

[54] LIQUID AERATING ROTOR ASSEMBLY

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[22] Filed: May 3, 1971

[21] Appl. No.: 139,557

[52] U.S. Cl.: 261/92, 261/120, 210/242

[51] Int. Cl.: B01f 3/04

[58] Field of Search: 261/92, 120; 210/242

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[57] ABSTRACT

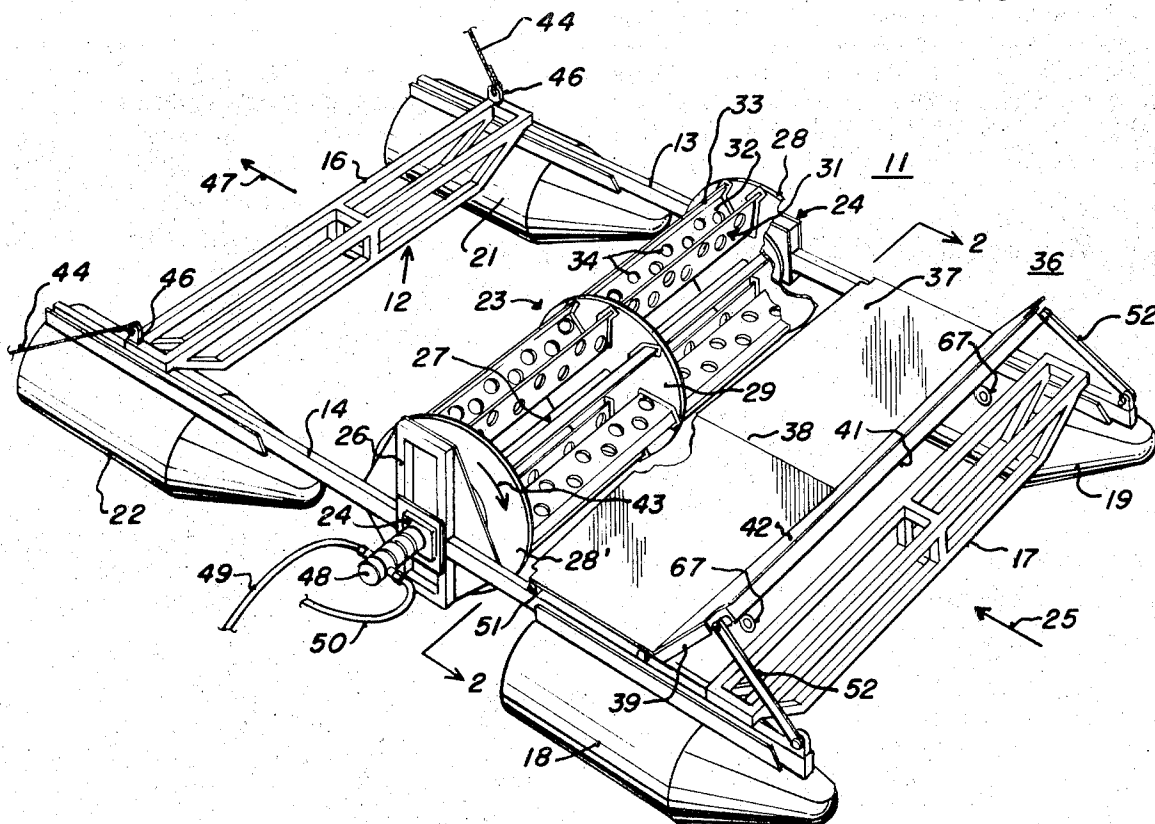
A liquid aerating and mixing rotor assembly suitable for sewage treatment in an aerobic bacterial activated sludge process includes a supporting frame mounted on floats or rigid supports. A rotor member is supported on the frame for rotation around a horizontal axis. It

