Dec. 6, 1966 C. C. LAVAL, JR 3,289,608

SEPARATING DEVICE

Filed April 23, 1965 5 Sheets-Sheet 1

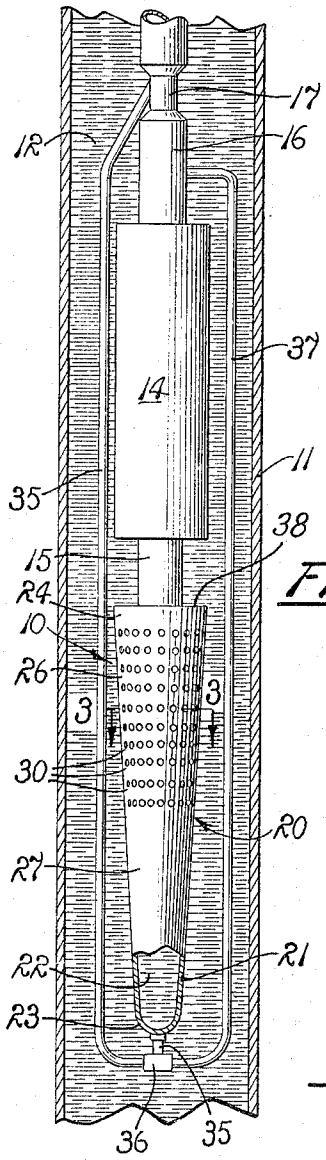


FIG. 1.

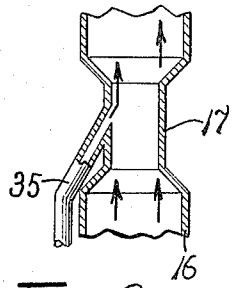


FIG. 2.

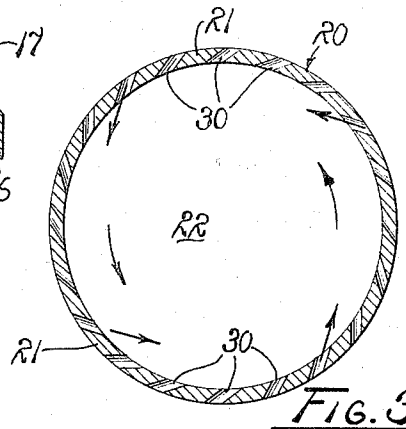


FIG. 3.

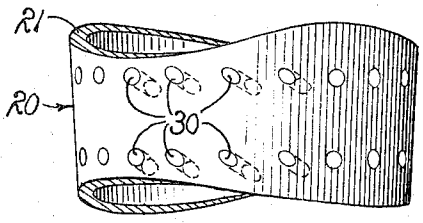


FIG. 4.

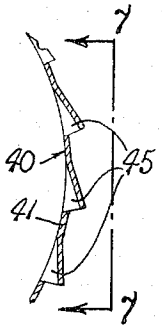


FIG. 6.

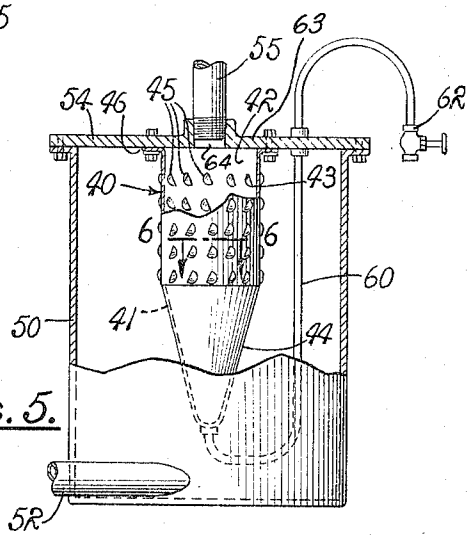


FIG. 5.

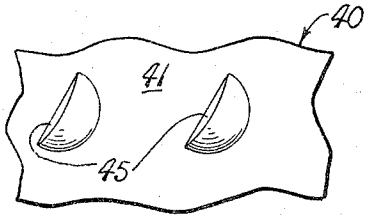


FIG. 7.

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Dec. 6, 1966 C. C. LAVAL, JR 3,289,608

SEPARATING DEVICE

Filed April 23, 1965 3 Sheets-Sheet 2

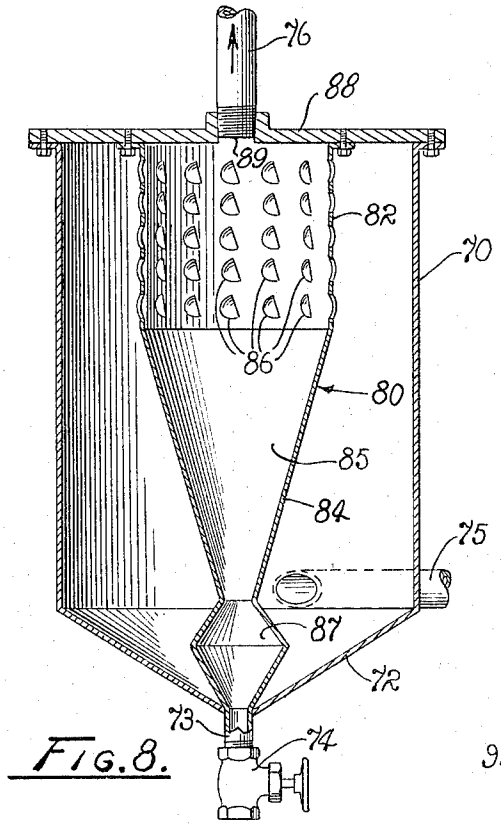


FIG. 8.

