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COMBINED FLOTATION AND CLARIFICATION DEVICE

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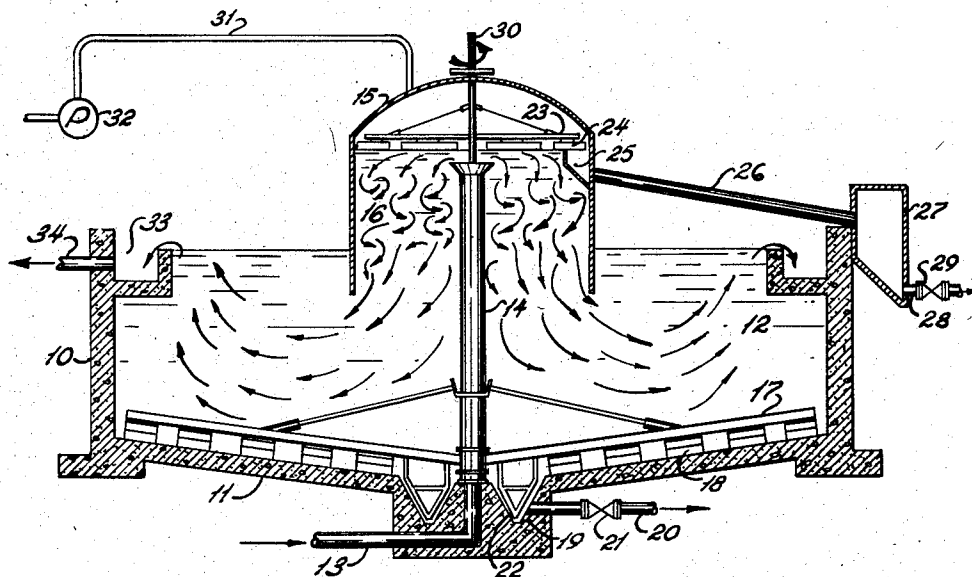


FIG. 1

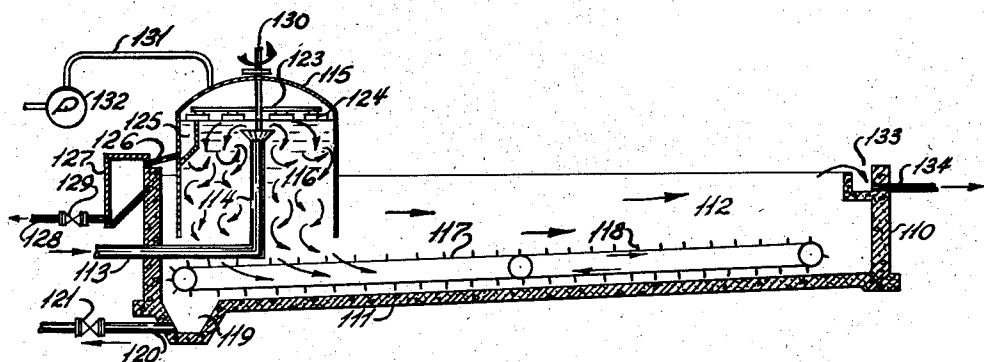


FIG. 2

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COMBINED FLOTATION AND CLARIFICATION DEVICE

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8 Claims. (Cl. 210—525)

This invention relates to a method and means for the purification of polluted liquids by the flotation and settlement of impurities. More particularly, it relates to a method and means for effecting such purification within a unitary apparatus containing a body of liquid undergoing treatment wherein one portion of said body is subjected to sub-atmospheric surface pressures in order to bring about both improved flotation and improved settling.

In the treatment of sewage, industrial wastes, and similarly polluted liquids, it is common practice to subject the material to relatively quiescent conditions of such a nature that a portion of the suspended solids present may settle out and be removed. It is likewise common practice to subject the material to flotation wherein suspended solids are caused to be buoyed up by small bubbles. Solids which reach the surface are skimmed off and disposed of by any of various methods and means.

