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COMPLETE SPECIFICATION

Improvements in or relating to an Apparatus and Process for Treating Polluted Liquid

We, INFILCO INCORPORATED, a corporation organised under the laws of the State of Delaware, United States of America, of 325, West 25th Place, Chicago, State of Illinois, United States of America, (assignees of ANTON A. KALINSKE), do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to apparatus and process for the treatment of polluted liquids, such as sewage and other waste liquids and polluted surface waters. More specifically, the invention relates to a novel apparatus and method for the biological purification of such liquids by what is generally called activated sludge, and the clarification of the purified liquid.

The present invention provides apparatus for biologically purifying and clarifying polluted liquid including a tank provided with an overflow for purified and clarified liquid from its upper portion and a waste solids outlet from a lower portion, a first partition spaced above the bottom of said tank and forming an aeration chamber, a second partition forming a passageway extending from the upper portion of said aeration chamber to an elevation above said overflow and thence downwardly to an elevation below said overflow, at least one rotor for dispersing newly entering liquid and oxygen through the contents of said aeration chamber, said rotor being disposed in the lower part of said aeration chamber and being so constructed and arranged that upon its rotation there is established in said aeration chamber a cyclic flow having radial outward and radial inward components, and means for introducing polluted liquid and oxygen, said means discharging into the path of said radial inward flow.

The present invention further provides a process for the biologicl purification of polluted liquid, such as sewage, in which sewage to be treated is mixed and agitated in an aeration zone with air and activated sludge separated from previously treated sewage, and the mixture is then separated into purified effluent and activated sludge, a portion of which sludge is returned to the aeration zone and reused for treatment of a further volume of sewage, characterised by dispersing the entering sewage to be treated and air under pressure and the activated sludge returning to the aeration zone through the entire contents of the aeration zone, retaining the sewage in said agitated mixture for a period of time sufficient for its purification, then separating the sewage from the mixture but retaining the activated sludge in said mixture for a longer period than the sewage, and withdrawing activated sludge to waste after such longer retention period.

For purposes of simplification and illustration there will be reference herein sometimes to "sewage"; it should however be understood, that the term "sewage" is used herein in its broadest sense, to denote polluted liquids irrespective of whether they are treated to make their discharge to waste or their use permissible. Thus, the term "sewage", as used herein, denotes in addition to domestic sewage, any kind of liquid wastes, mixtures of such wastes or of sewage with such waste or wastes, as well as polluted surface waters.

When using herein terms such as "holding time" or "treating time" it is intended to denote detention based on throughput only.

It is an object of this invention to provide an improved activated sludge apparatus and process.

A specific object of the invention is to reduce the treating time of an activated sludge process and thereby reduce the size and cost of the apparatus and of the

site for its installation, and the operating cost of the plant.

Another object of the invention is to provide better utilization of the compressed air in an activated sludge plant whereby the quantity of compressed air used can be much smaller than the quantity heretofore used in conventional diffused air plants.

Another object is to provide an activated sludge plant wherein raw or settled waste liquid and air or oxygen under pressure are instantaneously dispersed throughout the entire contents of the aeration chamber.

Another object is to provide an activated sludge process, and apparatus therefor, wherein the clarification of the mixed liquid is obtained by separation of clarified liquid from a circulating body of mixed liquor.

Another object of the invention is to provide an activated sludge process and apparatus wherein the activated sludge is held in suspension as long as it is used in the process, and only waste sludge leaving the process is allowed to settle.

Another object of the invention is to provide an apparatus and a process wherein the raw or settled waste liquid to be treated and the oxygen used in its treatment are introduced into the aeration chamber conjointly or at adjacent points and are quickly dispersed through a volume of mixed liquor under treatment several times the volume of newly added waste liquid.