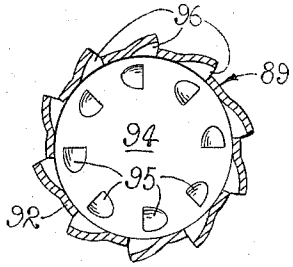


FIG. 10.

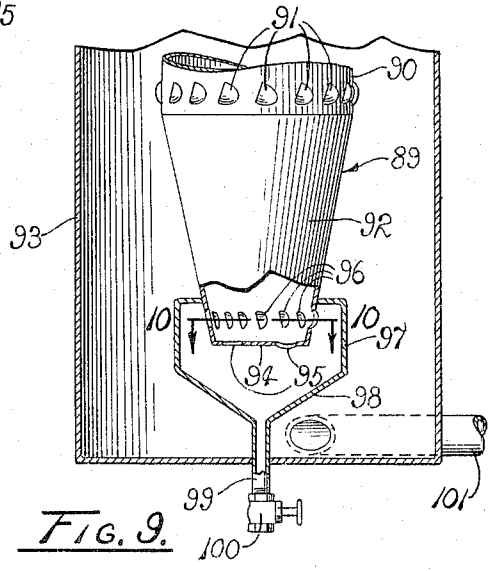


FIG. 9.

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Dec. 6, 1966 C. C. LAVAL, JR 3,289,608

SEPARATING DEVICE

Filed April 23, 1965 3 Sheets-Sheet 3

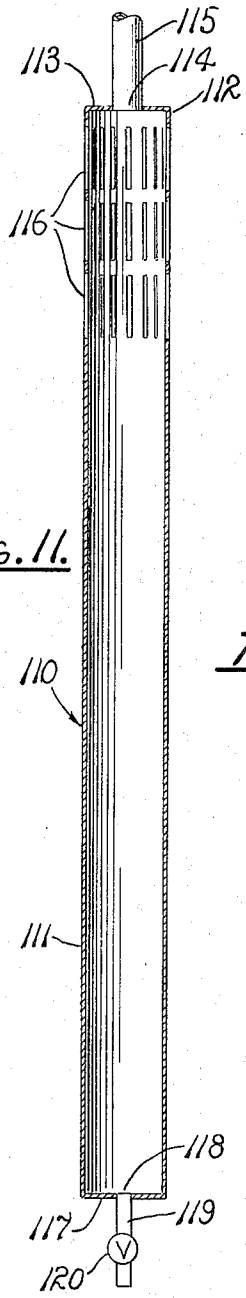


FIG. 11.

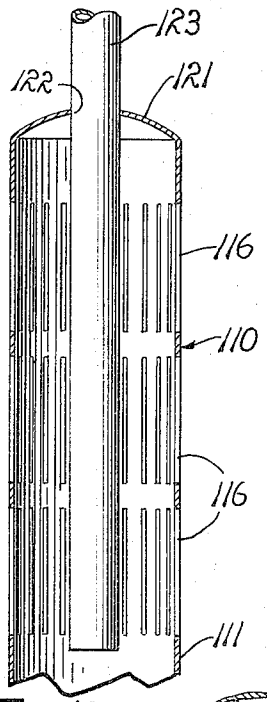


FIG. 12.

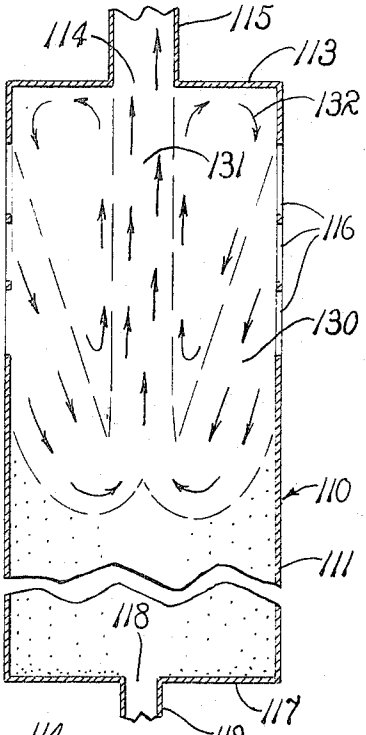


FIG. 14.