Apparatus for effecting flotation of solid impurities may be classified into two general types. One of these comprises the so-called atmospheric flotation devices which utilize a means for super-charging the liquid with gas to such an extent that bubbles are present in the liquid even when exposed to hydraulic pressures normally present in a treatment chamber open to atmosphere. The second type comprises the so-called vacuum flotation devices in which buoyance is induced or enhanced by subjecting the liquid being treated to sub-atmospheric pressures in a separate zone or chamber. The invention dealt with herein is concerned with the latter, or vacuum flotation, type.

Although flotation devices of the vacuum type are generally regarded as being considerably more efficient than the atmospheric types, their more general use, at least in the field of sewage and industrial waste treatment, has, in the past, been somewhat retarded by certain inherent difficulties. The first of these relates to a certain lack of operational flexibility. In order to conserve power requirements for generating the necessary vacuum, and in order to minimize the relatively high construction costs involved in the design of vessels capable of withstanding the negative pressures present in the unit, vacuum flotation devices are almost invariably designed with a minimal horizontal cross-sectional area, an area established almost solely by the requirements of flotation per se, and ignoring, in large part, the area requirements for adequate settlement of the heavier, non-floatable suspended matter. This has meant of course that, while floatable material was efficiently removed in the vacuum flotation device, separate means had to be provided for the removal by settlement of the non-floatable material, an expensive and space consuming expedient.

A second shortcoming of the vacuum flotation devices known to the art lies in the difficulties inherent in controlling the operation of a device wherein the principal functional elements were contained within a closed chamber under negative pressure head. Principal among the

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elements isolated from ready access by past design practices has been the effluent discharge means provided for removing from the unit liquid from which floatable solids had been separated. Since, in a properly operating unit, rising and floating solids were present throughout the upper portion and surface of the unit, it has been the practice to remove effluent from the unit by means of effluent ports disposed in the lower portion of the unit. However, because of the nature of the solid impurities generally present in sewage and industrial wastes, it has been found that submerged ports, no matter how carefully designed, are subject to clogging. Furthermore, since the ports are within the closed vacuum chamber, it is impossible to observe the clogging, and, even if clogging is suspected or known to exist, corrective measures cannot be taken without completely ceasing operation and emptying the unit.

As stated hereinabove, the subject matter of the invention comprises a device for effecting not only flotation, but also settlement of impurities from a liquid bearing such impurities in suspension. Consequently, it is important to observe its effect on the efficiency of settlement. Among the various elements which determine the efficiency of any settling or clarification device, it may fairly be said that two of the most important are the retention time, and the degree of non-turbulence and uniformity of flow of the influent stream entering the settling step. The first element, or namely retention time, is primarily a direct function of the dimensions of the settling zone. The second element, or namely non-turbulent and uniform introduction of feed, has been the subject of considerable research and experimentation in the art. Various solutions have been proposed, most of them revolving about influent baffling means, and feed wells of various sizes and configurations. In every case, however, one of the principal objects has been the dissipation of the kinetic energy of the influent liquid stream prior to the introduction of the liquid into the settling zone proper. Baffling, whether of the flow-directing or of the impingement type, while undoubtedly beneficial has, in most cases, not proven entirely satisfactory. Not only have results been spotty, but baffling has proven to be a relatively costly item.

The alternative to baffling has been the provision of a stilling chamber prior to the introduction of the liquid to settlement. Such stilling chambers are commonly referred to as feed wells and are, in circular units, centrally disposed about the vertical axis of the unit. In longitudinal flow units, they are disposed at or near the influent end. Obviously, other factors being equal, the greater the volume of these stilling chambers or feed wells, the greater will be the likelihood that detrimental turbulence will have been dissipated by the time the liquid being treated is permitted to pass to settlement. Equally obviously, while feed well enlargement has, in most cases, been effective, there are some very material practical limitations.

