N. C. CHRISTENSEN.

APPARATUS FOR THE COUNTERCURRENT WASHING OF FINELY DIVIDED SOLIDS.

APPLICATION FILED DEC. 13, 1920.

1,434,089. Patented Oct. 31, 1922.

3 SHEETS—SHEET 1.

Fig. I.

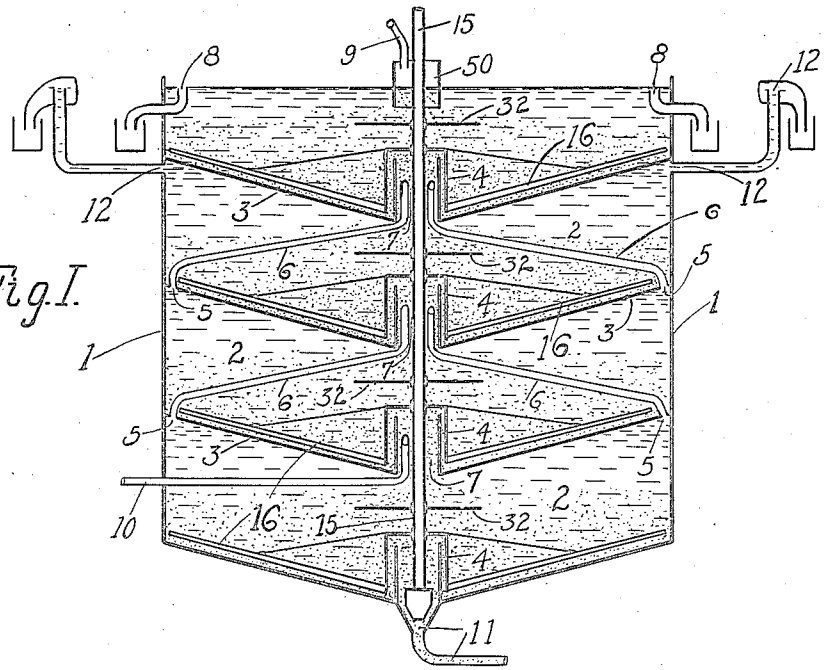
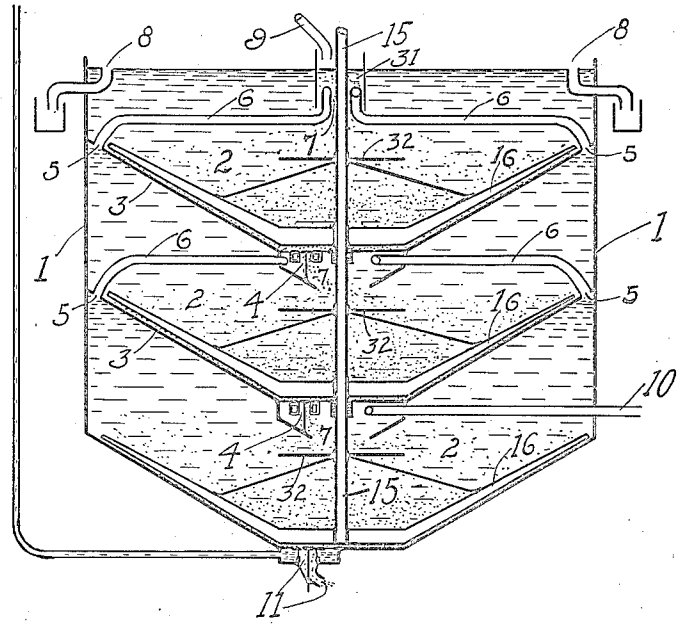


Fig. II.



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Fig. III.