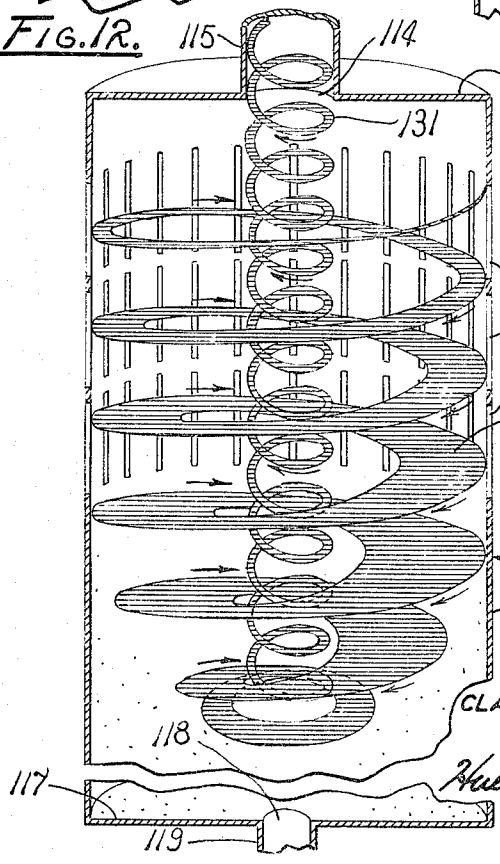


FIG. 13.

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United States Patent Office

3,289,608

Patented Dec. 6, 1966

3,289,608

SEPARATING DEVICE

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Filed Apr. 23, 1965, Ser. No. 451,697
2 Claims. (Cl. 103—220)

This application is a continuation-in-part of my copending application, Serial No. 272,734, filed April 12, 1963, entitled "Separating Device," and now abandoned. The present invention relates to a separating device for removing sand and other foreign particles from fluids in which they are carried and more particularly to such a device of the type generally referred to as a "sand trap" and which is suited for use within wells as well as exteriorly thereof.

The presence of sand, silt, clay and other foreign particles in fluid such as water and the like pumped from deep wells greatly accelerates pump wear. The pumps in such wells are frequently located several hundred feet below the surface of the ground and in some instances even several thousand feet. Such rapid wear requires that the pumps be elevated periodically to the ground surface for replacement of the worn parts. Pulling a pump from such depths is both tedious and expensive. Its frequent repetition because of excessive wear from sand can make a well too expensive to use.

Heretofore, there has been no effective device for removing sand from water deep in a well prior to its being drawn into a pump for discharge to the surface. Thus, there has been no effective device for protecting pumps from sand and other abrading materials in such water. Further, it has been generally accepted that it would be of no use to develop such a device because there was no place at the bottom of such wells to dispose of such sand and abrading material. As will subsequently become apparent, the present invention in highly successful in removing extraneous particles of material from rapidly moving fluid at pump intakes, even when deep in wells, at pump outlets, and in virtually all operational environments.

Further, the presence of such foreign particles also causes considerable inconvenience and annoyance in municipal, industrial, and agricultural water supply systems where the water is employed for washing, cooking, drinking, irrigating, sanitation, and other purposes. Water having large quantities of sand and the like accelerates wear and causes clogging of meters, sprinklers and other water dispensing fixtures at the service ends of the systems. This problem is particularly onerous in agricultural sprinkler installations having water fogging or spraying nozzle heads. Such nozzles frequently have small orifices which are easily clogged by even the most minute foreign particles in the water.

Therefore, it is an object of the present invention to provide a separating device for improved separation and removal of foreign particles from carrying fluids, such as sand from water pumped from wells.

Another object is to permit the removal of sand and other abrading materials from the intakes of pumps deep in wells and in other operational environments of difficult access and effectively to dispose of such materials.

Another object is to provide an improved separating device which swirls the flow of water therethrough for centrifugal separation of foreign particles from the water.

Another object is to provide such a centrifugal separating device which may be disposed on the inlet side of a

well pump to minimize the flow of such foreign particles therethrough to lengthen the period between servicing operations required by the pump.

Another object is to provide an improved separating device which may be used on the outlet side of a well pump to remove foreign particles from the water being pumped thereby prior to entry of such water into an associated distributing system.

Another object is to provide an improved separating device wherein a multiplicity of orifices are arranged circumferentially of the separating chamber throughout an appreciable length thereof which progressively boost swirling movement of the fluid and foreign particles.

Another object is to provide such a separating device which has a quiescent particle collecting chamber for separately removing such particles remotely of the fluid outlet therefrom.

Another object is to provide such a separating device having a by-pass system for directing collected particles around a pump for exhaust by flow into the pump discharge without passing through the pump.

Other objects and advantages of the present invention will subsequently become more clearly apparent upon reference to the following description in the specification.

Preliminary to specific structural reference to the illustrative embodiments of the present invention, it is helpful to refer to certain broad aspects of the invention which have enabled the attainment of the foregoing and other objects. The sand trap of the present invention utilizes the well known centrifuging principle attained in a body of rapidly swirling fluid but utilizes the principle in a novel manner which in commercial practice is revolutionizing the practical art. For example, sand traps embodying the principles of the present invention have been used in following relation to the best sand traps available on the market costing from three to ten times as much and have effectively removed sand in substantial quantities from the purportedly clean fluid discharged therefrom. In actual tests, commercial model sand traps of the present invention have removed from 90 to 95% of sand having a mesh of 200 per square inch or larger from a domestic water supply having a capacity of approximately one thousand gallons per minute. To achieve such capacity, such devices have been less than thirteen inches in diameter as compared with several feet in diameter for the best available conventional sand traps for the purpose. As will subsequently become more fully apparent, the devices of the present invention attain their improved results by:

(1) Inducing fluid into a chamber, having predetermined upper and lower ends and a wall concentric to a longitudinal axis, through a series of inlets substantially equally spaced about the axis and disposed tangentially to the axis in a common direction thereabout.