Their downward extension is limited by the depth of the basin in which they are mounted. They cannot be enlarged laterally without either encroaching on the area required for settlement, or necessitating the construction of a unit of larger over-all dimensions than would otherwise be required.

In view of all of the foregoing, the objects of this invention may be stated as follows. First, it is an object of this invention to provide a combined device for the flotation and the settlement of liquid-borne impurities, wherein flotation is achieved through the application of less than atmospheric pressures to a portion of the over-all body of liquid being treated, said device being adapted to eliminate the need for submerged ports or orifices

for the removal of liquid from the zone of flotation. A further object is to achieve a direct transition from a zone of flotation to a zone of settlement in a uniform and non-rolling manner. Still another object of this invention is to provide means whereby the dissipation of the initial kinetic energy of the influent stream to a settling device may be enhanced through the provision of increased feed well volume without the need for extending the feed well downwardly or laterally.

These and other objects are achieved, according to the teachings of this invention, by providing, in functional relationship to the influent to the unit, a vacuum chamber in direct hydraulic communication with the main body of liquid contained in the unit and adapted to maintain liquid therein at a mean elevation higher than that of the liquid body in the remainder of the unit. More particularly, this invention is predicated on the provision of a hollow dome-shaped vessel open at the bottom and closed at the top and sides and mounted in, or made integral with, a settling device in such a manner that the lower extremity of the said dome is at all times immersed in the main body of liquid contained in the settling device. Means are provided for producing sub-atmospheric conditions within the upper portion of said dome and for initially introducing all new liquid to be treated by the device, into the zone laterally enclosed by the dome. As a result of all of these provisions an apparatus is evolved wherein a liquid bearing floatable and settleable materials is introduced into a zone of low pressure wherein and whereby bubble formation is induced or enhanced and flotation of impurities facilitated. Following this, the liquid is displaced downwardly through the hollow chamber and passes thence, by way of the open bottom thereof, directly into a second zone wherein, under quiescent conditions, settlement of heavier solids takes place. In practice, the operation is continuous with means being provided for discharging treated effluent, floated materials, and settled materials.

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

Figure 1 is a schematic cross-sectional elevation of radial flow apparatus incorporating the teachings of this invention.

Figure 2 is a schematic cross-sectional elevation of longitudinal flow apparatus incorporating the teachings of this invention.

The apparatus of Figure 1 illustrates the application of the teachings of this invention to a settling device wherein the passage of liquid during the course of settlement is in a radially outward direction to treated liquid discharge means functionally and physically remote from a generally centrally disposed influent means. Thus, marginal wall 10, which is preferably circular in horizontal cross-section but may, particularly where an existing basin is modified to incorporate the teachings of this invention, be rectangular, together with bottom 11 forms a basin to contain a main body of liquid 12. The proportions of this basin are such that relatively quiescent conditions are maintained within said main liquid body whereby solid impurities are permitted to settle therefrom and deposit on the bottom 11 to form sludge. Vacuum dome 15 is centrally disposed within the basin and is, by way of its open bottom, in direct hydraulic communication with the main liquid body. Vacuum pump 32 and vacuum line 31 comprise means for generating sub-atmospheric pressures in the upper portion of dome 15 whereby a secondary liquid body 16 is retained within the dome

at a surface elevation substantially above that of the surface of the main liquid body 12, the latter elevation being established in the embodiment shown, by the elevation of the overflow edge of effluent launder 33. Influent conduit 13 and riser 14 comprise raw liquid feed means adapted to discharge directly into the region laterally encompassed by the dome 15. Effluent liquid having been exposed to treatment within the dome and basin, discharges into launder 33, and passes thence to use, further treatment or disposal by way of conduit 34. It may be observed that launder 33 comprises the sole liquid take-off means required by the unit, the need for submerged ports or orifices present in the usual vacuum flotation device having been effectively eliminated. By reason of the fact that the launder is disposed at or near the surface of the main liquid body undergoing treatment by settling, it is open to visual inspection and can readily be cleaned or otherwise serviced. This highly advantageous feature comprises one of the important elements of this invention.