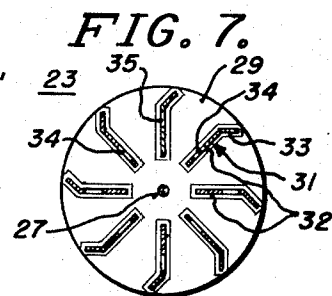
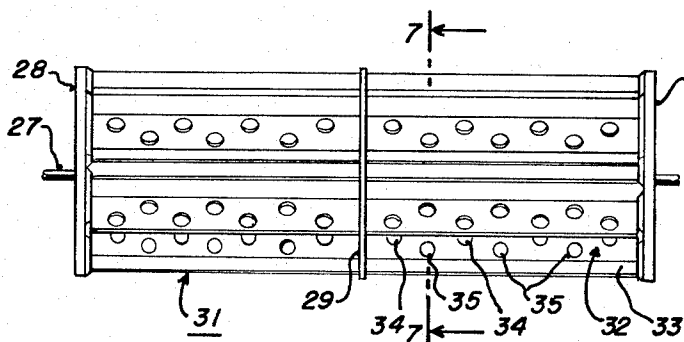
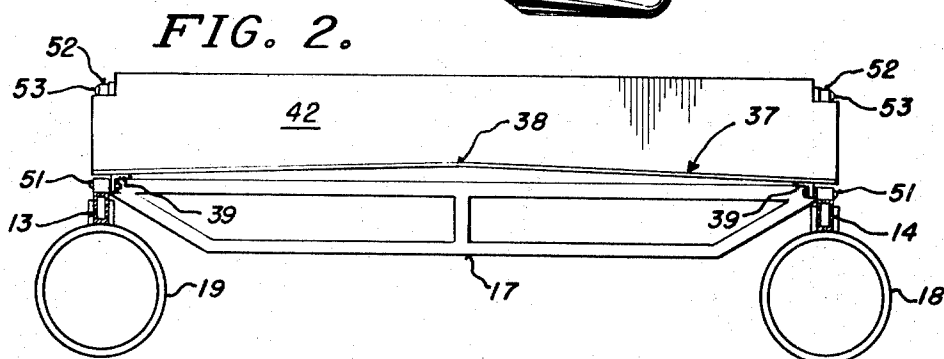
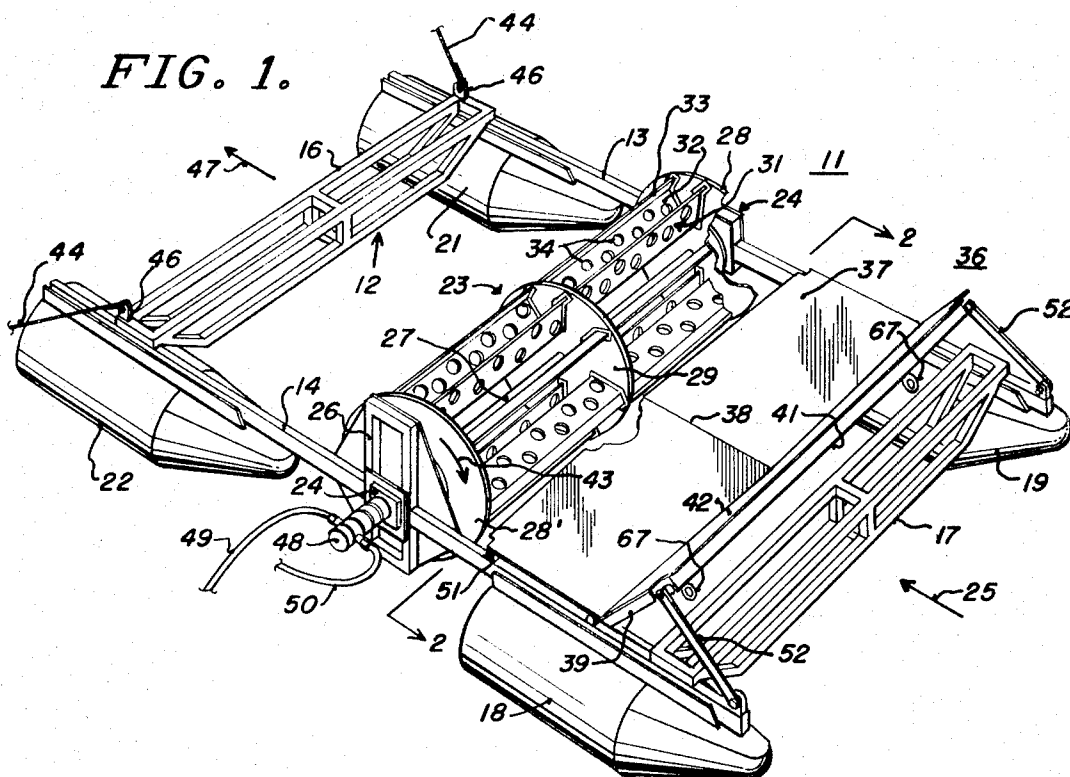
includes rotor surfaces for engaging the liquid, urging the liquid in a downstream direction along a path extending perpendicularly away from the rotor axis, and lifting and projecting substantial portions of the liquid upwardly in both upstream and downstream directions from the rotor, for aeration and mixing of the liquid. The assembly includes a deflecting member supported on the frame close to and upstream from the rotor member in a position to intercept the upstream projected portions of the liquid and guide them laterally to at least one side of the desired path, thereby preventing the projected liquid portions from passing under the rotor a second time for further aeration.

Preferably, the deflecting member is selectively movable from its lateral-deflecting position to a second position in which the liquid portions projected in an upstream direction can be passed beneath or into the rotor a second time for selective additional aeration. In a third position of the deflecting member, it may provide a lifting frame for engagement by a suitable lifting device to move the assembly from one position to another.

The rotor member for the assembly preferably includes a plurality of paddle-like surfaces extending radially from the rotor axis, with the outer edges of the surfaces inclined forwardly in the direction of rotation of the rotor to assist in retaining liquid on the rotor surface for projection of substantial quantities of liquid both upwardly and in an upstream direction for better aeration. Suitable openings in the paddle surfaces, with the locations of such openings in staggered relation in successive rotor surfaces, provide increased turbulence and greater aeration.