In its broadest sense, the activated sludge process may be said to involve treating raw or pre-clarified waste liquid, which may contain suspended, colloidal and dissolved pollute, with a sludge containing aerobic bacteria in the presence of sufficient oxygen to keep the bacteria in an active condition, and with sufficient agitation to maintain the sludge and waste liquid thoroughly mixed. Many diverse theories have been stated regarding the exact functioning of the activated sludge process, however it is now generally recognized that the process involves both bacterial oxidation of organic matter in suspension and solution, and agglomeration of suspended and colloidal solids.

In actual practice of the conventional activated sludge process the polluted liquid is usually settled in a primary clarifier to permit the depositing and removal of the more readily settleable solids. The overflow from the primary clarifier flows to an aeration basin or basins where it is mixed with activated sludge separated from previously aerated polluted liquid, and aerated, usually for periods of about eight to ten hours. The aerated mixture of activated sludge and polluted liquid, the so-called mixed liquor, is then commonly settled in a secondary clarifier for about two hours, and the effluent of the secondary clarifier is usually suitable for discharge into a water course. A portion of the sludge which settles in the secondary clarifier is returned to the aeration basin and provides the activated sludge used in the treatment of the polluted liquid therein, while another portion, which is in excess of the sludge needed in the aeration basin, is wasted.

The aeration of the polluted liquids has been carried out mainly by two different methods. In one method compressed air is diffused into the mixed liquor on its way through the aeration basin from the inlet end to the outlet end, usually through porous plates or nozzles arranged along the length of the aeration basin. In the other method mechanical equipment is used for introducing oxygen from the atmosphere into the mixed liquor and at the same time provide the necessary agitation for mixing of sewage and activated sludge and for keeping or maintaining the sludge in suspension. This is done in various ways, as by agitation of the liquid surface in the aeration basin by beaters, paddles and the like in such a manner as to induce circulation of the tank contents, or by spraying of a portion of the mixed liquor over the liquid surface, or by drawing surface liquid into the mixed liquor in the aeration basin. It has also been proposed to combine diffusion of compressed air with paddle agitation of the liquid surface.

In the diffused air method of aeration the oxygen is generally made available in a progressive manner, that is the mixed liquor on its way through an elongated aeration basin is dosed with successive portions of air, and, *vice versa*, each portion of oxygen supplied is diffused only in a small portion of the contents of the aeration basin. The same is true of paddle aeration, where the sewage usually flows through long channels and is acted upon by successive paddles. In the so-called mechanical aerators, air from the atmosphere is drawn into the mixed liquor and mixed with the entire contents of the aeration basin. However, the quantity of oxygen provided in this manner is relatively small and therefore a very long holding time is needed. Further, while the mechanical aerators do not in and of themselves use progressive aeration as do diffused air aerators, they are, except in very small plants, used in series, and then have the same characteristic of progressive aeration by successively introducing

site for its installation, and the operating cost of the plant.

Another object of the invention is to provide better utilization of the compressed air in an activated sludge plant whereby the quantity of compressed air used can be much smaller than the quantity heretofore used in conventional diffused air plants.

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small quantities of air into the mixed liquor, each quantity of air being introduced only into a portion of the entire mass of mixed liquor under treatment.

In the new apparatus and process aeration is carried out by means of air, or oxygen, under pressure. However, instead of introducing the air, or oxygen, progressively, as in the conventional diffused air methods, the air, or oxygen, is introduced in one location of the aeration chamber where it is immediately picked up by, and dispersed through the circulating contents of the chamber. The sewage to be treated is introduced in like manner, so that there is obtained an almost instantaneous mixing and dispersion of entering sewage and oxygen with each other and with the entire contents of the aeration basin.

Prior art activated sludge treating plants have in common that the final separation of the mixed liquor into purified effluent and activated sludge, (part of which must be returned to the aeration basin) is effected by depositing the sludge under quiescent conditions, be it in a settler or on a filter.