A rotating scum collector, actuated by torque shaft 30, and, comprising arms 23 with skimmer blades 24 is shown disposed within the vacuum chamber, said skimmer blades being in contact with the surface of the liquid body contained therein. In the course of their rotary movement blades 24 act to impel floating scum into trough 25, whence it passes, by way of conduit 26 into scum chamber 27; said scum chamber being, in turn, equipped with discharge pipe 28 with valve 29. Scum chamber 27 is, of course, maintained at substantially the same pressure as that prevailing over liquid body 16 within dome 15.

Rotating sludge collecting means, comprising arms 17 and scraper blades 18, are also shown. Actuated directly by rotating riser 14 and indirectly by torque shaft 30, this assembly acts to transport settled solids or sludge to a generally centrally disposed sludge sump 19. It should be noted however that, by the simple expedient of changing the angle of the blades 18, with or without a reversal of the slope of the bottom of the basin, the sludge collecting means could also be readily adapted to rake away from the axis of the unit to a non-central sludge sump. Sludge thickening blades such as shown at 22 are preferably provided to increase the density of the sludge prior to discharge by way of conduit 20 with valve 21.

The apparatus of Figure 1 is intended for continuous operation. Raw liquid entering by way of conduit 13 passes upwardly through riser 14, and enters the liquid body 16 at a level proximate the surface thereof. That portion of the liquid body 16 which lies above the surface elevation of the main liquid body 12, is, of course, under sub-atmospheric pressure, pressures being at a minimum at the surface of liquid body 16. Consequently, the flotation inducing effect of the vacuum is at a maximum in the region prescribed for the introduction of raw feed, and, if floatable material is contained therein, there will be a strong tendency for this material to be retained at the surface of liquid body 16 in the form of scum composed of floatable solids and/or liquids together, in most cases, with entrained gas. This scum is collected by the rotating skimming assembly comprised of arms 23 with skimmer blades 24, and discharged into scum trough 25. Although scum can be pumped directly from this scum trough, it is preferred that a separate, readily accessible scum chamber such as at 27 be provided for receiving scum trough contents, by way of a connecting conduit such as at 26.

The movement of the liquid within dome 15, or, namely, that of liquid body 16, is generally downward. It has been stated hereinabove, that one of the objects of this invention is to provide means for adequately dissipating the kinetic energy of the influent flow to a settling device, thereby to improve the functional efficiency of the latter. Figure 1 clearly shows how this desirable effect may be achieved without the need for baffling, encroachment on settling area, mechanical energy

absorbers, or any of the other means proposed heretofore. As indicated by the wavy flow lines lying below the radial flow near the surface, the liquid commencing its downward movement through dome 15 is likely to be quite turbulent with numerous eddies and velocity differentials. By reason of the relatively large volume of the liquid body 16, induced by the raising of the surface thereof through the application of vacuum thereto, the natural dumping effect of internal shear is given an opportunity to equalize the flow, and substantially eliminate turbulences. By the time the stream reaches the open bottom of dome 15, and enters into the main body of liquid 12, there is substantially uniform velocity distribution over its entire cross-section and disturbance of settlement within main liquid body 12 is minimized.

After having entered the main body of liquid 12, the flow moves substantially radially, and under quiescent conditions, toward and into launder 33, whence it passes from the apparatus by way of conduit 34. During the course of its passage through the settling basin, settleable solids descend to bottom 11 and are transported to sump 19 by rotating rake arms 17 with blades 18. Rotating blades such as at 22 may be furnished to thicken the sludge prior to its discharge from the sump by way of conduit 20 with valve 21.