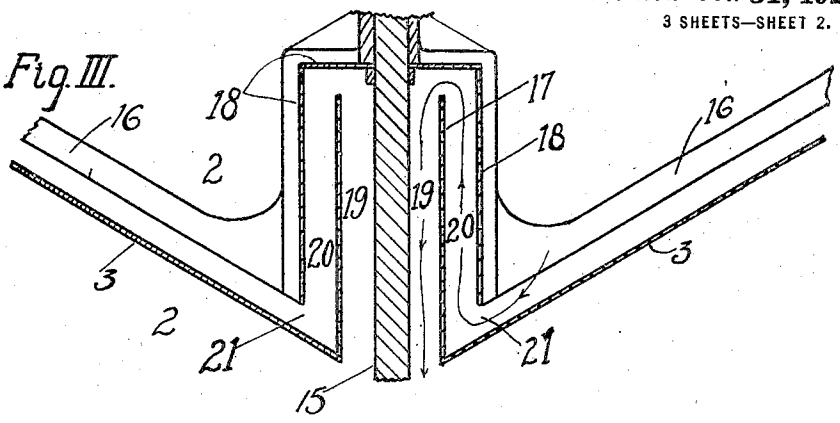


Fig. IV.

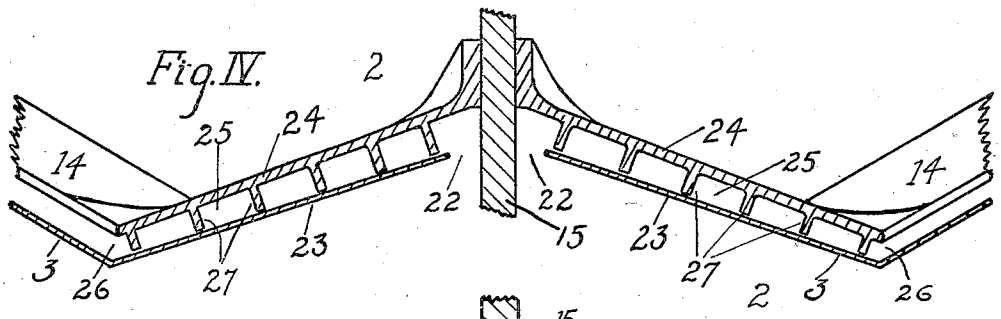
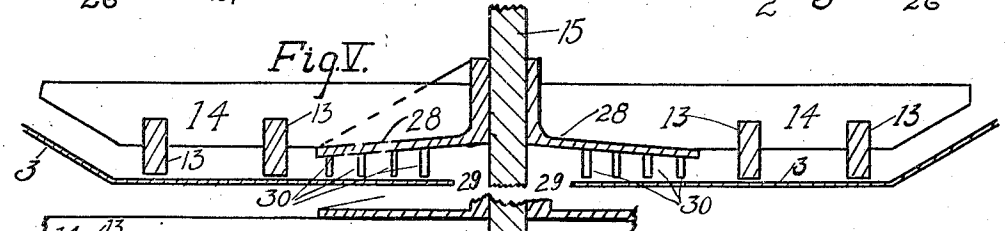


Fig. V.



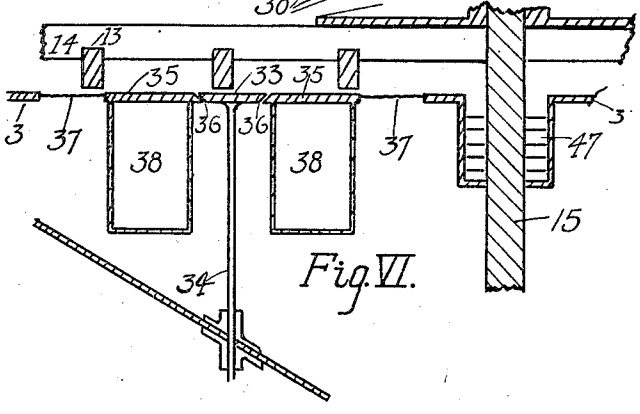


Fig. VI.

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3 SHEETS—SHEET 3.

Fig VII.