The use of a fully deposited sludge as the source of activated sludge for the treatment of sewage is objectionable in various respects. In the first place, the sludge has to be resuspended and this involves loss of power as compared with holding the sludge in suspension. Further, settling impairs the faculty of the sludge of assisting in the agglomeration of fine particles into larger sludge flocs. It is a well known fact that once solids have been fully deposited as a sludge, whether they be thereafter resuspended or not, their capacity of assisting in coagulation and in agglomeration is not nearly as high as that of unsedimented suuspended solids. Further, and most important, such separation of sludge by depositing necessitates holding the sludge for prolonged periods under non-aerobic conditions, whereby the sludge becomes somewhat dormant and the bacteria are not in the most vigorous state for active biological oxidation of the sewage pollute. Such deposited activated sludge must either be aerated before its reuse in the aeration basin, to re-activate the bacteria, or the oxygen provided in the inlet portion of the aeration basin will be consumed to the greatest part in activating the bacteria and the biological purification of the sewage will proceed relatively slowly.

In the present apparatus and process this drawback is avoided. The activated sludge formed in the treatment of polluted liquid in the aeration chamber and used therein over and over again, is not permitted to deposit, or even remain quiescent, or exposed to anærobic conditions at any time, but is maintained in suspension and circulation under aerobic conditions in the treating zone until it is discarded as waste sludge. According to the invention, only the waste sludge is permitted to deposit in a quiescent concentration chamber from where it is sent to waste. Since only a small quantity of sludge is allowed to settle, the concentrator can be located within the treating apparatus and the cost and space for separate final clarifiers and for pumping return sludge can be saved.

Briefly, when considered as a process, this invention comprises the rapid dispersion of oxygen and sewage throughout a large body of mixed liquor in an aeration zone, the continuous circulation of mixed liquor from the outlet portion of the aeration zone to its inlet portion, which circulation is at least partially effected by air lift, the separation of undissolved gas from the circulating liquid, the separation of clarified sewage from the circulating mixed liquor, the displacement of an output portion of clarified sewage by newly entering sewage and the withdrawal of waste sludge from the process.

The present process utilizes compressed air, or pure oxygen under pressure. Therefore, it should be understood that where "air" is referred to herein, this term is used to denote also pure oxygen, and *vice versâ*, where reference is made to oxygen, this term denotes both the oxygen contained in compressed air and pure oxygen introduced *per se*.

The new apparatus provides an aeration chamber, a passageway for the circulation of the mixed liquor under aerobic conditions, a quiescent clarified liquid zone and a quiescent zone for settling the waste sludge, all conveniently located in one relatively small tank. The entire holding time of the apparatus, for the combined biological purification and clarification steps for treatment of normal strength domestic sewage may be of the order of about two and one-half hours, with results which compare favorably with those obtained with holding times of from eight to ten hours for the biological purification and about two hours for final clarification in the known activated sludge process and with holding times of about three or more hours for the biological purification and about two hours for clarification in the high-rate activated sludge process.

This invention will be more fully understood by reference to the accom-

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panying drawings which form a part of this specification and wherein:—

Figure 1 is a cross sectional view of a preferred embodiment of the invention;

Figure 2 is an enlarged cross sectional view of a modification of the adjustable sleeve of Figure 1; and

Figure 3 is a diagrammatic plan view of the invention as applied to an elongated tank.

The preferred apparatus comprises a tank, which may be of any suitable size and shape but in Figure 1 is shown for purposes of illustration as a round tank 10 having a side wall 11 and a substantially flat bottom 12. The lower portion of the tank wall may be sloped inwardly as shown at 13 to facilitate flow to the center of the tank and avoid deposits on the floor along the wall 11. A valved drain 14 may lead from the tank to permit draining of the apparatus for inspection, repair and the like. A peripheral launder 15 communicates with an effluent pipe 16 and establishes the liquid level L in the tank 10.