The Figure 2 embodiment is similar to that of Figure 1 in all fundamental functional aspects, differing therefrom primarily by reason of the fact that it represents an adaptation of the invention to longitudinal flow settling basins. Thus, in Figure 2 marginal wall 110 and bottom 111 define a generally rectangular settling basin containing a main body of liquid 112. The proportions of this basin are such that relatively quiescent conditions are maintained within said main liquid body whereby solid impurities are permitted to settle therefrom and deposit on the bottom 111 to form sludge. Vacuum dome 115 is disposed at one end, the influent end, of the basin, and is by way of its open bottom, in direct hydraulic communication with the main liquid body 112; the latter elevation being established by the elevation of the overflow edge of effluent launder 133. Vacuum pump 132 and vacuum line 131 comprise means for generating sub-atmospheric pressures in the upper portion of dome 115 whereby a secondary liquid body 116 is retained within the dome at a surface elevation substantially above that of the surface of the main liquid body. Influent conduit 113 and riser 114 comprise raw liquid feed means adapted to discharge directly into the region laterally encompassed by the dome. Effluent liquid, having been exposed to treatment within the dome and the basin, discharges into launder 133, and passes thence to use, further treatment or disposal by way of conduit 134.

A rotating scum collector, actuated by torque shaft 130, and comprising arms 123 and skimmer blades 124 is shown disposed within the vacuum chamber or dome, said skimmer blades being in contact with the surface of the liquid body contained therein. In the course of their movement, blades 124 act to discharge floating scum into trough 125, whence it passes, by way of conduit 126 into scum chamber 127; said scum chamber being, in turn, equipped with discharge pipe 128 with valve 129. Scum chamber 127 is, of course, maintained at substantially the same pressure as that prevailing over liquid body 116 within dome 115.

Mechanical sludge collecting means, comprising endless belt or chain 117 and scraper blades 118 are also shown. Actuated by an external drive mechanism (not shown), this assembly acts to transport settled solids or sludge to a sludge sump 119, shown, in this case, as being disposed near the influent end of the basin. It should be noted that travelling bar scrapers moving cyclically from one end of the basin to the other may be used in lieu of endless belt scrapers. Sludge collected in sumps 119 is removed therefrom by way of pipe 120 with valve 121.

The apparatus of Figure 2 is, of course, also intended for continuous operation.

Raw liquid entering by way of conduit 113 passes upwardly through riser 114, and enters the liquid body 116 at a level proximate the surface thereof. That portion of the liquid body 116 which lies above the surface elevation of the main liquid body 112, is, of course, under sub-atmospheric pressure, pressures being at a minimum at the surface of liquid body 116. Consequently, the flotation inducing effect of the vacuum is at a maximum in the region prescribed for the introduction of raw feed, and, if floatable material is contained therein, there will be a strong tendency for this material to be retained at the surface of liquid body 116 in the form of scum composed of floatable solids and/or liquid together, in most cases, with entrained gas. The scum is collected by the rotating skimming assembly comprised of arms 123 with skimmer blades 124, and discharge into scum trough 125. Although scum can be pumped directly from this scum trough, it is preferred that a separate, readily accessible scum chamber such as at 127 be provided for receiving scum trough contents, by way of a connecting conduit such as at 126.

The movement of the liquid within the dome 115, or namely that of liquid body 116, is generally downward. It has been stated hereinabove, that one of the objects of this invention is to provide means for adequately dissipating the kinetic energy of the influent flow to a settling device, and thereby to improve the functional efficiency of the latter. As was the case with the Figure 1 embodiment, the embodiment of Figure 2 clearly shows how this desirable effect may be achieved without the need for baffling, encroachment on settling area, mechanical energy absorbers, or any of the other means proposed heretofore. The wavy flow lines lying below the radial flow lines near the surface are intended to show that the liquid commencing its downward movement through dome 115 is likely to be quite turbulent with numerous eddies and velocity differentials. By reason of the relatively large volume of the liquid body 116, induced by the raising of the surface thereof through the application of vacuum thereto, the natural damping effect of internal shear is given an opportunity to equalize the flow, and substantially eliminate turbulence. By the time the stream reaches the open bottom of dome 115, and enters into the main body of liquid 112, there is substantially uniform velocity distribution over its entire cross-section, and disturbances of settlement within the main liquid body 112 are minimized.