(2) Providing an annular barrier at the upper end of the chamber so that fluid entering the chamber is initially forced to pass downwardly therein.

(3) Utilizing inlets through an appreciable length of the upper end of the chamber so that fluid entering through the inlets swirls downwardly in the chamber and the cumulative effect of the fluid entering through the successive inlets forms a progressively thicker influx layer of accelerated velocity downwardly along the wall of the chamber to centrifuge heavy particles such as sand therefrom.

(4) Removing fluid from the chamber axially upwardly through the barrier so as to cause the downwardly swirling influx layer to have a sudden reversal of direction adjacent to the lowermost inlets to pass upwardly in a vortex of further reduced diameter internally of the influx layer in a spiral of the same direction of retation. As the fluid reverses its downward movement in the influx layer to the upward movement in the vortex, sand and other heavy impurities are thrown downwardly for further gravitational descent and accumulation in the chamber. As the fluid moves upwardly in the vortex, the increased centrifugal forces incident to the decreased diameter of the rotation cause remaining sand and the like to be thrown outwardly into the influx layer. Further, the upwardly moving vortex, acting against gravity, is less capable of transporting sand and heavy particles.

(5) Returning the peripheral portions of the upwardly moving vortex of discharging fluid by engagement with the annular barrier for return downwardly in said influx layer for further centifuging.

(6) Providing a quiescent zone in downwardly spaced relation to the position at which the influx layer turns upwardly into the vortex where sand and other heavy impurities may accumulate and/or be drained axially downwardly from the chamber.

The British patent to Lott No. 709,606 of May 26, 1954, the United States patents to Bretney No. 453,105 of May 26, 1891, and to Hill No. 2,539,019 of January 23, 1951 typify prior art sand traps which use a centrifuging system. However, the devices of these patents swirl fluids by a single tangential entry which is found to cause turbulence and to interfere with the attainment of maximum rotation and centrifuging.

The United States patent to Donaldson No. 1,286,250 of December 3, 1918; Schutz No. 1,539,435 of May 26, 1925; Work No. 2,790,554 of April 30, 1957; and Porter No. 2,822,157 of February 4, 1958, typify sand traps which utilize a series of inlets to impart a swirling action to fluid. However, the Donaldson device endeavors to obtain its swirling action by means of a series of inlets disposed in a common plane and thus is unable to achieve the downward acceleration of rotation during downward movement attained by the successive impulses to which the influx layers of the present invention are subjected. In fact, Donaldson emphasizes that he reduces the velocity of the entering air, in direct contradiction to the present invention. The Schutz device provides a series of inlets but fails to attain the downward cumulative increase in thickness of the influx layer because of the tangential discharge H at the bottom of the device. It does not provide the significant discharge effect of the applicant's reversing of the downwardly moving influx layer upwardly into the vortex and endeavors to remove the sand or other heavy particles tangentially rather than by relatively quiescent accumulation.

Somewhat similarly the Work and Porter patents have a series of inlets of appreciable longitudinal extent but do not attain the results of the reversal of the downwardly moving influx layer into the upwardly moving vortex, the downwardly cumulative increase in thickness of the influx layer, and the return of the outer peripheral portions of the vortex into the influx layer for re-cleaning but both involve a reversal of the direction of rotation during passage of fluid radially inwardly through the devices. Thus, Work and Porter strive to interrupt centrifuging action so as to decrease fluid velocity for gravitational sand deposit. The devices of the present invention increase the swirling velocity to increase the centrifuging effect and augment this result by decreasing the diameter of the circular path. This is done by causing an influx layer of fluid to swirl downwardly while receiving successive accelerating jets of influx fluid which also supplements the influx layer to form a conical body of downwardly decreasing internal diameter and thence causing the fluid to return upwardly in a vortex of the same direction of rotation within said influx layer and thus of further reduced diameter.

The Bretney, Hill, Donaldson, Work and Porter devices impede the swirling action of fluid passing through them to permit gravitational settling as contrasted with the devices of the present invention which progressively accelerate the swirling action and reduce the diameter thereof to increase the centrifuging effect in the discharge of sand and the like outwardly for subsequent gravitational descent in a quiescent area.

In the drawings:

FIG. 1 is a side elevation of a separating device of the present invention associated with the inlet side of a pump disposed within a well casing and having a bypass extended around the pump.

FIG. 2 is a somewhat enlarged sectional view of the bypass at the outlet side of the pump.

FIG. 3 is a somewhat enlarged horizontal section through the inlet portion of the separating device, taken on line **3—3** of FIG. 1.

FIG. 4 is a somewhat enlarged fragmentary elevation of the separating device showing a multiplicity of inlet orifices into the inlet portion.

FIG. 5 is a side elevation of a second form of separating device of the present invention, with a portion of a side wall thereof removed for illustrative convenience, shown adapted for above ground installations and having louvered openings in the inlet portion of the separator.

FIG. 6 is a somewhat enlarged fragmentary horizontal section through the separating device of the second form taken on line **6—6** of FIG. 5.