Axially aligned within the tank 10 is a vertically extending partition structure 20 comprising a frusto-conical hood 21 spaced above the floor 12 and a cylindrical wall or inner tube 22 extending upwardly from the upper portion of the hood 21 as shown. An annular wall or outer tube 23 surrounds the inner tube 22 and extends from an elevation above the liquid level downwardly to an elevation adjacent the lower end of the inner cylindrical wall 22. The partition structure 20 may be supported in spaced relationship to the tank bottom by any suitable means, such as legs, or brackets 24 as shown. The outer tube 23 may derive support from the inner tube, as by brackets 25, which may also serve as baffles, or it may be supported from a beam, or bridge 26 spanning the tank 10.

The partition structure 20 and the outer tube 23 form in the tank 10 an aeration chamber 30 located under the hood 21 which is open at its bottom to the lower portion of the tank, and a passageway 31 for mixed liquor leading from the upper portion of the aeration chamber 30 to the liquid surface and thence back to the lower portion of the tank. The passageway 31 comprises an upflow section 32 within the inner tube 22 and a downflow section 33 within the outer tube 23. The downflow section 33 must be of sufficient width that the downward flow of the mixed liquor returning to the lower portion of the tank is relatively slow in order to permit undissolved gas entrained in the mixed liquor to escape to the surface countercurrently to the flow of the liquor. Between the partition structure 20 and the wall of the tank 10 is a chamber 34.

It is desirable to control the rate of flow through the passageway 31. This can be done by adjusting the elevation at which flow from the inner tube 22 to the outer tube 23 takes place. As shown in Figure 1 a sleeve 35 is provided which fits snugly in the inner tube 22. The sleeve may be supported from the bridge 26 by turnbuckles, or the like, so that it can be raised or lowered as desired. The sleeve 35, in effect, forms a vertically adjustable weir 36.

Instead of using the upper edge 36 of the sleeve 35 as an overflow weir, the sleeve may be apertured, as shown in Figure 2, to provide a submerged overflow area, which is shown in the form of a plurality of submerged orifices 37 but may be a continuous slot. By lowering the sleeve 35a any desired portion of the orifices 37 can be closed by the inner tube 22, while in the uppermost position of the sleeve the orifices are entirely uncovered. In large installations the sleeve 35a may be rigidly fixed to the bridge 26 and individual vertically movable gates may be provided for the several orifices. Obviously, the orifices 37 could be in the inner tube and the sleeve be made solid with the same result.

Radial baffles 38 are provided under the hood 21 and extend inwardly therefrom, to reduce the rotation of liquid along the hood.

Axially aligned within the partition structure 20 is a shaft 40 which may be journaled in a bearing 41, as shown. The shaft 40 may be driven by any suitable means, such as a motor-reducer 42 which may be supported above the tank as on the beam or bridge 26. A rotor 43 is rigidly affixed to, and rotatable with the shaft.

The rotor 43 may comprise a horizontal plate 44 and a plurality of vertically extending blades 45 mounted on the underside of the plate 44. The blades 45 are spaced around the periphery of the plate 44 and extend approximately radially inwardly therefrom only partway to the shaft 40. Preferably, the width of the blades may be approximately one-seventh of the diameter of the plate—and their length from about one-fourth to about one-third the diameter of the plate. Eight blades are indicated in the drawing for purposes of illustration, but the actual number of blades used will depend on the size of the rotor which again will depend on the size of the aeration chamber and the capacity of the apparatus. The peripheral distance between blades preferably should not exceed 15 to 20 inches, so that

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with large rotors a much larger number of blades is desirable.

Such a rotor provides a very efficient means for breaking up the air into very fine bubbles and for rapidly dispersing the entering air and sewage through, and intimately mixing them with, the entire body of mixed liquor in the aeration chamber. The rotor 43 is so positioned in the aeration chamber 30 and so proportioned to the size of the aeration chamber that the vortex set up by its rotation embraces all the liquid in the aeration chamber. The cyclic flow pattern set up by the rotor includes a radial outward discharge flow at the level of the blades and a radial inward suction flow along the bottom of the tank 10.