26 Claims, 9 Drawing Figures





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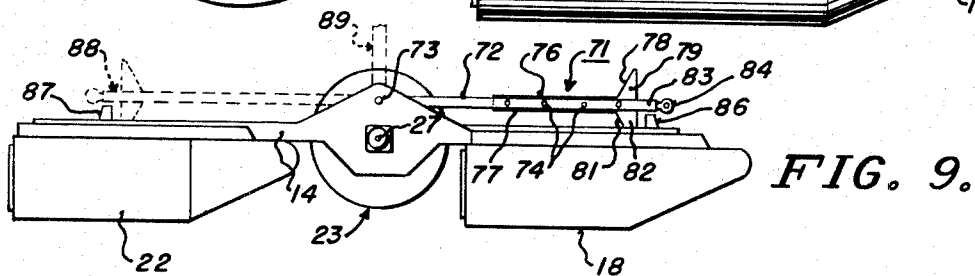
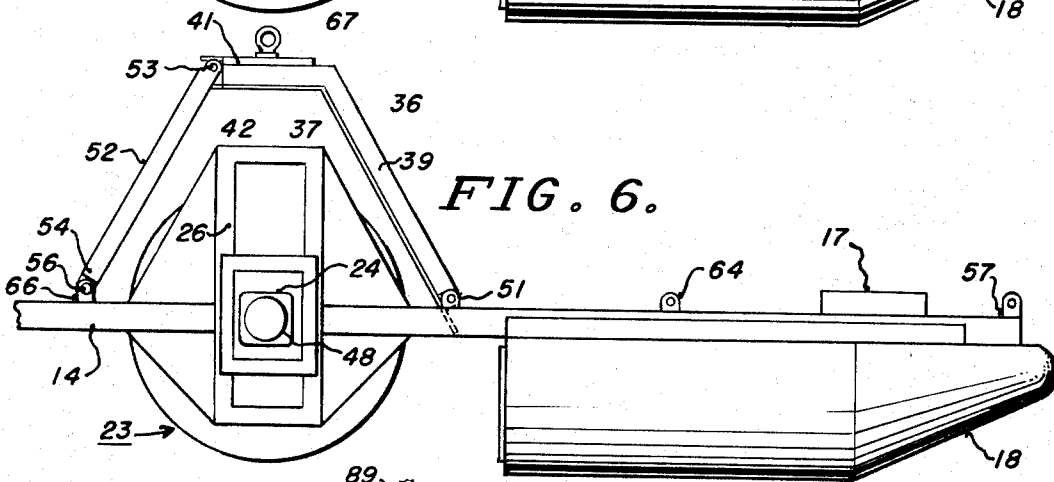
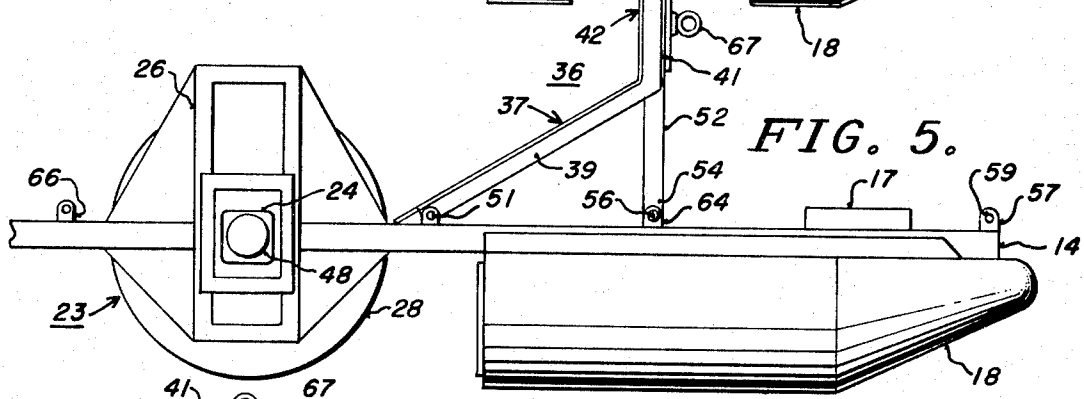
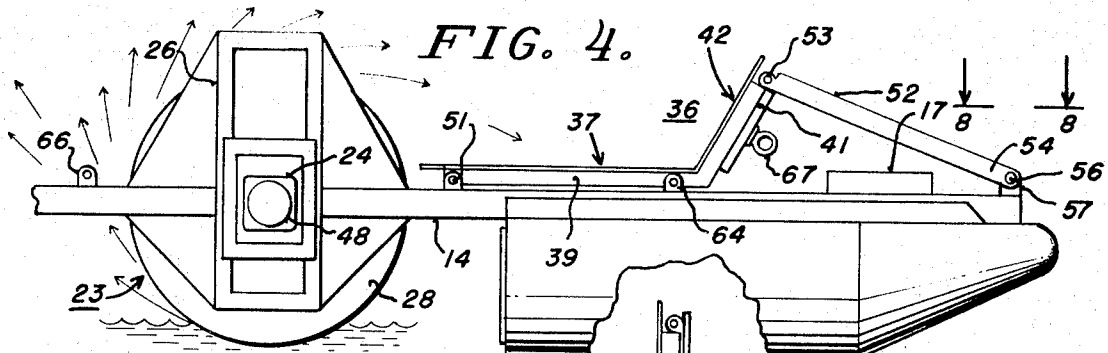
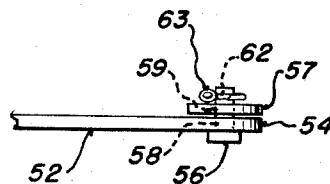


FIG. 8.



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LIQUID AERATING ROTOR ASSEMBLY

BACKGROUND OF THE INVENTION

Aeration rotors of various types have been used for the treatment of liquid for purposes of aeration, as in the case of sewage treatment by aerobic bacterial activated sludge processes. Rotors of a paddle-wheel type are known which are adapted to rotate on a horizontal axis spaced above the surface of liquid so that the rotor surfaces, in the form of radial paddles or blades, cause relative movement of the liquid with respect to the rotor in a downstream direction determined by the direction of rotation of the rotor. In addition to moving portions of the liquid in a downstream direction, such rotor members may also lift some of the liquid portions and project them upwardly and primarily on the downstream side of such a rotor during its operation. To the extent that rotation of the rotor member carries any of such liquid all the way around above the rotor to the upstream side of the rotor, the liquid portions carried to such an upstream position would normally drop into the liquid path and again move beneath the rotor for further aeration.

SUMMARY OF THE INVENTION

The present invention provides an improved liquid aerating rotor assembly in which a rotor member, rotating on a horizontal axis extending transversely of a desired path of relative liquid movement with respect to the rotor, can move portions of the liquid in a relative downstream direction along said path in response to rotation of the rotor in one direction, while the liquid engaging surfaces of such rotor also lift and project substantial additional portions of the liquid both upwardly from the surface of the liquid and in a relative upstream direction from the rotor. As the projected portions of the liquid fall downwardly toward the surface of the liquid at a relative upstream position from the rotor, they are intercepted by a deflecting member which constitutes part of the rotor assembly and which deflects the liquid laterally to at least one side of the desired liquid path. Thus these projected liquid portions, which have already achieved a certain degree of aeration, can be moved downstream past the outer ends of the rotor member without immediate additional engagement and projection by the rotor. Hence the rotor receives another portion of substantially unaerated liquid from the upstream portion of the liquid path, so that the power required to drive the rotor is used primarily for aeration or reaeration of liquid portions which have a relatively low oxygen content, rather than those liquid portions in which the oxygen content has just been increased by action of the rotor itself. The deflecting member of the present invention is preferably selectively movable from a forward position in which it intercepts and diverts the liquid projected in an upstream direction, to a second position in which these liquid portions can re-enter the rotor or the liquid upstream from the rotor and be subjected to a second aerating step by such rotor. In a third position of the deflecting member, it may serve as a lifting frame portion for engagement by a suitable lifting device to move the entire rotor assembly from one position to another.

The liquid aerating rotor assembly of the invention includes an improved rotor construction in which a plurality of paddle-wheel blades extend generally parallel to and spaced around the axis of rotation of the rotor

member, with the blades providing rotor surfaces extending radially outwardly from the rotor axis. The aerating effect of such a rotor is enhanced by providing outer edges on each blade surface which project forwardly in the direction of rotor rotation, thereby delaying movement of liquid radially away from the blade surface and increasing the lifting and upstream projection of liquid from the blade surface. The aerating effect is also enhanced by provision of a plurality of openings through the surface of each rotor blade, with openings in successive blades being out of alignment with each other, so that liquid portions which pass through the openings in one blade strike the impermeate portions of a following blade as well as the liquid carried by such portions of the following blade.