FIG. 7 is a somewhat enlarged fragmentary side elevation of the separating device looking in the direction of the arrows on line **7—7** of FIG. 6 showing the louvered openings of the second form of the invention.

FIG. 8 is a vertical section of a third form of the separating device of the present invention providing a particle collecting and exhaust chamber.

FIG. 9 is a fourth form of the present invention shown partially in vertical section and partially in side elevation having a modified particle collecting chamber.

FIG. 10 is a somewhat enlarged horizontal section through the separator of FIG. 9, taken on line **10—10** of FIG. 9.

FIG. 11 is a vertical section of a fifth form of the present invention.

FIG. 12 is a modified version of the form of the invention shown in FIG. 11 illustrated in fragmentary vertical section.

FIG. 13 is a schematic flow diagram of the form of the invention shown in FIG. 11 intended to represent three dimensional fluid movement.

FIG. 14 is a schematic flow diagram similar to that of FIG. 13 but showing the flow pattern in vertical section.

First form

Referring more particularly to the drawings, a separating device of the present invention is indicated generally at **10** and in FIG. 1 disposed within a deep well casing **11** in submerged relation to a volume of fluid **12**, such as well water containing sand and other abrading material. A fluid pump **14** is disposed within the casing and has an inlet conduit **15**, commonly referred to as a suction pipe, and an opposite outlet conduit **16**. The suction pipe is adapted to support the separating device **10** in depending relation therefrom and the outlet conduit is adapted to be connected to a suitable fluid distributing system, not shown, above the ground. The outlet conduit has a venturi section **17** of reduced diameter disposed in closely spaced relation to the pump to provide a high velocity low pressure area therein for a purpose soon to be described.

The separating device **10** provides an elongated tubular frusto-conical chamber **20** formed of a continuous wall **21** of preferably non-corrosive material which circum-

scribes a separating compartment **22**. The separator includes a constricted lower end **23** and an opposite relatively large diameter upper fluid outlet end **24**. The outlet end is rigidly connected to the inlet conduit **15** of the pump to communicate the pump with the separating compartment **22** within the chamber. The separator also provides a fluid inlet section **26** adjacent to the outlet end **24** and a separating section **27** adjacent to the constricted end **23**. The fluid inlet section has a plurality of circumferentially spaced rows of orifices or inlets **30** longitudinally thereof. As best shown in FIGS. 3 and 4, the orifices are directed substantially tangentially inwardly in a common direction circumferentially of the separator through the wall **21** and are obliquely angularly directed toward the constricted end **23**. The orifices thereby provide a multiplicity of individual fluid inlet paths for fluid passing into the compartment **22** of the chamber and are substantially equally spaced about the chamber.

A particle outlet conduit **35** is connected at one end to the constricted end of the chamber and at its opposite end to the venturi **17** of the outlet conduit **16** of the pump **14**. The particle outlet conduit also provides a venturi section **36** disposed closely adjacent to the constricted end of the separator. The venturi section **36** is connected to the outlet conduit **16** of the pump by way of an elongated high pressure conduit **37**.

The upper end **24** of the chamber **20** provides a flat annular fluid barrier **38** concentric to the axis of the chamber and having an outlet opening, not shown, concentrically thereof to which the suction pipe **15** is connected.

Second form

A second form of the separating device **10** is shown in FIGS. 5, 6 and 7 for removing foreign particles from the fluid at the outlet end of a pump prior to its delivery to the distributing portion of the system. As best shown in FIG. 5, the separating device provides an elongated tubular chamber **40** similar to the chamber **20** of the first form and conveniently formed of a relatively thin lightweight non-corrosive sheet material providing a continuous wall **41** to define a separating compartment **42**. The wall is concentric to an erect axis, not shown. The chamber includes a fluid inlet section **43** and an opposite constricted separating section **44**. The inlet section provides a plurality of circumferentially spaced rows of louvered openings or inlets **45** formed therein by stamping or the like. As in the first form, the louvered openings **45** provide a multiplicity of individual fluid paths or inlets through the wall **41** in a common direction circumferentially of the wall and preferably obliquely angularly directed toward the constricted separating end thereof. The inlets are substantially equally spaced about the chamber. The wall **41** further provides an end flange **46** for mounting the separator concentrically within a fluid supply tank **50**. The tank is adapted for above ground or other installation and provides a relatively large diameter inlet conduit **52** disposed tangentially of the tank in the same circumferential direction of the tank as the openings **45** to provide cooperative swirling effect. A top cover **54** is secured in fluid sealing relation to the tank and provides an outlet conduit **55** which communicates with the separating compartment **42** of the separator. A particle outlet conduit **60** is connected to the constricted end **43** of the separator and is outwardly extended therefrom through the cover **54** and terminates in a manually controllable drainage valve **62**.

As best shown in FIG. 5, the upper end of the chamber **40** is closed with a flat annular fluid barrier **63** concentric to the axis of the chamber and having an outlet **64** coaxially thereof into which the conduit **55** is screw threadably connected.

Third form

A third form of the separating device is shown in FIG. 8 which is adapted to be received in a fluid supply tank **70**, somewhat similar to the supply tank **50** utilized in the second form of the invention. The tank **70** provides a substantially conical bottom wall **72** which has a particle exhaust conduit **73** and blow-off valve **74** connected thereto. The tank **70** also includes a tangentially connected inlet conduit **75** and an axially extended outlet conduit **76**.