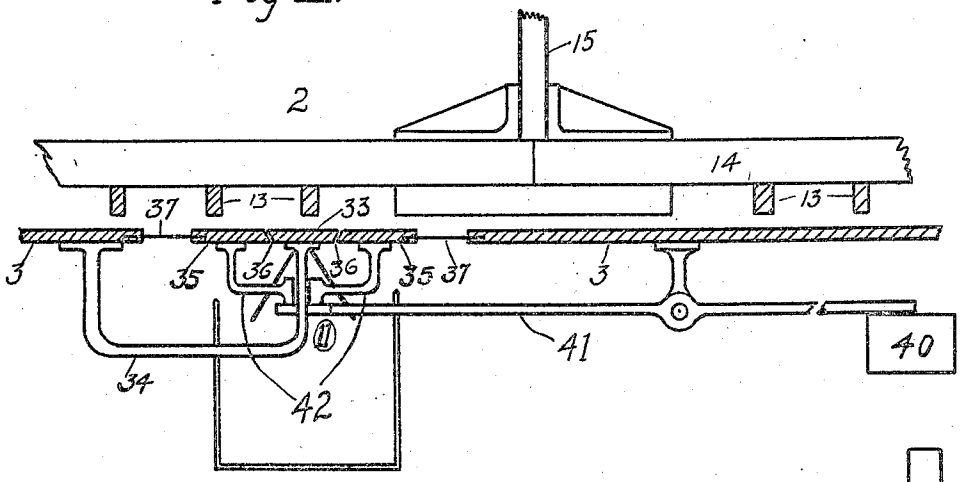
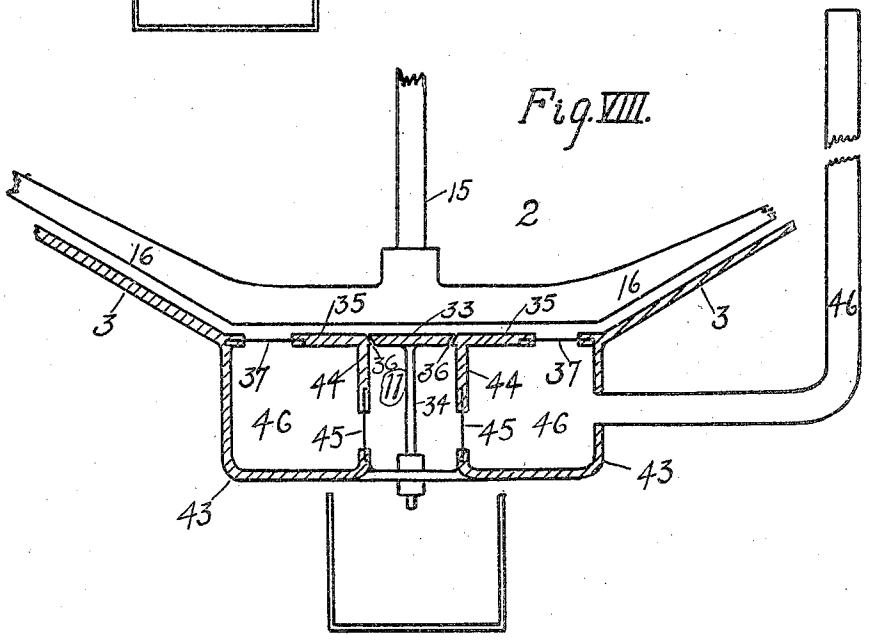


Fig. VIII.



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Patented Oct. 31, 1922. 1,434,089

UNITED STATES PATENT OFFICE.

NIELS C. CHRISTENSEN, OF SALT LAKE CITY, UTAH.

APPARATUS FOR THE COUNTERCURRENT WASHING OF FINELY-DIVIDED SOLIDS.

Application filed December 13, 1920. Serial No. 430,245.

To all whom it may concern:

Be it known that I, NIELS C. CHRISTENSEN, a citizen of the United States, residing at Salt Lake City, in the county of Salt Lake and State of Utah, have invented certain new and useful Improvements in Apparatus for the Countercurrent Washing of Finely-Divided Solids, of which the following is a specification.

This invention relates to apparatus for the continuous washing of finely divided solids with liquids to remove soluble material. The invention may be used for the washing of slimes (i. e. slowly settling material) or sands (i. e. granular relatively rapidly settling material) or a mixture of slimes and sands.