A propeller 46 is shown affixed to the shaft 40 within the inner tube 22. Usually, such a propeller will not be needed, as the circulation through the tubes 22, 23 can be maintained by air lift. However, in some cases, especially when pure oxygen is used in the apparatus for the aeration of the mixed liquor there may not remain a sufficient amount in the form of undissolved gas bubbles to establish a lift for circulating the mixed liquor through the passageway 31. In such case a propellor 46 may be used to supplement the lift due to rising gas bubbles.

It is essential in the apparatus that the liquid to be treated and the air or oxygen used in the treatment be introduced into the suction flow to the rotor 43, so that both the liquid and the oxygen are immediately picked up and dispersed by the rotor throughout the entire contents of the aeration chamber. The inlets for air and liquid can discharge separately, at spaced points, but the air should always be discharged below the plate 44 to prevent its escape before it has been dispersed through the mixed liquor. One way of doing this is to make the shaft 40 hollow and introduce the compressed air or oxygen therethrough directly into the centre of the rotor, in known manner. Preferably however, oxygen and sewage are introduced at adjacent points or, as shown in Figure 1, at a common point of discharge 50 just below the rotor. Obviously but not necessarily, the air inlet line 51 can discharge into the sewage inlet conduit 52 at any suitable distance from the tank, whereby a pre-mixing of sewage and air and pre-aeration of the sewage is effected.

While so far there has been described for the purpose of illustration and exemplification the use of a single rotor, which is preferred in non-elongated tanks, it is possible to use two or more rotors in longitudinal tanks. Such an arrangement is shown diagrammatically in Figure 3. The rotors 43a and 43b are placed at the longitudinal axis of the tank 10a under the elongated hood 21a. The incoming sewage and air are introduced in parallel into the suction flow of the two rotors as shown, each rotor receiving half of the entering sewage and air. Each of the rotors sets up a vortex flow of the type described in connection with the rotor 43 of Figure 1. The rotors are so proportioned to the size of the aeration chamber under the hood 21a that the vortices set up by them are tangent to one another and embrace substantially all the liquid in the chamber and the underlying portion of the tank. Thus also in this form of apparatus, the air and sewage are immediately dispersed through and intimately mixed with the entire contents of the aeration chamber in the same manner as described for a round tank.

A sludge concentrator 53 is provided in the lower portion of the tank 10. A waste sludge pipe 54 provided with a valve 55 leads from the concentrator 53 to outside the tank 10. The concentrator 53 can be quite small, as it serves only for thickening the excess or waste sludge which is withdrawn from the process, this being the only sludge permitted to settle in the apparatus. The balance of the activated sludge returns from the outer draft tube to the aeration chamber without settling. By regulating the quantity of activated sludge withdrawn through the waste sludge line—the mixed liquor surface can be maintained at any desired elevation. Preferably, the mixed liquor surface is maintained approximately at the elevation of the lower end of the outer draft tube, so that clarified treated sewage separates from the stream of mixed liquor leaving the outer tube 23 and spreading out across the chamber 34 laterally to the vertical main direction of the flow. This separation is well defined, with a sharp demarcation line between the clarified sewage above and the turbid mixed liquor below.

The operation of the apparatus will be readily understood. The sewage to be treated in the apparatus may be raw sewage, but preferably is settled raw sewage, i.e., sewage from which settleable solids have been previously removed in conventional manner, as in a grit chamber or a primary clarifier, not shown. The lower portion of the tank, and the upflow section 32 and downflow section 33 of the passageway 31 are normally completely filled with mixed liquor, and the upper outer portion of the tank is normally filled with purified and clarified sewage. Rotation of the rotor 43 by the

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motor-reducer 42 sets up a cyclic flow of mixed liquor throughout the aeration chamber 30 and the underlying portion of the tank. The sewage arriving through conduit 52 and air or oxygen under pressure arriving through pipe 51 are discharged into the suction flow to the rotor 43 and quickly dispersed by the rotor through the entire body of mixed liquor in the aeration chamber 30. The air is broken up in minute bubbles from which oxygen is readily absorbed by the mixed liquor. The retention times in chamber 30 is from 10 to 30 minutes.