The invention involves recognition of the fact that in sewage treatment processes where the sewage liquid is treated by an aerobic bacterial activated sludge process, the sewage liquid not only requires the addition of substantial amounts of oxygen, but can more efficiently increase its oxygen content by the aeration of liquid portions of relatively low oxygen content as compared to those liquid portions which already have a substantially higher oxygen content. Thus, the invention makes it possible to selectively control the particular portions of liquid in a sewage treatment conduit which are to be preferentially subjected to aeration. When a rotor is used which projects substantial quantities of liquid both downstream and upstream from the aeration rotor location, the present invention provides a deflecting surface preventing any substantial liquid portions projected in an upstream direction from re-entering the direct path of the liquid toward the rotor. Thus, the rotor can be positioned and operated so that it operates on that portion of the sewage liquid which has the greatest need of aeration, without consuming substantial power requirements in the immediate further aeration of liquid portions which have already reached a substantially higher level of oxygen content. Selective positioning of a deflector upstream or downstream from the rotor helps control the rate of liquid flow.

BRIEF DESCRIPTION OF THE DRAWING

In the drawings which form a part of this application, and in which like reference characters indicate like parts,

FIG. 1 is a perspective view of an improved liquid aerating rotor assembly according to the invention;

FIG. 2 is a sectional view on the line 2—2 of FIG. 1;

FIG. 3 is a rear view, partly in section, of the rotor member shown in the assembly of FIG. 1;

FIG. 4 is a side elevation of the assembly of FIG. 1 showing a deflecting member in its liquid deflecting position according to the invention;

FIG. 5 is a view similar to FIG. 4 showing the deflecting member in a second position, in which liquid portions projected upstream of the rotor may pass into the rotor or the liquid beneath the rotor for re-engagement by the rotor and further aeration;

FIG. 6 is a view similar to FIG. 4 with the deflecting member in a third selective position in which it provides a lifting frame for the entire rotor assembly;

FIG. 7 is section view on the line 7—7 of FIG. 3, showing details of the rotor surfaces;

FIG. 8 is a partial view of a manually releasable retaining means for holding the deflecting member in one of its selected positions; and

FIG. 9 is a view similar to FIG. 4 of another embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. 1, a preferred liquid aerating rotor assembly according to the invention is designated generally at 11. It includes a supporting frame 12 which is made up of side members 13 and 14 rigidly interconnected by end cross members 16 and 17. Such a supporting frame may be designed either for floating support on the surface of a liquid to be treated or for location at fixed positions on rigid supporting members, depending on the particular application involved. In the present case the supporting frame 12 is provided with suitable floats or pontoons. Two of these are positioned at a forward or upstream end of the assembly at 18 and 19, in such a manner that they will be located at the outer edges of a desired path or flow of liquid to be treated. Similar rear float members 21 and 22 are located at the rear or downstream end of frame 12.

A suitable rotor member 23 is rotatably supported in bearings 24 at the sides of frame 12. For convenient adjustment, bearings 24 may be adjustably secured in vertical bearing portions 26 at the longitudinal central area of the side frame members 13 and 14. Thus, the relative vertical position of the rotor may be adjusted with respect to the surface of the liquid on which the supporting frame floats.

As shown in FIG. 1, the rotor member is adapted to rotate on a substantially horizontal axis extending transversely of the path of desired relative movement of the liquid lengthwise of the frame between the pairs of floats. This direction of liquid movement is shown by the arrow 25 at the upstream end of the assembly. Although the flow path of such liquid is described in this application as if the position of the rotor assembly along the liquid path is substantially fixed, with the liquid being moved underneath the rotor assembly in the direction of arrow 25 at least partly by the action of the rotor member, it will be understood that in some liquid aeration applications, the liquid itself may remain substantially stationary in a flat pond, and the rotor assembly can be arranged to move around the surface of the liquid under the propelling effect of the rotor member 23. In either case, the operation of the rotor assembly provides relative movement of the liquid along the path 25 with respect to the rotor assembly.

The rotor member itself is preferably formed with a plurality of circular supporting members such as the end plates 28 and 28' and the central plate 29. Rigidly connected between these plates, which in turn are keyed to rotate with the shaft 27 of the rotor member 23, are a plurality of paddle-wheel blades 31 which may take a variety of shapes and configurations.

As shown particularly in FIGS. 3 and 7, these paddle-wheel blades provide rotor surfaces 32 extending transversely of the liquid path and radially outwardly from the axis of the rotor in such a manner that they can act substantially like paddle wheels during movement of the rotor, to cause relative movement of the liquid in a downstream direction as shown by arrows 25 and 47 in FIG. 1. According to a further feature of the invention, the outer edges of the surfaces 32 are provided with retaining means to delay the radial movement of liquid from the blade surface. The retaining means is illustrated as a sloping outer edge portion 33 on each

blade which projects forwardly in the direction of rotor rotation at a slight angle from the remaining portion of the surface 32. Thus, the blade 31, at the line of intersection between these portions, provides an effective retaining area or pocket which increases the tendency of the rotor blades to lift a portion of the liquid above the surface of liquid in the path and project such liquid portions in a cylindrical pattern all the way around the upper portions of the rotor which are exposed above the surface of the liquid. Some portions of the liquid engaged by the rotor will merely be driven longitudinally in a relative downstream direction to provide the desired propulsion effect for movement of the liquid. Other portions of the liquid will be projected upwardly from the surface of the liquid and rearwardly of the unit in a relative downstream direction from the rotor. Other liquid portions will be projected radially upwardly from the rotor and their degree of aeration will depend on the distance which they are projected, their break-up into droplets, and the time required for such liquid portions to drop back into the liquid in the path. Still other portions of the liquid will be projected upwardly and ahead of the rotor toward the upstream end of the assembly. The relative quantity of liquid projected upstream in this fashion is enhanced by the forwardly inclined outer edges 33 on the rotor blades 31. Thus, the rotor is designed to increase the total projection and aeration of liquid particles by taking advantage of the entire area above the rotor member, including those areas directly above the rotor as well as the adjacent areas both downstream and upstream from the rotor.

The aerating effect is further enhanced by insuring extra turbulence and break-up of particles of liquid as they are engaged by the rotor blades 31. For this purpose, the main radial surface 32 of each blade is preferably provided with spaced openings 34 and 35, some of these openings 34 being located radially closer to the axis of rotation than the remaining openings 35. These openings in the rotor surfaces are designed to provide delivery of some liquid portions backwardly through the rotor surface openings and into engagement with a following rotor blade. On striking the following blade or the liquid carried by the following blade, these portions of liquid are further dispersed and aerated. The turbulence provided by such openings is further increased by locating the relative inner and outer openings 34 and 35 in successive blades so that they are in alternating positions, i.e., an inner opening 34 at a given point longitudinally of the rotor axis in one blade, is circumferentially aligned with an imperforate portion 32 of a following blade. In other words, a corresponding opening in the following blade would be an opening 35 at a greater radius from the axis. Thus, the liquid passing through any one of openings 34 and 35 in a given blade will strike a solid portion of the following blade and be deflected with increased turbulence. (See FIG. 7.)

