 5—5.

Referring in detail to the drawings, the numeral 5 generally designates an upright substantially cylindrical casing having suitable support means (not shown), and indented circumferentially at successively reduced distances from the top 6, as indicated by the numerals 7 and 8, respectively. The indentations are characterized by oppositely tapering walls 9 and 10 joined to produce interior annular restrictions 11. The casing 5 is divided into three chambers or zones 5a, 5b and 5c diminishing in volume, all of the same diameter. The lower end 12 of the lowermost casing section 5c defined by the presence of the indentations is downwardly tapered to a relatively small diameter neck 13 which connects with the top wall of a declining tube section 14 passing beneath the casing 5. The upper end of the tube section 14 connects with the lower end of the tube 15 which rises alongside of the casing to a point sufficiently elevated above the upper end or top 6 of the casing to provide for a hydraulic head in the tube 15 in a manner to be described. The depressed end of the declining tube section 14 enters a short horizontal section 16 from the outer end of which

rises the tube 17 which has a downturned gooseneck 18 on its upper end discharging onto a particular section of the multiple screen 20. An air jet 19 is arranged through the bottom of the short horizontal tube section 16 and projects axially upwardly into the lower part of the tube 17, with a valved air supply pipe 22 connected to the air jet.

The upper end of the tube 15 has eccentrically mounted thereon the cylindrical hopper 22 which has laterally displaced tapering bottom portions 23 and 24, the upper end of the pipe 15 being connected to the bottom portion 23. An adjustable partition 25, horizontally hinged at 26 between the two tapering bottom sections, is operable by a hand crank equipped screw 27 for a purpose to be explained herein. The bottom portion 24 is connected by a short declining tube 28 to the short vertical tube 29 at a point between its upper and lower ends. The lower end of the tube 29 depends into the upper end of the casing 5, while the upper end of the tube 29 which projects above the casing 5 is provided with a hopper 30 to properly receive the material, such as ore, from the conveyor conduit 31 which discharges thereinto.

At each separation stage or zone or region in the casing 5 defined by the indentations and by the tapered bottom 12, there is provided a draw-off. These draw-offs are similar in form and arrangement in the casing but are graduated in size and in diameter from the upper part of the casing to the lower part thereof, the corresponding draw-offs being generally designated by the numerals 32, 33 and 34.

The uppermost draw-off 32 which is largest in size and diameter connects with the air lift tube 32' which has a goose neck in its upper end discharging onto the section 32a of the multiple screen 20. The next smaller intermediate draw-off 33 connects with the air lift tube 33' which has a gooseneck on its upper end discharging onto the section 33a of the screen, which the smallest draw-off 34 connects with the air lift tube 34' having its gooseneck discharging onto the section 34a of the screen 20.

The overflow mouth 35 at the side of the top 6 of the casing 5 discharges onto the section 35a of the said screen, while the gooseneck 18 on the upper end of the tube 17 discharges onto the screen section 36a.

Each draw-off comprises a vertically disposed cylindrical conduit 37 arranged concentrically in the casing 5 with its open lower end 38 positioned close to the level of the upper boundary 39 of the related constriction. The upper part of the conduit 37 is conical as indicated at 40 and rises to a point at or beyond the middle height of the related casing section. The apex of the cone is formed with a small hole 40' to prevent an air

trap in the cone. A lateral tube 41, somewhat smaller in diameter than the conduit 37, declines at the same angle as and communicates with the conical top 41 of the conduit. The depressed laterally outward end of the tube 41 passes horizontally through the side of the casing 5 as indicated at 42 at substantially the same level as the open lower end of the conduit 37. An air jet 43 rises through the bottom of the horizontal portion 42 and rises axially well into the corresponding one of the described air lift pipes, the jet being fed by a related valved air pipe 44. A vertical baffle 45 depends below the top of the horizontal portion 42 and somewhat below the upper end of the air jet 43 to confine the action of the air jet to its lift pipe.

The multiple screen 20 has a tapered hopper 46 receiving the strained medium from all of the screen sections 34a, 33a, 35a, 36a, and 32a, this hopper emptying into the declining tube 47 which connects with the lower part of the lift tube 48 at a point above its lower closed end 49. An air jet 50 fed by an air supply pipe 51 projects through the said closed end 49 and axially upwardly into the tube 48. The upper end of the tube 48 is formed with a downturned gooseneck 52 which, as shown in Figure 4 of the drawings, discharges into the hopper 22 midway between its distinct bottom sections 23 and 24, so that the partition 25 can be adjusted by tilting to direct more or less of the recirculated medium flowing from the tube 48, either into the pipe 15 or into the pipe 29, thereby determining whether more or less of the recirculated medium is returned to the bottom or to the top of the casing 5. In actual practice the liquid medium level in the casing 5 is at the point indicated by the numeral 53, while the liquid level in the section 23 of the hopper and in the tube 48 is at the point 54. The difference in elevation of the two liquid levels creates a hydrostatic head in the tube 48 which acts to circulate the medium downwardly therein, to produce rise of the medium in the casing 5 and in the draw-offs.

A suitable flotation medium of selected specific gravity being present in the casing to the proper level and some of the material to be handled having been charged onto the top of the medium by the conveyor conduit 31, the floatable material such as tailings overflows with the medium through the overflow 35 onto the screen 20. The particles of next higher specific gravity sink through the medium to the region of the first indentation where they are arrested and confined by the fact of their having reached a point in the medium whereat the velocity of the uprising current of medium offsets the specific gravity of the particles and prevents their sinking any further in the medium. The congregation of the arrested particulars adjacent to the open lower end of the uppermost draw-off 32 enables the arrested particles to be drawn off by the controlled rising current of medium through the draw-off, to the region of the air jet 43 whereby they join the resultant rising column of fluid and are discharged onto the screen 20 and retained, while the medium returns into the system via the pipe 47.