The gas bubbles rising through the upflow section 32 produce an air lift action which causes a circulation of mixed liquor through the inner tube 22 and the outer tube 23 back to the lower part of the tank. Due to the air lift action the liquid level L^1 in the inner tube is somewhat higher than the liquid level L established by the overflow of launder 15. If lift due to rising gas is not sufficient to maintain the circulation, the propeller 46 may be used to supplement or replace it. The mixed liquor flows from the inner tube 22 into the outer tube 23 over the weir 36 formed by the adjustable sleeve 35, or through the submerged orifice or orifices 37 in the sleeve 35a. From the surface of the mixed liquor flowing laterally from the bottom of outer tube 23 an output portion of treated clarified sewage separates and passes upwardly into the clarified liquid zone from where it is withdrawn through the launder 15 and effluent conduit 16. The balance of mixed liquor returns downwardly to the bottom portion of the tank and is picked up by the suction flow to the rotor 43 and drawn back into the aeration chamber 30 to be redispersed therethrough.

During the flow through the inner and outer tubes undissolved air separates in form of bubbles from the mixed liquor and escapes through the open top of the tubes, carrying with it carbon dioxide formed by the bacterial activity in the sludge. Most of the air will escape during the upflow. However, the downflow must be sufficiently slow to permit the counter-current escape of air bubbles still entrained in the mixed liquor in order to prevent their release at the mixed liquor surface where they would disturb proper clarification. This counter-current flow of mixed liquor and air offers additional time for oxygen adsorption by the mixed liquor.

The mixed liquor surface from which the clarified sewage emerges may be maintained at the desired elevation by regulating the quantity of sludge wasted through concentrator 53.

The rate of circulation through passageway 31 is controlled by adjusting the height of the weir 36 or the size of the orifices 37 through raising or lowering of the sleeve 35 and 35a, respectively. Proper control of the circulation rate is quite essential in this apparatus. If the circulation rate is excessive too much disturbance at the mixed liquor surface will result in consequent poor clarification. If, on the other hand, the circulation is insufficient, there will be a tendency for the intense agitation under the hood to be carried into the outer portion of the tank and disturb proper clarification.

Pilot plant tests of the new apparatus and process have been conducted for several months' continuous operation, treating screened domestic sewage taken from a conventional sewage plant. The B O D of the screened raw sewage varied from about 50 to 200 p.p.m. (parts per million). The pilot plant produced an effluent having a B O D of 10 to 25 p.p.m. with a total retention time of two and one-half hours. The B O D and suspended solids reduction obtained were consistently practically identical with those obtained in the known plant treating the same sewage with mechanical aerators in series but having a retention time of about ten to twelve hours. The sludge produced was denser than the sludge from the conventional mechanical aeration plant and its Mohlman's Index was lower, i.e., its volume was smaller relative to the weight of solid. The air requirement of the apparatus and process is very low. The pilot plant results were obtained using one-half cubic foot of air per gallon of sewage treated, while in a known diffused air plant one cubic foot per gallon is needed to produce the same results.

These results show an enormously increased rate of oxidation and clarification of sewage when treated by the process and apparatus of the present invention and a very favorable rate of oxygen utilization.

Another important factor contributing to the rapid oxidation of the sludge is the complete elimination of any quiescent holding period, or stagnant condition, between periods of aeration of the sludge in the aeration chamber. Due to the continuous circulation of mixed liquor described, the bacterial population of the sludge is constantly held under aerobic conditions and the organisms are enabled to work at their maximum efficiency.