According to the present invention, the relative efficiency of aeration is increased and the relative power required for a given degree of aeration is kept to a minimum, not only by taking advantage of the entire area above the rotor member for projection and aeration of liquid particles, but also by providing deflecting means substantially preventing the already aerated liquid portions from re-entering the liquid path upstream from the rotor member and thus again being subjected to

further aeration by the same rotor. For this purpose, the invention provides a deflecting member indicated generally at 36 supported on the frame 12 in a forward position close to and upstream from the rotor member 23. This deflecting member has a deflecting surface or surfaces located and oriented to intercept those upwardly projected liquid portions which might otherwise fall into the liquid path upstream from the rotor member. Thus, deflecting member 36 has a substantially horizontal main area 37 substantially bridging the entire liquid path upstream of the rotor when the deflecting member is in the forward position shown in FIGS. 1, 2, and 4. The center line 38 of this deflecting surface area 37 may be raised slightly as shown in FIG. 2 to provide a slope laterally toward each of the side edges of the rotor assembly, to assist in guiding liquid laterally from the central area 38 to the sides of the deflecting member and rotor assembly. Thus, liquid discharged laterally from surface 37, to at least one or both sides of the assembly, will tend to move downstream past the outer ends of rotor member 23 without again being immediately subjected to the projecting and aerating effect of the same rotor member.

Since the rotor member 23 of the invention projects substantial quantities of liquid in an upstream direction, the deflecting member 36 is further provided with an upwardly projecting upstream barrier edge portion 41. Thus, the liquid projected in an upstream direction strikes the upwardly extending surface 42 of this barrier edge portion, which blocks discharge of the liquid in an upstream direction from the main area of the deflecting surface 37. The barrier edge portion, in effect, guides the forwardly projected liquid portion laterally to the sides of the liquid path for downstream passage around the ends of the rotor member, as described. The lateral edges of the deflecting member 36 are reinforced by and supported by longitudinally extending frame members 39 (FIG. 1) which may be fixed rigidly in position on the frame, but are preferably movably supported for selective movement of the deflecting member to alternate positions as hereinafter described with reference to FIGS. 5 and 6.

The rotor member of FIG. 1 is supported for rotation on its horizontal transversely extending axis in the direction shown by arrow 43. Thus, the entire rotor assembly tends to move to the right, as shown in FIG. 1, on the surface of the liquid. In those applications where it is desired to retain the rotor assembly in relatively fixed position, securing lines 44 are connected to brackets 46 at the downstream corners of the assembly. Lines 44 are connected to appropriate anchoring means at fixed positions along the liquid path. Thus, the rotation of the rotor member 23 in the direction of arrow 43 tends to propel the rotor assembly in an upstream direction. However, the retaining lines 44 hold the assembly in position so that the liquid in the path beneath the rotor is necessarily urged in a downstream direction as shown by arrow 47 at the left of the assembly. In effect, rotation of rotor member 23 draws liquid from the upstream end of the assembly, i.e., at the location of arrow 25, and urges the liquid downstream beneath the rotor member 23 toward the downstream arrow 47. At the same time, the direction of rotation of the rotor member and the configuration of the rotor blades projects substantial portions of the liquid upwardly above the entire assembly in the manner previously described.

Any appropriate power means may be provided for rotating the rotor in one direction around its axis. As illustrated, the power means 48 is a rotary hydraulic power unit which receives high pressure fluid through an inlet or supply line 49 and discharges such fluid through an outlet line 50. The direction of rotation can be reversed, if desired, by changing the direction of flow of high pressure fluid in the respective lines 49 and 50. Such hydraulic rotary power units are well known.

As described to this point, the rotor assembly of the present invention provides for enhanced projection and aeration of liquid particles above a rotor member of the type described and substantially prevents the immediate further projection and aeration of the same liquid by the same rotor. In a sewage treatment conduit in which liquid flows around a closed path during aerobic bacterial treatment by an activated sludge process, substantial quantities of oxygen are required for the desired bacterial action. As the sewage liquid moves around the desired path and the oxygen incorporated in the liquid is consumed by the bacterial action, the oxygen content of liquid arriving at an upstream location such as 25 in FIG. 1 may have an oxygen content as low as 0.25 p.p.m. (parts per million), or even zero. When portions of the liquid are projected upwardly above the rotor assembly and permitted to fall back into the liquid, the relative absorption of oxygen by the projected particles can increase the oxygen content of the projected liquid to a substantial degree. For example, the oxygen content of the liquid caught by deflecting member 36 and passing laterally off the side edges of the deflecting surface 37 may be raised to a level in the range of 3 to 8 p.p.m. Although such liquid may be capable of further aeration to as much as 10 to 15 p.p.m., the present invention recognizes that it is more difficult to obtain a given increase in oxygen content by a particular aeration step when the oxygen content of the starting material is higher. Thus, the efficiency of aeration is greater for a given amount of power supplied to rotor member 23, when the rotor member is operating on liquid with only zero to 0.25 p.p.m. of oxygen, than when the rotor is operating on liquid having an oxygen content of 3 p.p.m. or higher. By raising the oxygen content of the projected liquid to 3 to 8 p.p.m., however, and by diverting that liquid laterally so that it mixes into the remaining liquid moving along the path, it is possible to increase the oxygen content of the liquid immediately downstream from the rotor up to the range of 1 to 2 p.p.m. As the liquid then continues around its sewage treatment path, the oxygen will soon be gradually consumed by the aerobic bacterial action, until the oxygen content is again reduced to as little as zero to 0.25 p.p.m. The deflecting member of the present invention accordingly insures that the rotor member 23 is operating at all times at substantially its greatest efficiency, by receiving primarily that portion of the sewage liquid which has the lowest oxygen content.