While the first separation above described is taking place, the still denser particles sink through the arrested particles and are in turn arrested at levels within the casing 5 corresponding to their specific gravity and where they are in turn drawn off by the related draw-off. This operation proceeds until the final separation, such as free metal in an ore separation operation col-

lects in the tube 14 and is raised through the tube 17. Beyond the hopper 46 the screen 20 has a hopper 55, not involved in the operation of the described system, but provided to catch the washings from separated particles moving along the screen sections from the region of the hopper, and carrying the diluted medium to the thickeners (not shown). As shown in Figure 3 the screen sections may be declined away from the casing 5 or otherwise suitably arranged to effect the desired transit of the particles retained on the screens.

In actual operation of the apparatus, the draw-off air jets are adjusted to produce draw-off of the desired particles from the related separation regions in the casing 5. If the draw-off air jets are jetting too much air they are valved down so that the draw-off action will not be excessive and tend to draw-off particles other than those congregating in the particular region which otherwise would properly sink to a lower region in the medium.

The jet 50 in the conduit 47, 48 is adjusted to keep the medium in the screen hopper 46 at a constant predetermined level.

The jet 19 in the conduit 14, 17 is adjusted so as to produce positive rise in the tube 17 of the heaviest material reaching the horizontal portion 16.

The partition 25 is adjustable by the crank 27 to properly apportion the flow of medium from the tube 48. For instance, if the upflow in the casing 5, caused by too much medium coming down the tube is keeping separated particles from sinking through the neck 13 into the tube 14, the partition 25 is adjusted to cause less of the medium from the tube 48 to flow down in the tube 15 and cause more of the medium from the tube 48 to by-pass and flow into the top of the casing 5 through the tube 29.

The fragmentary material to be processed in accordance with the present invention does not require to be ground to uniform or small mesh sizes, so that the trouble and expense of preliminary grinding is reduced over other separation processes. However, in order to avoid spoiling the medium the crushed or ground material is washed to remove slime and fine sand, before charging it into the casing 5. Much larger material can be separated and recovered with the present process than can be successfully handled by other available processes. Material of 10-mesh size and larger can be successfully handled by the present invention.

Although there are shown and described herein preferred embodiments of the invention, it is to be understood that the invention is not to be limited thereto, except as may be required by the scope of the subjoined claims.

Having described the invention, what is claimed as new is:

1. Apparatus for multiple separation of fragmentary material into batches of particles characterized by different specific gravities, said apparatus comprising a vertical substantially cylindrical tank having a plurality of vertically spaced, circumferential constrictions defining cylindrical zones of one diameter and graded length containing a body of high density fluid medium having a specific gravity greater than that of the lightest particles and less than that of the heaviest particles, charging means for charging the fragmentary material into the top zone of the tank, overflow means at the top zone of the tank for overflowing the lightest particles

floating on the top of the body of medium and draw-off means in middle and lowermost zones of the medium, the heaviest particles sink relatively rapidly through the medium in the middle zone and reach the bottom zone of said tank while the particles of intermediate weights sink into the middle zone through said medium at slower rates according to their respective specific gravities, circulating means for producing a rising current in said medium and means for positively drawing off the heaviest particles accumulating in the bottom zone, said draw-off means located in the respective zones at different levels in said tank acting vertically and at levels corresponding to the points in the medium at which the velocity of uprise of the medium offsets the sinking rate of the different intermediate weight particles, said draw-offs operating to draw-off the particles arrested in the medium of their corresponding zones in the medium and conveying drawn off particles to points outside said tank; each of said draw-off means comprises a radial conduit extending through the side of the tank and a vertical air-lift connected with the outward end of the conduit, said conduit comprising a radially inwardly inclined portion terminating in a vertical portion depending substantially axially in said tank, said vertical portion being open at its bottom to receive the combination of intermediate particles and medium at the level corresponding thereto.

2. Apparatus for multiple separation of particles of different specific gravity, comprising a vertical tank composed of a series of tubular zones in alinement one above the other of one

diameter but of different length joined together by annular restrictions, means for circulating media upwardly through the tank, the upper one of said zones being adapted for containing a rising current of density media of lower velocity than the zone next below after such media having been charged into the bottom zone; a vertical draw-off column for each of said zones, each draw-off column of a smaller diameter than in the zone next above, an exterior connecting conduit for said draw-off columns and means adjacent the top of said tank for screening and removing the media and particles and returning them to the bottom of said vertical tank.

3. Apparatus for multiple separation of particles of different specific gravity, comprising a vertical tank composed of a series of tubular zones in alinement one above the other of one diameter but of different length joined together by annular restrictions, means for circulating media upwardly through the tank, the upper one of said zones being adapted for containing a rising current of density media of lower velocity than the zone next below after such media having been charged into the top zone; a vertical draw-off column for each of said zones, each draw-off column of a smaller diameter than in the zone next above, an exterior connecting conduit for said draw-off columns and means adjacent the top of said tank for screening and removing the media and particles and returning them to the bottom of said vertical tank, and air lifts provided at the bottom of each of said exterior columns for removing media.

CHARLES B. HEBBARD.