The rapid clarification obtained in the present apparatus is due to the fact that clarification is obtained by separation of clarified sewage from a laterally flowing

stream of mixed liquor. The density and good settling characteristics of the sludge produced further enhance the clarification rate.

Due to these high oxidation and clarification rates, relatively small apparatus can handle large volumes of sewage. In large plants several of the present apparatus may be used and will usually be operated in parallel. However, they may be connected in series, if desired. When treating, for example, waste waters which are difficult to purify, it may be advantageous to use a stage treatment. Furthermore, the present process and apparatus can be used for treatment of polluted liquids that have had a prior treatment by other methods, such as chemically, or on a trickling filter. Therefore, while usually raw or raw-settled sewage will be treated in the present apparatus, it is to be understood that when reference is made to the "liquid to be treated" this term includes also polluted liquids that have been partially treated whether by the same or by different methods.

It will be seen that the present invention provides a new process and apparatus for the treatment of ~~polluted~~ liquids with activated sludge whose results are comparable to those of known plants but are obtained in a fraction of the time needed in known plants, and with a smaller amount of air per gallon of sewage treated.

Many modifications and variations of the invention, as set forth herein, may be made without departing from the scope of the invention. Accordingly, the figures and specification herein are to be considered for purposes of illustration rather than of limitation.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Apparatus for biologically purifying and clarifying polluted liquid including a tank provided with an overflow for purified and clarified liquid from its upper portion and a waste solids outlet from a lower portion, a first partition spaced above the bottom of said tank and forming an aeration chamber, a second partition forming a passageway extending from the upper portion of said aeration chamber to an elevation above said overflow and thence downwardly to an elevation below said overflow, at least one rotor for dispersing newly entering liquid and oxygen through the contents of said aeration chamber, said rotor being disposed in the lower part of said aeration chamber and being so constructed and arranged that upon its rotation there is established in said aeration chamber a cyclic flow having radial outward and radial inward components, and means for introducing polluted liquid and oxygen, said means discharging into the path of said radial inward flow.

2. Apparatus according to claim 1, wherein said rotor is mounted on a vertical rotatable shaft extending axially in said aeration chamber, said rotor comprising a horizontally extending plate affixed to said shaft at a lower elevation of said aeration chamber, a plurality of vertically extending plates extending from, and affixed to, the underside of said plate in spaced relationship to said shaft, and wherein the polluted liquid and oxygen are delivered into said aeration chamber below said horizontal plate.

3. Apparatus according to claim 1, wherein said second partition comprises an inner tube extending from the upper end of said first partition to an elevation below said overflow, and an outer tube which surrounds said inner tube and extends from adjacent the top of said tank to an elevation spaced substantially above the lower end of said first partition and is in open communication with the tank at said elevation, said first and second partitions forming in said tank said aeration chamber and a passageway from the aeration chamber to the top portion of the tank and back to the lower portion of the tank.

4. Apparatus according to claim 3, wherein the first partition is in the form of a hood.

5. Apparatus according to claim 4, having adjustable means for controlling the rate of flow through said passageway.

6. Apparatus according to claim 5, wherein said adjustable means comprises a vertically adjustable weir associated with the upper end of the inner tube.

7. Apparatus according to claim 5, wherein said adjustable means comprises at least one submerged orifice affording communication from said inner tube to said outer tube, and means for controlling the effective size of said orifice.

8. Apparatus according to claim 5, 6 or 7, wherein the space between said inner and outer tubes is of sufficient width to permit entrained undissolved gas to rise countercurrently to the downward flow of liquid.

9. Apparatus according to claim 5 or 7, wherein said adjustable means comprises a sleeve associated with, and vertically adjustable with respect to, the upper end portion of the inner tube, and having a number of orifices providing a submerged overflow area from the inner tube to the

outer tube, the area provided by said orifices being variable by ~~vertical~~ adjustment of said sleeve.