The third form of separating device provides an elongated tubular chamber **80** having a fluid inlet section **82** and an opposite constricted separating section **84** circumscribing a separating compartment **85** and concentric to a longitudinal axis. The inlet section, as in the second form, provides a multiplicity of louvered openings or inlets **86** for inlet purposes. The constricted end, however, has a dual frusto-conical particle collecting container **87** outwardly extended from the separating section to provide communication of the separating compartment **85** of the separator with the exhaust conduit **73** of the tank.

The upper end of the chamber **80** is closed by a flat annular barrier **88** providing a concentric outlet opening **89** into which the outlet conduit **76** is screw threadably connected.

Fourth form

A fourth form of the separating device of the present invention is shown in FIGS. 9 and 10. This form provides a chamber **89** which has a fluid inlet section, fragmentarily indicated at **90**, providing louvered openings or inlets **91** identical to the inlet sections **43** and **82** of the second and third forms of the invention and a frusto-conical separating section **92**. The chamber **89** is disposed concentrically within a tank **93** identical to the tank **50** of the second form. The separating section **92** of the separator includes a substantially flat end wall **94** which, as best shown in FIG. 10, has a plurality of circumferentially arranged louvered outlet openings **95** therethrough. An additional set of louvered outlet openings **96** is circumferentially arranged through the side wall of the separating section closely adjacent to the end wall **94**. The openings **95** and **96** are disposed in the opposite circumferential direction about the separating section **92** as the openings **91** are disposed about the chamber **89** effectively to receive sand and other extraneous material. The louvered openings **96** and the end wall **94** of the separator are enclosed within the tank by a circumscribing collecting container **97**. The collecting container provides an opposite constricted wall **98** which is connected to an exhaust conduit **99** extended outwardly of the supply tank **93** which is controlled as in the other forms by a drain valve **100**. An inlet conduit **101**, as in the other forms, is tangentially connected to the tank **93**.

Fifth form

A fifth form of the present invention is shown in FIG. 11 and is schematically illustrated in FIGS. 12 and 13. It provides a cylindrical chamber **110** having a side wall **111** which is concentric to a vertical axis, not shown. The chamber has an upper end **112** closed by an annular flat fluid barrier **113** having a concentric outlet **114** axially disposed from the chamber and into which a discharge conduit **115** is connected. A series of slots **116** are cut through the wall **111** longitudinally of the chamber and in substantially equally spaced relation circumferentially thereof. As are the inlets **30**, the slots are cut through the wall in planes tangential to a circle concentric to the axis of the chamber. The lower end of the chamber **110** is closed by a wall **117** and provides an axial drain opening **118** therein to which a drain pipe **119** may be connected having a valve **120** for selective sand discharge.

If desired, and as shown in FIG. 12, the upper end of the chamber may be closed by a dome-shaped annular barrier **121** having an outlet **122** concentric thereof into which a discharge conduit **123** is extended in fluid tight engagement. It will be noted that the flat annular barriers **38**,

63 and 88 block upward flow of fluid from the inlets 30, 45 and 86 directly to the outlets 15, 64 and 89; however, it has been found that a dome-shaped barrier 121 is not a sufficient impediment to such direct flow of fluid. Thus, when such an inefficient barrier is utilized, the conduit 123 should be extended into the chambers to serve as an auxiliary barrier, preferably to a position coincident with the lower limits of the inlets, as shown in FIG. 12.

Operation

The operation of the described embodiments of the subject invention is believed to be clearly apparent and is briefly summarized at this point. With the pump 14 and the chamber 20 disposed within the well casing 11, the water 12 therein is forced through the inlet orifices 30 under a hydrostatic head of pressure depending upon the depth of submersion of the chamber in the well. The resultant flow of water through the orifices is enhanced by the relatively low pressure within the separating compartment 22 formed by operation of the pump in drawing water through the inlet conduit 15. The fluid swirls within the chamber in a direction indicated by the arrows in FIG. 3 downwardly toward the constricted end 23 of the separator. Fluid entering the orifices adjacent to the outlet end 24 of the chamber is thereby given a boost by succeeding circumferentially and downwardly spaced orifices to increase the velocity of such swirling action. Thus, the entering fluid forms an influx layer of downwardly cumulative thickness and accelerating velocity. During such swirling movement of the fluid, the foreign particles borne by the fluid having a higher specific gravity are thrown outwardly by centrifugal force against the wall 21 of the chamber in a centrifuging effect. The particles then move downwardly along the wall partially by gravity and also by the movement of swirling fluid toward the constricted end 23 of the separator where the particles are collected. Near the lower limits of the inlets 30, the swirling fluid is diverted upwardly in the form of a vortex of the same direction of rotation concentrically of the influx layer and into the inlet conduit 15 of the pump. As will be apparent, sand and other extraneous particles are thrown outwardly against the casing as the water moves downwardly. The sudden change of downward movement of the downwardly swirling influx layer to upward movement in the vortex is found to be highly effective in discharging sand and particles of other heavy material downwardly in the chamber. Any such extraneous heavy particles that move upwardly in the central vortex are likewise thrown outwardly into the downwardly swirling outer influx layer of water.