The object of my invention is to secure an efficient continuous countercurrent flow of solids and liquid in a single simple piece of apparatus of relatively small size, and thus secure a very considerable saving in the size and cost of apparatus, in the buildings and foundations and auxiliary apparatus required and in the cost of installation and operation as compared with the systems of counter current washing now in general use. My invention consists of a series of superimposed chambers down through which the solids continuously pass, and up through which the wash solutions pass, the chambers or compartments being so arranged that settled or thickened pulp (sands, slimes, or both) continuously enters each compartment from the one above and is mixed with clear solution continuously entering from the compartment beneath the solids thereafter being continuously allowed to settle out of this mixture, (or dilute pulp) giving thickened pulp and clear solution, and the thickened pulp being discharged into the compartment beneath and the clarified solution to the compartment above, thus securing a counter-current flow of solids and liquid through a series of successive mixing and separating (settling) operations, and thus separating the soluble material from the solids in the solution.

My apparatus consists in general as shown in Figs. I and II of an upright tank 1, preferably of cylindrical horizontal section, divided into a number of similar superimposed compartments (2) by the similar parallel separating surfaces (3) (which are preferably conical in shape with lowest point near the center of the tank) each of which surfaces (3) forms the floor of one compartment and the roof of the compartment beneath. At a suitable place in each of these separating surfaces (3), but preferably at the lowest point and at or near the center, if the preferred conical surface is used, is placed a suitable feeding and sealing device (4) for substantially continuously feeding the settled solids (or thickened pulp) from the compartment above through the separating surface (3) into the compartment beneath and at the same time preventing the flow of liquid from one compartment to another at this place. At suitable places near the periphery of each separating surface (3) (or at points as distant as possible from the feeders (4) if the conical bottoms are not used) holes (5) are cut through the surfaces and pipes (6) run from these openings to the mixing space (7) beneath the feeding device (4) to carry the clarified solution from the compartment beneath the surface and to mix this solution with the settled or thickened solids flowing through the seal (4) into the compartment above the surface. The uppermost compartment has a number of suitable overflow pipes (8) and an inflow pipe (9) spaced with regard to each other in such a manner that the clear solution may flow out without disturbance from the incoming pulp. The lowermost compartment has an inflow pipe (10) for bringing the wash water or wash solution into this compartment beneath the feeder admitting settled material into this compartment, and is arranged in such a manner as to mix the solution and pulp flowing into the compartment. The lowermost compartment also has an outlet (11) for discharging the settled or thickened pulp. This discharge device may be a suitable diaphragm pump or an automatic device as described later. If the wash solution is to be kept separate from the solution entering the uppermost compartment with the solids (which would be the case in most instances) no pipes (6) would be used to bring clear solution from the second compartment into the first, but the uppermost and second compartments would both be supplied with separate outflow pipes (8 and 12). The feeding devices (4) in each separating surface or deck (3) may differ somewhat with the different materials to be handled, but should furnish

a practically uniform feed of settled solids or thickened pulp from each upper compartment to the one beneath, and also form a seal so that no flow of solution alone may take place between compartments at this place, i. e., so that the only solution passing through the seal will be that carried between the sand particles or in the thickened slime. The separating surfaces (3) may be horizontal planes or may slope to a low point at the seals (4). If the surfaces (3) are flat or only slightly hoppered or coned, the sands and slimes are moved toward the seals and feeders (4) by suitable scrapers or plows (13) on the arms (14) which are attached to and slowly turned by the central shaft (15). If the surfaces (3) are more steeply hoppered or coned, so that the sands or slimes (or mixture) will flow by gravity toward the feeders (4), the flights or plows (13) are not used, but the stirring arms (16) are used to slowly stir the thickened or settled pulp so as to prevent packing and thus secure a pulp of uniform consistency which will give a uniform flow through the feeders (4). If a very steep cone or hopper (3) is used, or with sands alone, the stirring arms may be dispensed with in some cases.