After having entered the main body of liquid 112, the liquid moves, under quiescent conditions, toward and into launder 133, whence it passes from the apparatus by way of conduit 134. During the course of its passage through the settling basin, settleable solids descend to bottom 111 and are transported to sump 19 by scraper blades 118.

I claim:

1. Apparatus for the treatment of impurity bearing liquids by flotation and settlement comprising a treatment basin with bottom and marginal walls for containing a body of liquid undergoing treatment, settled solids discharge means, floated material discharge means, treated liquid draw-off means functionally remote from said influent means and adapted to function under atmospheric pressure, influent means for introducing raw liquid to be treated, and a vacuum dome disposed in co-operative relationship with said influent means and in direct hydraulic communication with said body of liquid undergoing treatment, whereby newly introduced raw liquid is, prior to settlement, subjected to pressures less than atmospheric for the flotation of impurities, said liquid being introduced at an upper level within the liquid contained in said dome, and passing therethrough in a generally downwardly direction to and into the main

body of liquid undergoing treatment said main body of liquid having its upper free surface open to atmosphere.

2. Apparatus according to claim 1 wherein said basin is of the radial flow type, said vacuum dome being mounted within said basin about the vertical central axis thereof, whereby the unsettled liquid passing downwardly through said dome passes radially outward into the main body of liquid undergoing treatment, said main body being maintained in relative quiescence whereby solids are permitted to settle out.

3. Apparatus according to claim 2 wherein said treated liquid draw-off means comprises a launder disposed in functional relationship to the surface of the main body of liquid undergoing treatment and external to and functionally remote from said vacuum dome, said launder being adapted to draw surface proximate liquid from said main liquid body following settlement of impurities therefrom.

4. Apparatus according to claim 1 wherein said settled solids discharge means comprise a rotating rake assembly adapted to move settled solids across the bottom to a sludge sump, wherein said solids are collected prior to discharge from the apparatus.

5. Apparatus according to claim 1 wherein said floated material discharge means comprises a mechanically rotated skimmer mounted within said vacuum dome and rotating about the central axis thereof, a scum trough mounted within said dome and adapted to receive floated material collected by said scum skimmer, and a conduit leading from said scum trough to a scum chamber maintained at substantially the same pressures as are maintained above the surface of the liquid within said dome.

6. Apparatus for the treatment of solids-bearing liquids to separate solids therefrom by both gravity settling and vacuum flotation, comprising in combination a settling basin and a vacuum dome; said settling basin having a bottom and marginal sidewalls to contain liquid being

treated, launder means associated with said sidewalls having an overflow edge for discharging treated liquids, conduit means for discharging settled solids, and raking means for impelling such settled solids to said discharge means; said vacuum dome comprising a vertically disposed hollow elongated member mounted concentrically with respect to said settling basin and physically remote from said marginal sidewalls of said settling basin, said dome having an open lower end located at an elevation below the overflow edge of said launder means as well as a closed upper end located at an elevation above said overflow edge; skimming means operative in an upper portion of said vacuum dome above the elevation of said overflow edge enabling removal of floated material from said vacuum dome; means for maintaining a vacuum within the upper portion of said dome; and means for introducing liquid to be treated into said dome at an elevation above said overflow edge.

7. Apparatus according to claim 6 in which said means enabling removal of floated material from said vacuum dome includes trough means within said dome for receiving floated material.

8. Apparatus according to claim 7 in which said trough means are associated with conduit means which lead from said trough means to a chamber remote from said vacuum dome and means for maintaining a vacuum in said chamber.

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