Fluid entering the inlet conduit 15 of the pump is exhausted therefrom through the outlet conduit 16 and through the venturi 17 therein. With passage of the fluid through the venturi, its velocity is increased and its pressure correspondingly decreased to lower the pressure in the particle outlet conduit 35. At the same time, water under pressure is forced into the upper end of the conduit 37 causing high velocity of water passage through the conduits 35 and 37 and the venturi 36. As a result, the water pressure in the venturi is substantially reduced. Being connected to the lower end of the separator, the venturi draws water and accumulated sand and other particles from the chamber at their zone in the chamber of greatest concentration. Such water and extraneous material passes through the conduit 35 about the pump 14 and is returned to the water stream pumped out of the outlet conduit. The connection of the venturi to the chamber 20 is of such capacity as to accommodate the flow of water and extraneous material therethrough but is constricted sufficiently that the extent of water flow is not appreciably relatively greater than that required to carry the extraneous material away and is not sufficient to cause a disturbance in the quiescent body of water in the lower end of the chamber. For example, in a unit in which the separator is eight feet long, has a maximum diameter of fourteen inches, and the inlet conduit is of a diameter of ten inches, the passage between the separator and the venturi is approximately one inch in diameter. In another separator which is three feet in length, the maximum diameter is eight inches, the inlet conduit is two and one-half inches in diameter and the passage between the separator and the venturi is one-half an inch in diameter. As a result, substantially all of the foreign particles such as sand and the like present in the water 12 within the well casing 11 is separated from such water prior to entry into the pump 14. The separated particles are then bypassed around the pump and reintroduced into the outlet conduit so that the particles are removed from the well along with the fluid being pumped therefrom without being physically transported through the pump itself. Such bypassing of the particles is accomplished automatically by the venturi and bypass conduit without additional pumping devices externally of the well. However, it is readily apparent that if desired a separate jet pump or the like, not shown, could be connected to the particle outlet conduit 35 in place of the venturi 17 in the outlet conduit of the pump to maintain separation of the fluid and the particles.

The operation of the separator of the second form of the present invention shown in FIGS. 5, 6 and 7 is substantially identical to the operation of the first form but is specifically intended for above ground installation. The fluid 12 is introduced into the tank 50 by way of the inlet conduit 52 which swirls such fluid in a direction corresponding to the entry angle of the louvered openings 45. Such a separator may be used in conjunction with the pump bypass and separating device of FIG. 1 wherein the inlet conduit 52 to the above ground tank 50 is connected to the outlet conduit 16 of the well pump 14. In this way, the foreign particles in the fluid 12 within the well are first separated, bypassed around the pump and subsequently separated in the chamber 40 from the fluid exhausted to the outlet conduit 55 of the tank 50 to the distributing portion of the system. The louvered inlets 45 of the chamber 40, as the inlets 30 of the first form, provide a multiplicity of co-directional fluid paths inwardly of the chamber angularly directed toward the separating section 43 of the separator centrifugally to separate the foreign particles and to divert the fluid back through the outlet conduit 55 of the tank. In this form of the invention, the heavier foreign particles accumulate in the constricted end of the chamber which is quiescent and are periodically drained outwardly therefrom through the particle outlet conduit 60 by opening the valve 62.

The third form of the separating device of the present invention as shown in FIG. 8 provides a chamber 80 which, in operation, is nearly identical to the operation of the preceding forms. Fluid entering the inlet conduit 75 of the tank 70 swirls within the tank in a downwardly accelerated influx layer in a predetermined direction of rotation corresponding to the tangential entry angle of the inlets 86. As before, the foreign particles are centrifugally separated during the rapidly swirling of fluid within the chamber with the fluid being exhausted by way of a vortex formed by such swirling fluid upwardly from the chamber through the outlet conduit 76. The separated foreign particles gravitate into the collecting chamber 86 for accumulation and periodic removal through the valve 74.

The fourth form of the separating device, as shown in FIGS. 9 and 10, provides a less constricted separating section 92 for the chamber 89 and encloses the end wall 94 within the sealed collecting container 97. As the fluid and heavy particles are centrifuged and thrown outwardly, the gravitate toward the constricted end of the separator, the louvered openings 95 and 96 in the side walls and end wall of the separator, which open in the direction of huch swirling movement, exhaust the foreign particles therethrough into the collecting

container **97**. The main body of swirling fluid within the container is diverted by the end wall **94** for return movement in the form of a vortex concentrically within the separator toward the outlet conduit, not shown, of the tank **93**. The foreign particles accumulated in the collecting container **97** are, as in the second and third forms, periodically removed through the valve **100**.

In the fifth form of the invention, shown in FIGS. 11 through 14, fluid enters through the inlet slots **116** from immersion of the chamber **110** in a well or from any other suitable source. Of course, a proper pressure differential must be established between the inlets and the outlet **114** to insure vigorous jet action through each inlet. The fluid fills the chamber and immediately after passing through the inlets forms a swirling influx layer against the wall **111** which progressively increases in thickness and velocity as it moves downwardly past the successive inlets. Such influx layer is shown at **130** in FIGS. 13 and 14. When the influx layer reaches a position somewhat below the inlets **116**, it reverses its downward movement while maintaining the same direction of rotation and swirls upwardly in a vortex **131**. Precisely the same effect is achieved in the earlier forms of the invention and, in fact, is even enhanced in a chamber having downwardly conically constricted walls. When the vortex reaches the opening **114**, peripheral portions thereof strike the barrier **113** and are deflected at **132** back to the influx layer **130** while the central and cleanest portion of the vortex passes up the conduit **115**.