The feeder and seal (4) may vary somewhat in design according to the feed which is to be handled. If slimes alone are to be handled, a seal of the form shown in Fig. III may be used. The seal consists of the stationary collar (17), which is an extension of the dividing surface (3), and the moving cap or cover (18). The collar (17) extends upward around the shaft (15) leaving the annular space (19) between it and the shaft. The height of this collar will be a little less than the desired height of thickened slime in the settling compartment, and is attached to the surface (3) at its lower end. The cap or cover (18) consists of an annular collar concentric with (17) and large enough so that there is an annular space (20) between the two collars. The cover (18) is open at the bottom but closed at the top by a plate by which it is attached to the shaft (15) with which it rotates. The lower edge of the cover (18) extends down within a short distance of the surface (3) leaving a space (21) between it and the deck (3). Attached to the inner surface of (18) (or the outer surface of 17, or both) are several projections (preferably helical spirals) projecting into the space (20) to prevent clogging or sticking of the slimes. When sufficient depth of thickened slime has accumulated in the compartment above the seal, the slime will flow through the openings (19) and (20) into the compartment beneath. The size and proportions of the seal will depend upon the volume of slime to be handled and the depth of settled slime to be carried in the compartments. The seal may be cylindrical as shown or may be conical if but a small amount of slime is to be stored.

If both sands and slimes are to be handled the feeder must be of such a character as to lift the sands to the height of the top of the stationary seal ring (such as 17) which is required to secure the desired storage of slimes in the settling compartments. The feeder would in this case take the form such as that shown in Fig. IV and consists of a truncated conical upward extension of the surface (3) around the shaft (15), with an annular space (22) between the top of the cone (23) and the shaft, and a concentric conical surface or cap (24) attached to the shaft (15) at its apex above (22) leaving the annular conical space (25) between the two conical surfaces. The lower edge of the movable cone (24) is a short distance above the deck (3) and thus leaves an annular opening (26) between it and the deck. Attached to the under surface of the cap cone (24) are a number of spirally arranged scrapers or plows (27) which scrape the sand and slime from the opening (26) up over the upper surface of the stationary cone (23) to the opening (22) where it is discharged into the compartment beneath. The size and proportions of the seal will depend on the amount of sands and slimes to be handled, and the depth of thickened slimes it is desired to hold in each compartment.

If sands alone are to be handled a seal similar to the one shown in Fig. IV may be used or preferably such a one as shown in Fig. V, which consists of a flat conical plate (28) attached to the revolving shaft (15) at the apex of the cone and with the lower edge of the cone a short distance above the flat portion of the deck (3) in which is the opening (29) through which the shaft (15) passes and through which the settled sands are fed from each upper compartment to the one beneath. Attached to the inner part of the cone are a number of rods (30) which stir the sands entering beneath the lower edge of the cone (28) and cause them to flow to the outlet opening (29). The wash solution pipes (6) are arranged, as shown in Figs. I and II, to deliver the clear solution near the discharge opening of the seals in the mixing space (7) beneath each seal so as to thoroughly mix the settled material flowing through the seal with the clear wash solution. Beneath each seal is placed a distributing plate (32) to divert the downward flow of incoming pulp laterally in such a way that the settled material beneath shall not be disturbed. This plate (32) may be attached to the shaft (15) and revolve with it or may be suspended from the deck or dividing surface (3) above and have a hole in it through which the shaft may pass. If desired scrapers may be arranged to remove

any settled material from this plate, though this will not be necessary in most cases.