In some cases, however, it may be desirable to permit some of the upwardly projected liquid particles to be immediately subjected to further projection and aeration by the same rotor. For this purpose, deflecting member 36 is preferably supported on frame 12 for relative movement from the forward position shown in FIG. 1 to at least one alternate or second position in which the liquid falling upstream from the rotor member can again pass through or under the same rotor member. For this purpose, deflecting member 36 is piv-

totally supported at 51 for swinging movement between the forward position of FIGS. 1, 2, and 4 and the second position shown in FIG. 5. The pivotal axis for such swinging movement is parallel to the axis of rotation of rotor shaft 27. Thus, the edge of deflecting surface 37 closest to rotor number 23 remains at substantially the same upstream location immediately adjacent the rotor, while the remaining portions of surface 37 are inclined upwardly in an upstream direction away from the rotor. This inclination of surface 37 urges a substantial portion of the projected liquid back downwardly along the surface 37 and over the downstream edge of that surface directly into the rotor member 23. Such liquid is then immediately subjected to further turbulence, aeration and possible projection. In this second position, in FIG. 5, some of the liquid striking the surfaces 37 and 42 may still be diverted laterally to the sides of the deflecting member and rotor assembly, but the inclination of surface 37 is sufficient to insure re-engagement of a substantial amount of liquid with the rotor 23 for further aeration of that portion of the liquid. The location of the pivotal axis of support 51 at a level near that of the rotor axis and spaced longitudinally between the main surface area of the deflecting member and the rotor axis when the deflecting member is in the forward position of FIGS. 1, 2, and 4, and with the pivotal axis 51 close to the outer periphery of rotor member 23, provides for convenient shifting of the deflecting member between its forward position and its second position, with a limited degree of movement and with immediate discharge of substantial portions of the liquid directly into the path of rotor 23 when the parts are in the second position shown in FIG. 5.

For the purpose of releasably retaining the deflecting member selectively in either of these positions, the deflecting member is provided with manually releasable retaining means, including one or more retaining arms 52. In this case, two such retaining arms are provided one at each side of the assembly. One end of each retaining arm 52 is pivotally connected at 53 to the upper corner or edge of the barrier edge 41 for swinging movement on a common axis parallel to the pivotal support axis 51 and the rotor axis 27. The other end 54 of each retaining arm 52 has a releasable first connecting means adapted for selective engagement with selected cooperating second connecting means spaced longitudinally on the frame 12. Thus fixed brackets 57 at the upstream corners of the side frame members 14 are located for selective connection to the retaining arm ends 54. As shown in FIG. 8, a manually removable connecting bolt 56 is inserted through aligned openings 58 and 59 in the respective retaining arm end 54 and fixed bracket 57. The inserted bolt portion is retained in position by a cotter pin or other manually removable pin 63 inserted in a cross opening 62 in the bolt portion to prevent inadvertent removal of the bolt 56. Other appropriate manually releasable connections may be used. Thus, when the parts are engaged as shown in FIGS. 4 and 8, the retaining arms 52 provide an effective brace for the upwardly projecting edges of the barrier edge portions 41, 42 to hold these portions firmly in position against the force of the projected liquid thrown against them by rotor member 23.

To move the deflecting member from the position of FIG. 4 to the position of FIG. 5, the bolt 56 is disengaged from the bracket 57 and the end 54 of retaining arm is then aligned with a second supporting bracket

64 on side frame member 14 at a location shown in FIG. 5. In this position the retaining arm 52 is substantially perpendicular and thus holds the deflecting member in the elevated second position shown in that figure.

The rotor assembly shown in the drawings also provides for movement of the deflecting member to a third selected position as illustrated in FIG. 6. For this purpose the bolt 56 is disengaged from bracket 64 and retaining arm 52 may be swung in a counter-clockwise direction as seen in FIGS. 5 and 6, while the deflecting member 36 swings further on its pivotal support 51 until the end 54 of retaining arm 52 can be aligned with a retaining bracket 66 at the downstream side of the rotor axis to secure the deflecting member 36 rigidly in the position of FIG. 6. In this position, it will be noted that retaining arm 52 has substantially the same length as that portion of that supporting frame 39 of the deflecting member 36 which extends beneath the main surface area 37. In the position of FIG. 6, the barrier edge portion 41 and its surface 42 are substantially horizontal. One or more lifting eyes 67 located along the barrier edge portion 41 can thus serve as means for engagement of suitable lifting hooks by which a crane or other lifting device can lift the entire rotor assembly in order to move it from one desired location to another.

FIG. 9 shows another embodiment in which a deflecting member 71 is supported for selective swinging movement between an upstream position (shown in solid lines at the right half of the figure) and a downstream position (shown in dotted lines at the left half of the figure). Deflecting member 71 bridges the liquid path beneath the rotor assembly and is supported at each of its side edges by arms 72 pivoted at 73 to the center of the assembly in the same vertical plane as the rotor axis 27. Pivotal support axis 73 is parallel to rotor axis 27. Securing members 74 fasten the member 71 to arms 72.

In the heavy-line upstream position, deflector 71 has a flat upper surface 76 which intercepts the upstream projected drops and deflects them laterally as in the arrangement of FIGS. 1 and 4. An upwardly projecting barrier edge portion 79 at the upstream end of surface 76 has a deflecting surface 78 which prevents upstream discharge of liquid from surface 76 and assists in deflecting the liquid to the sides of the assembly.

Member 71 is symmetrically constructed so that it can function in a similar manner when it is swung to a downstream position shown in dotted outline 88. Thus the opposite surface 77 of member 71, which was on the underside of the member in the upstream position will provide the upwardly facing deflecting surface when the member is in its downstream position. In that position a barrier edge portion 82 and deflecting surface 81 will prevent direct downstream discharge of liquid from surface 77 and will assist in guiding such liquid laterally and discharging it over the sides of surface 77.

The supporting arms 72 at opposite sides of deflecting member 71 are connected to each other by a cross member 83, to which one or more lifting eyes 84 may be secured. Thus the deflecting member 71 can be swung to still a third selective position, as shown in dotted outline 89. In this position a crane hook or other lifting device can be connected to lifting eyes 84 to lift the entire rotor assembly from one position to another.

Suitable supporting stops 86 at the upstream end of the rotor frame are engaged at the upstream end of sup-

porting arms 72 to support the deflecting member in the desired upstream position. Similar supporting stops 87 at the downstream end of the frame are engaged by the ends of supporting arms 72 to hold the deflecting member 71 in its desired downstream position.