It is significant that in all forms of the present invention, the series of inlets, whether they be in the form of bores **30**, louvers **45**, **86** or **91**, or slots **116** extend downwardly from their respective barriers an appreciable extent so as to provide the progressive thickening and acceleration of the influx layer **130**. The extent of the series of inlets longitudinally of the chamber should in all instances be less than one-half of the total length of their chambers and in many instances is preferably approximately 20% of such lengths. The chambers from the lower limits of the series of inlets to the lower ends thereof are imperforate to provide a quiescent settling area for sand and the like which is centrifuged outwardly from the influx layer **130**, which is thrown downwardly by the upward movement of the influx layer into the vortex **131**, which is centrifuged from the vortex and which is gravitationally deposited in the chamber.

It will be noted that the schematic diagrams of FIGS. 13 and 14 have been distorted by substantially increasing the representational diameter of the chamber **110** in relation to its length for illustrative convenience. In FIG. 13 effort is made to represent the three dimensional flow of fluid in the chamber. As fluid enters the inlets **116** it successively augments and accelerates the downwardly moving influx layer **130**. This is illustrated as a successively widening helical ribbon but it will be understood that the influx layer externally conforms to the wall **111** and internally is conical. This is illustrated at **130** in FIG. 14. From the lower end of the influx layer, the fluid ascends in a vortex having the same direction of rotation as the influx layer and passing upwardly concentrically thereof at **131**.

In each of the illustrative forms of the invention, it is desired to impart the highest velocity of swirling movement to the water commensurate with maximum fluid flow through the device. The swirling action in the chambers **20**, **40**, **80**, **89** and **110** is induced by the successive jet action of the inlets **30**, **45**, **86**, **91** and **116**, respectively. It is found that the jetting effect is substantially improved if the aggregate areas of said inlets is somewhat less than the areas of the outlets **15**, **64**, **89** and **114**. Although not critical, the total area of the inlets is preferably from 60% to 100% of the smallest cross-sectional area of the fluid supply conduit to, or fluid discharge conduit from, the separator. Further, it is necessary to have a sufficiently large volume of fluid flow through the chambers to cause the downward movement of the influx layers and subsequent return vortices. If insufficient volume or pressure differential is involved to cause the inlets to provide high velocity influx action, the fluid simply drifts from the inlets to the outlets without the described action.

Further, although the chambers **20**, **40**, **80** and **89** are illustrated as having a frusto-conical portion, and such form is somewhat preferred because of operational characteristics, it is not essential to proper operation of the device. The chamber may be cylindrical, as shown at **110**, a more economical form to produce, or may even distend in the direction of particle movement to discharge. However, the chamber must have a circumscribing wall which is a surface of revolution to obtain most effective centrifuging effect.

In view of the foregoing, it is readily apparent that the separating device of the present invention provides improved separation and removal of the foreign particles carried in rapidly moving fluid, such as water pumped from wells. As shown in FIG. 1, the separator and bypass arrangement insures substantially complete removal of such foreign particles from the fluid in the well and accomplishes such removal without physically transporting these foreign particles through the pump. Furthermore, the separator of the present invention is readily adapted to above ground installation for removing the foreign particles from the fluid which particles may be periodically or continuously removed from the device remotely of the exhaust flow of clean fluid therefrom.

Although the invention has been herein shown and described in what is conceived to be the most practical and preferred embodiments, it is recognized that departures may be made therefrom within the scope of the invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices and apparatus.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In combination with a pump adapted for location in a well in water having particles of sand or the like borne thereby and providing a downwardly extended intake conduit and an upwardly extended discharge conduit; a venturi located in the discharge conduit; a device for separating sand and the like from the water of the well having a fluid outlet connected to the intake conduit of the pump, a side wall concentric to a predetermined axis immersed in water in the well, and a lower end, said side wall having a multiplicity of inlets disposed tangentially concentrically about said axis in a common circumferential direction and directed inwardly obliquely toward the lower end of the tubular member; and a bypass conduit connected to the lower end of the separating device and to the venturi whereby upon actuation of the pump, water and particles of sand and the like borne thereby are drawn into the separating device through the multiplicity of inlets and the particles centrifuged from the water for descent in the separating device and passage through the bypass conduit to the venturi in bypass relation to the pump while the cleaned water rises in a vortex from the lower end of the separating device to the intake conduit of the pump for discharge through the discharge conduit and venturi.

2. The combination of claim **1** in which the venturi is located in spaced relation to the pump in the discharge conduit thereof, a second venturi is connected between the bypass conduit and the lower end of the separating device; and a pressure conduit is connected to the discharge conduit between the pump and the first venturi and to the second venturi to facilitate withdrawal of the particles and sufficient water for flowability

from the lower end of the separating device and their bypass of the pump to the discharge conduit.

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