For feeding the settled material between compartments an automatic valve may be used (instead of the feeders) if desired, said valve being arranged so that it automatically opens when the required depth of sand or slimes is reached and allows a flow of settled material to the compartment beneath and automatically closes if the level of slimes or sands sinks below the required level. This valve or automatic feeder is shown in Fig. VI. It consists of a stationary plate or plug (33) attached to the deck (3) by suitable arms (34) and a movable plate (35) (preferably circular) with a central hole (36) arranged to fit the plate or plug (33). The plate (35) is placed in the middle of a hole in the dividing surface (3) and the outside periphery of the plate is connected with the enclosing edge of the dividing surface (3) by a continuous flexible membrane (37) which prevents any flow of material between the edge of the movable plate (35) and the edge of the deck (3). The movable plate (35) is buoyed up by the annular hollow float (38) so that when the tank is filled with solution the plate is pressed up against the plate or plug (33), and thus closes the hole (36) in the plate (35). When a sufficient depth of sand or slime has accumulated above the plate (35) the plate (35) and buoy are forced down partially opening the hole (36) and allowing the settled slimes and sands to flow into the compartment beneath. The size of buoy and size of plate will depend upon the depth of slime (or sand) it is desired to accumulate in each settling compartment. If this type of valve is used the stirring shaft (15) should pass through a stuffing box (47) or sleeve attached to the deck (3), in order to prevent the flow of material from one compartment to another through the hole through which the shaft passes.

The automatic discharge of the settled material from the lowermost compartment may be accomplished by a valve similar to the one shown in Fig. VI placed in the bottom of the tank as shown in Figs. VII and VIII. In this case however, the buoy (38) may not be used but the pressure of the pulp and water in the tank on the plate (35) and membrane (37) is counterbalanced by the weight (40) which is connected with the plate (35) by the lever (41) and arms (42) or is counter balanced by a column of liquid as shown in Fig. VIII, the liquid being held beneath the plate in the space enclosed between the stationary pan (43) (attached to or an extension of the bottom of the tank), the movable plate (35) with the cylinder (44) attached beneath, and the two flexible membranes (37) and (45) connecting the movable part of the valve to the stationary part. Water under the required head is supplied to the annular space (47) thus enclosed, through the stand pipe (46). When sufficient sand or slime, or both, has accumulated to counterbalance the head of water in excess of that in the tank (or the excess weight supplied by the balance weight) (40) the plate (35) is forced down and the settled material flows out, until the pressure from the stand pipe or weight is sufficient to lift the plate (35) and close the valve.

The horizontal area of the compartments (2) should be sufficient for the settling area required to give clear solution overflow from the pipes (6) and the volume of the compartments (2) should be large enough to allow sufficient storage for the required accumulation of thickened slimes and also sufficient to give time for the flocculation of the slimes required before settling.

The general method of operation of my invention is described in the following: The first case described is that in which the feed to the apparatus consists of a relatively dilute pulp made of solids and pregnant solution and in which the pregnant solution which can be decanted is kept separate from the wash solution. The description is illustrated in Fig. I. The mixture of solids and pregnant solution is continuously fed into the apparatus through the feed pipe (9) into the cylinder (50) and flows down on the distributing plate (32) which distributes it laterally out into the upper settling chamber without disturbing the settled material beneath. The solids settle out into the lower part of the chamber and the clear pregnant solution overflows from the outflow pipes (8). The settled solids, thickened slimes, settled sands or mixture of both, carrying some of the pregnant solution mixed therewith, are continuously fed or caused to flow through the sealed feeder or valve (4) into the mixing space (7), beneath the valve, in the second chamber or compartment. The clear wash solution from the third compartment flows continuously through the solution pipes (6) into the space (7) and is mixed with the incoming settled solids and this diluted pulp is distributed laterally into the second compartment by means of the distributing plate (32). The solids settle out into the lower part of this compartment and the clear wash solution flows out through the outflow pipes (12). The settled solids from the second compartment are fed into the third compartment as previously described and mixed with clear solution from the fourth compartment and settled out and fed into the next lower compartment, and the clear solution flows into the next upper compartment. In this way the solids pass down through the successive compartments being