The selective shifting of deflecting member 71 to either its upstream or downstream position provides the possibility of modifying the rate of flow at which liquid is fed in a downstream direction by a given rate of rotation of rotor 23. When member 71 is in its upstream position, the propulsion of the liquid underneath the rotor assembly will take place partly because of the direct engagement of the rotor blades with liquid portions which remain in the stream. Other liquid portions will be lifted up and projected with a significant downstream velocity. Thus when these additional liquid portions are permitted to fall directly back into the liquid downstream from the rotor, they will provide an additional propulsion effect. Selective positioning of deflector 71 at the downstream position 88 results in interception of at least part of the downstream projected liquid. Thus such liquid does not strike the surface with a downstream component of thrust, but is deflected laterally to the sides of the assembly and drops into the stream without contributing to its rate of flow.

At the same time, those particles of liquid which are projected upstream by rotor 23 can fall freely into the liquid path with a component of velocity and thrust in an upstream direction. These upstream projected particles, when allowed to reach the surface of the liquid, thus provide a braking or retarding effect on the rate of flow.

In contrast to the retarding effect on the rate of flow, when the member 71 is in downstream position, the location of the same member in its upstream position can significantly increase the propulsion effect, in addition to its previously described function of preventing immediate re-engagement of the upstream projected particles with the rotor member. The interception of these upstream projected drops eliminates their possible retarding effect on the rate of flow. At the same time, the particles of liquid which are projected downstream are free to strike the surface of the liquid in a downstream direction and increase the rate of flow. Thus the embodiment of FIG. 9 may be adjusted to achieve desired differences in either the extent of aeration or the rate of liquid flow or a combination of such factors. If a given sewage treatment installation includes a number of rotor assemblies, all of which tend to propel the liquid in a given path, there is the possibility that the rate of flow might become greater than 4 feet per second, which could cause unwanted wave action. The excess rate of flow can be controlled readily by shifting deflectors of the type shown in FIG. 9 to their downstream positions, with very little attenuation of oxygen input. Conversely, if maximum efficiency of oxygen absorption is desired, and if the rate of flow is not excessive, deflectors 71 can be moved to their upstream positions to make sure that each rotor is operating most efficiently on liquid of minimal oxygen content.

The liquid aerating rotor assembly described in this specification thus provides a new and improved device for controlled liquid aeration, which is particularly adaptable to treatment of sewage liquid by an aerobic bacterial activated sludge process. The device is capable of utilizing substantially the complete space above a rotor member, both upstream and downstream from

said member, for projection and aeration of liquid particles. The device further provides for selective control of the extent, if any, to which liquid particles projected upstream from such a rotor member are permitted to pass directly into the flow path for re-engagement with the same rotor member. In the preferred operation of the assembly, the liquid portions projected upstream of the rotor member are substantially diverted laterally for movement downstream past the rotor member without substantial immediate re-engagement of the aerated liquid portions with the same rotor member. The assembly includes means for selectively positioning a deflecting member at an alternate second position where at least some degree of immediate re-engagement of the upstream projected liquid with the same rotor member can take place. The deflecting member may also be positioned selectively to control the effective rate of flow.

It will be apparent to those skilled in the art that the particular shapes, dimensions, and other details of construction of the liquid aerating rotor assembly and its component parts could be further modified in various ways within the principles of the present invention. The present specification, however, sets forth some of the ways in which the invention may be put into practice, including the best mode presently contemplated for carrying out the invention.

We claim:

1. A liquid aerating rotor assembly for aeration of liquid during relative movement of the liquid and the rotor assembly along a desired path, said rotor assembly comprising a supporting frame, a rotor member rotatably supported on said frame for rotation on a horizontal axis extending transversely above the liquid path, power means for rotating the rotor around its axis, the rotor member having rotor surfaces for engaging the liquid and urging the liquid in a relative downstream direction along said path in response to rotation of the rotor, said rotor surfaces also lifting and projecting substantial portions of the liquid upwardly and forwardly from said rotor member in a relative upstream direction for aeration of the liquid as it is projected forwardly and falls downwardly toward the surface of the liquid in said path at a forward position relatively upstream from the rotor member, and a deflecting member supported on said frame in a forward position close to and upstream from the rotor member, said deflecting member having a deflecting surface intercepting at least some of the upwardly and forwardly projected liquid portions and guiding said portions laterally to at least one side of the liquid path, thereby preventing some of the projected liquid portions from returning to the liquid surface at a location where they will again be engaged and projected by said rotor member.

2. A liquid aerating rotor assembly according to claim 1 in which said rotor member includes a plurality of paddle wheel blades extending generally parallel to and spaced around said axis, said blades providing rotor surfaces extending radially outwardly from said axis and transversely of said path, each of said blades having a plurality of openings through its rotor surface for delivery of some liquid portions from the rotor surface through said openings and into engagement with a following blade.

3. A liquid aerating rotor assembly according to claim 2 in which the openings in the rotor surfaces of immediately successive blades are at different relative

locations in the respective blade surfaces for turbulent delivery of liquid portions through the openings of one blade surface into engagement with liquid portions carried by an imperforate portion of an immediately following blade surface.

4. A liquid aerating rotor assembly according to claim 2 in which an outer edge of each blade surface projects forwardly in the direction of rotor rotation, thereby delaying radial movement of liquid from the blade surface and increasing the effective upstream projection of liquid from the blade surface.

5. A liquid aerating rotor assembly according to claim 2 in which an outer edge of each blade surface projects forwardly in the direction of rotor rotation, thereby delaying radial movement of liquid from the blade surface and increasing the effective upstream projection of liquid from the blade surface, and in which the openings in the rotor surfaces of immediately successive blades are at different relative locations in the respective blade surfaces for turbulent delivery of liquid portions through the openings of one blade surface into engagement with liquid portions carried by an imperforate portion of an immediately following blade surface.

6. A liquid aerating rotor assembly according to claim 1 in which said rotor member includes a plurality of paddle wheel blades extending generally parallel to and spaced around said axis, said blades providing rotor surfaces extending radially outwardly from said axis and transversely of said path, and in which an outer edge of each blade surface projects forwardly in the direction of rotor rotation, thereby delaying radial movement of liquid from the blade surface and increasing the effective upstream projection of liquid from the blade surface.

7. A liquid aerating rotor assembly according to claim 1 in which said deflecting member is movable from said forward position to a second position at which the projected liquid portions are returned to said liquid path directly upstream from said rotor member for possible further engagement and projection of said portions by said rotor.