10. Apparatus according to any of claims 4 to 9, having radial baffles extending inwardly from said hood.

11. Apparatus for biological purification and clarification of polluted liquid, comprising an aeration chamber spaced above the bottom of an elongated tank, a passageway having an inner section leading from the upper portion of said aeration chamber upwardly to adjacent the top of said tank and an outer section leading thence downwardly to a lower portion of said tank, an outlet for purified and clarified liquid from the upper portion of said tank, an outlet for waste solids from the lower portion of said tank, at least two rotors mounted in said aeration chamber aligned on the longitudinal axis of said tank, each of said rotors being so constructed, proportioned and positioned as to set up, upon its rotation, a vortex flow pattern, said vortices being tangent to one another and embracing the contents of said aeration chamber and the underlying portion of said tank, means for discharging polluted liquid to be treated and air under pressure under each of said rotors.

12. Apparatus according to any of claims 1 to 11, having a sludge concentrating chamber in the lower portion of said tank, said waste solids outlet leading from said sludge concentrating chamber.

13. A process for the biological purification of polluted liquids such as sewage in which sewage to be treated is mixed and agitated with oxygen containing gas and activated sludge derived from previously treated sewage for a period of time, the mixture is then separated into purified effluent and activated sludge, a portion of which sludge is reused in the treatment of a further volume of sewage, characterised by maintaining a suspension of activated sludge in an aeration zone in the lower portion of a body of sewage, introducing newly entering sewage to be treated and oxygen containing gas under pressure into said aeration zone, applying mechanical energy in said aeration zone immediately to disperse newly entering sewage and oxygen containing gas through said suspension and to prevent sedimentation of solids from said suspension, circulating a portion of said suspension through a path leading from said aeration zone to the top of said body of sewage and back to said aeration zone with a velocity sufficient to prevent sedimentation of solids from the circulating suspension but insufficient to disturb the separation of clarified sewage from the circulating suspension, separating clarified sewage from the suspension circulating through said path while retaining the solids left behind by the clarified sewage in said circulating suspension returning to said aeration zone, and withdrawing excess activated sludge to waste.

14. A process according to claim 13 in which the circulation is at least partially effected by air lift action, undissolved gases are separated from said circulation in one part of said path and purified and clarified sewage is separated from said circulation in another part of said path.

15. A process according to either of claims 13 and 14, characterized by circulating a quantity of suspension in excess of the quantity of polluted liquid entering for treatment through said path.

16. A process according to claim 13 or 14, comprising establishing in a tank an aeration zone in the lower portion of the tank, a mixed liquor circulation zone extending from the bottom to adjacent the top of the tank and including a confined flow path and an unconfined portion, and a clarified liquid zone overlying the unconfined portion of said circulation zone and in open communication therewith, introducing the polluted liquid to be treated and the air for its treatment jointly into, and dispersing them through, the contents of said aeration zone, applying mechanical energy in said aeration zone to effect said dispersion and to hold said mixed liquor in suspension and circulation within said aeration zone, maintaining a continuous air lift supported circulation of mixed liquor through said circulation zone under conditions conducive to the separation of undissolved gas from the circulating mixed liquor during its flow through the confined path, separating an output portion of clarified liquid from the circulating mixed liquor during its flow through the unconfined portion of said circulation zone and withdrawing the clarified liquid through said clarified liquid zone, retaining in the circulating mixed liquor the solids left behind by the clarified liquid and returning them therewith to said aeration zone, and controlling the solids content of the mixed liquor by withdrawing solids to waste.

17. Apparatus for biologically purifying and clarifying polluted liquid, constructed and adapted to operate substantially as herein described with reference to Figure 1 or 2 of the accompanying drawings.

18. A process for the biological purification and clarification of polluted liquid, substantially as herein described with reference to the accompanying drawings.

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