diluted in each with clear solution and settled out therefrom and finally discharged from the lowermost compartment through the pipe or valve (11). In the lowermost compartment the water (or solution) for washing is continuously supplied to the mixing chamber, under sufficient head or pressure, through the pipe (10) and mixed with incoming thickened or settled solids in the lowermost mixing space (7), the solids settle out and clear wash solution passes through the pipes (6) up into the mixing chamber next above and is mixed again with incoming thickened pulp and again clarified and passed on up to the next upper compartment and so on upward through the successive compartments and finally discharged from the second compartment or uppermost mixing and settling compartment, through the outflow pipes (12). The outlets of the overflow pipes (8) and (12) should preferably be all on the same level so that there shall be no tendency for leakage of solution from one to the other. The continuous inflow of wash water (under sufficient head) in the lowermost compartment causes a steady flow of wash solution upward through each successive compartment through the pipes (6) and a continuous discharge of wash solution through the outflow pipes (12), and the continuous feeding and settling of the solids causes a steady downward flow of solids through each successive compartment and in this way a continuous counter current of solids and solutions through a series of successive mixing and separating operations is secured and the soluble material washed away from the solids.

If no pregnant solution is to be separated from the inflowing solids the operation of the apparatus, as illustrated in Fig. II, is the same as described except that instead of the wash solution overflowing through pipes (12) in the second compartment, the pipes (6) carry the clear wash solution from this compartment up into the uppermost mixing box (31) where it is mixed with the inflowing solids from the inflow pipe (9) and distributed by the plate (32) and clarified by the settling out of the solids and discharged through the overflow pipes (8). This method of operation would be used in case thickened pulp or moist sands or dry solids were fed into the uppermost compartment.

From the foregoing it will be seen that my invention makes possible the continuous counter current washing of slimes and sands, or a mixture of both, in a series of mixing, or diluting, and settling operations, in a simple self contained automatic apparatus requiring a minimum of space, and requiring no outside auxiliary apparatus such as pumps, pipes, etc. which therefore brings about a very large saving in the cost of the apparatus and of foundations and buildings, and in cost of installation and operation, as compared with the apparatus now in use for counter current washing of slimes or sands. My invention is especially applicable to cases in which a relatively small amount of slimes, or small amount of slimes mixed with a large amount of sands, is to be continuously handled, owing to the compactness of the installation as compared with those now used for this purpose. The great advantage of the apparatus is especially evident in cases where both sands and slimes are to be handled since with my invention this may be done in a single machine instead of a number of separate machines for both sands and slimes as is the general practice at the present time.

The foregoing description of my invention is of a necessity very general and I do not therefore, desire to be limited entirely by the foregoing description as to the mechanical details or method of operation of my invention, since it will be apparent that many minor variations in construction and operation may be used in the practical application of the invention under the various conditions of operation.

Having described my invention, what I claim and desire to hold is:

1. In an apparatus for the continuous washing of finely divided solids to remove soluble material mixed therewith, comprising in combination, a vertically disposed tank; a series of inclined decks mounted therein and forming a series of superimposed compartments; discharge means for the separated material, located centrally of each deck, said means serving to maintain a predetermined depth of settled and washed material upon the deck; and means for causing an upflow of the wash fluid from the upper portion of each compartment into the one next above and into and through the settled material as it is discharged from the second above compartment.

2. In an apparatus of the character specified, the combination of a tank having a series of superimposed settling chambers formed therein; means for maintaining the settled material at a substantially fixed depth in each chamber and discharging the same from one chamber to that next below through a sealing opening; and means for causing an upflow of wash liquid from the upper part of each chamber into the settled material being discharged from the chamber second above.

3. In an apparatus for the continuous washing of finely divided solids to remove soluble material mixed therewith, comprising, in combination, a vertical container divided into a series of separate, similar, superimposed compartments, each compartment

of said series having a space therein arranged to act as a mixing space and so disposed that the solids and liquids entering said space will be continuously mixed therein and the solids discharged from said space into a settling space; means to afford a continuous outflow of clarified liquid from the settling space of the upper compartment; means for supplying said uppermost compartment with solids to be washed; means for continuously supplying wash liquid to the mixing space of the lowermost compartment; means for conducting the wash liquid successively into the mixing spaces of the superimposed compartments; means in each of said compartments, other than the lowermost, for continuously collecting the settled solids from the settling space thereof and passing said solids into the mixing space of the compartment next below and into contact with the upflowing wash liquid; and means in said lowermost compartment for continuously collecting the settled solids and discharging the same therefrom.

4. In an apparatus for the continuous washing of finely divided solids to remove soluble material mixed therewith, comprising in combination, a vertical container; a decanting compartment in the upper portion thereof; a series of separate, similar, superimposed compartmetns located beneath said decanting compartment; means extending from the decanting compartment to provide for a continuous outflow of clear solution; means located in said decanting compartment for continuously collecting the settled solids and discharging the same into a mixing space of the compartment next below, and each of said lowermost compartments being likewise provided with a mixing space; means for deflecting the solids from said mixing space in each compartment outwardly and away from the underlying settling space of the compartment; means for introducing wash liquid into the mixing space of the lowermost compartment; means for withdrawing the clarified liquid from the upper portion of each compartment, other than the decanting compartment, and discharging the same into the mixing space of the compartment next above; and means for discharging the solids from the lowermost compartment.

5. In an apparatus of the character specified, the combination of a tank having a series of superimposed settling chambers formed therein; means located at the bottom of each of said chambers for collecting the solid materials which will settle, and discharging the same into the compartment next below; means for introducing wash liquid into the lowermost compartment and in line with the solids discharged from the compartment next above, whereby such solids will be subjected to the direct action of a clear wash liquid; and a conduit extending from the upper part of each compartment, other than the uppermost, for discharging the relatively clear liquid which collects in the upper portion of said compartment, to the point of discharge of the solid material which passes from the compartment second above, whereby such solid material will be subjected to the washing action of a relatively clear liquid; and means for discharging the solid material from the lowermost compartment.

6. In an apparatus of the character specified, the combination of a tank; a decanting compartment formed in the upper portion thereof; means for permitting a continuous outflow of clear solution from said decanting compartment; a series of similar washing compartments arranged below the decanting compartment; means located in said decanting compartment, and in each of the other compartments, for collecting the solids settled in said compartments, and discharging the same into a mixing space of the next compartment below; means for feeding the material to be treated to the decanting compartment; means for admitting wash liquid to the mixing space of the lowermost compartment; means for permitting the outflow of the clarified liquid from the upper portion of each of the compartments, other than the decanting compartment, and discharging the same into the solid material as it passes from the compartment second above, whereby a continuous upward flow of the wash liquid will take place, and a continuous downward movement of the settled material will be effected, such settled material, as it passes from one compartment to the other, coming into direct and intimate contact with the wash liquid which passes upwardly through the apparatus.

7. In an apparatus for the continuous washing of finely divided solids to remove soluble material mixed therewith, the combination of a vertically disposed tank; a series of decks mounted therein and forming a plurality of superimposed compartments; a centrally disposed trapped discharge opening for the solid materials for each of said compartments; a shaft extending downwardly through said discharge openings; stirrers carried by said shaft and working adjacent the floor of each compartment; means for supplying wash water to the discharge opening entering into the lowermost compartment; pipes extending from the upper portion of each compartment, other than the uppermost, for discharging the clarified liquid from the upper portion of the compartment into the discharge opening of the compartment second above, and, consequently, into contact with the solid material which is passing therethrough; means for discharging the solid

material from the lowermost compartment; and means for withdrawing the liquid from the uppermost compartment.

8. In an apparatus for the continuous washing of finely divided solids to remove soluble material mixed therewith; the combination of a vertically disposed tank; a series of decks mounted therein and forming a plurality of superimposed compartments; a centrally disposed trapped discharge opening for the solid materials for each of said compartments; a shaft extending downwardly through said discharge openings; stirrers carried by said shaft and working adjacent the floor of each compartment; means for supplying wash water to the discharge opening entering into the lowermost compartment; pipes extending from the upper portion of each compartment, other than the uppermost, for discharging the clarified liquid from the upper portion of the compartment into the discharge opening of the compartment second above, and, consequently, into contact with the solid material which is passing therethrough; a deflector plate, one for each compartment, carried by the shaft, and located below the discharge opening; means for discharging the solid material from the lowermost compartment; and means for withdrawing the liquid from the uppermost compartment.

In testimony whereof I have signed my name to this specification.

NIELS C. CHRISTENSEN.