8. A liquid aerating rotor assembly according to claim 7 in which said deflecting member is pivotally supported for swinging movement between said forward and second positions around a pivotal axis parallel to said rotor axis.

9. A liquid aerating rotor assembly according to claim 8 in which said pivotal axis is located at a level near said rotor axis and spaced longitudinally between said deflecting member and rotor axis when the deflecting member is in forward position, said deflecting surface having a generally horizontal main area bridging the liquid path upstream of the rotor when the deflecting member is in its forward position, and said main area extending upwardly and forwardly from the pivotal axis when the deflecting member is in its second position.

10. A liquid aerating rotor assembly according to claim 9 in which said deflecting surface has an upwardly projecting upstream barrier edge portion blocking upstream discharge of liquid from the main area of said surface into said liquid path when the deflecting member is in forward position, said barrier edge portion guiding the forwardly projected liquid portions laterally to the sides of the liquid path for downstream passage around the ends of said rotor member.

11. A liquid aerating rotor assembly according to claim 8 in which deflecting member is selectively movable to a third position, said deflecting member having connecting means for engagement by a lifting device for lifting and moving the deflecting member and remaining portions of the rotor assembly as a unit, when the deflecting member is in said third position.

12. A liquid aerating rotor assembly according to claim 11 including manually releasable retaining means for selectively and rigidly securing said deflecting means in each of its three positions on said frame.

13. A liquid aerating rotor assembly according to claim 12 in which said releasable retaining means includes a pair of retaining arms each having one end pivoted to an outer corner of said deflecting member for swinging movement on a common axis parallel to said pivotal support axis and rotor axis, the other end of each retaining arm having releasable first connecting means, and said frame having three corresponding pairs of cooperating second connecting means spaced longitudinally on said frame for selective engagement and retention of said releasable first connecting means.

14. A liquid aerating rotor assembly according to claim 7 in which said deflecting member is supported for movement between said forward position on said frame upstream from the rotor member and a second position on said frame downstream from the rotor member, said frame providing a relatively clear path for movement of said projected liquid portions directly back into the liquid path at a location upstream from the rotor member, when the deflecting member is in its second position.

15. A liquid aerating rotor assembly according to claim 14 in which the deflecting member, in its second position intercepts some of such upwardly projected liquid portions as are falling back toward the liquid downstream from the rotor and deflects such portions into the liquid in a direction reducing the liquid propulsion effect otherwise caused by impact of such portions with the liquid at an angle having a downstream component of thrust, selective movement of the deflecting member between its first and second positions thereby modifying the rate of relative liquid movement along said path.

16. A liquid aerating rotor assembly according to claim 1 in which the deflecting surface of the deflecting member includes a generally horizontal main surface area substantially bridging the liquid path directly upstream from the rotor and an upwardly projecting upstream barrier surface area blocking direct upstream discharge of liquid from the main surface area into said liquid path ahead of the rotor member, and said barrier surface area guiding the forwardly projected liquid portions laterally to at least one side of the liquid path for relative downstream passage around an end of the rotor member without substantial further aeration by the same rotor member.

17. A liquid aerating rotor assembly according to claim 16 in which the deflecting member is pivotally supported on said frame for swinging movement around a pivotal support axis parallel to the rotor axis and spaced longitudinally of the liquid path between the main surface area and the rotor axis, said deflecting member having manually releasable retaining means for selectively and rigidly securing the member in its forward position, the retaining means including a retaining arm having one end secured to the deflecting

member near an upper edge of the upwardly projecting upstream barrier surface area, the retaining arm having its opposite end secured to said supporting frame at a location thereon spaced in an upstream direction from said upper edge of the barrier surface area and thereby providing a reinforcing connection between said upper edge and frame for holding the barrier surface area firmly in position against the upstream forces applied by the forwardly projected liquid portions.

18. A liquid aerating rotor assembly according to claim 1 in which said supporting frame has a plurality of supporting floats spaced laterally from each other at opposite sides of said liquid path and providing a relatively clear passage for relative fluid movement directly along the path and into the engagement with the rotor member.

19. A liquid aerating rotor assembly for aeration of liquid during relative movement of the liquid and the rotor assembly along a desired path, said rotor assembly in unobstructed and direct communication with the atmosphere and comprising a supporting frame, a rotor member rotatably supported on said frame for rotation on a horizontal axis extending transversely above the liquid path for projection of the liquid both upwardly above the rotor and forwardly in an upstream direction along said path, and power means for rotating the rotor around its axis, the rotor member having a plurality of paddle wheel blades extending generally parallel to and spaced around said axis, said blades providing rotor surfaces extending radially outwardly from said axis and transversely of said path for engaging the liquid and urging the liquid in a relative downstream direction along said path in response to rotation of the rotor, each of said blades having a plurality of openings through its rotor surface for delivery of some liquid portions from the rotor surface backwardly through said openings and into engagement with a following blade.

20. A liquid aerating rotor assembly according to claim 19 in which the openings in the rotor surfaces of immediately successive blades are at different relative locations in the respective blade surface for turbulent delivery of liquid portions through the openings of one blade surface into engagement with liquid portions carried by an imperforate portion of an immediately following blade surface.

21. A liquid aerating rotor assembly according to claim 19 in which an outer edge of each blade surface projects forwardly in the direction of rotor rotation at a slight angle from the radially extending rotor surface,

thereby delaying radial movement of liquid from the blade surface and increasing the effective projection of liquid from the blade surface both upwardly above the rotor and forwardly in an upstream direction along said path.

22. A liquid aerating rotor assembly according to claim 21 in which the openings in the rotor surfaces of immediately successive blades are at different relative locations in the respective blade surfaces for turbulent delivery of liquid portions through the openings of one blade surface into engagement with liquid portions carried by an imperforate portion of an immediately following blade surface.

23. A liquid aerating rotor assembly according to claim 19 in which at least some of said openings are completely surrounded by imperforate portions of the rotor surface in which said openings are provided, the imperforate portions of the rotor surface urging the liquid in its relative downstream direction along said path.

24. A liquid aerating rotor assembly according to claim 23 in which all of said openings are completely surrounded by imperforate portions of the rotor surface in which said openings are provided.

25. A liquid aerating rotor member for aeration of liquid during relative movement of the liquid and the rotor member along a desired path; the rotor member being in unobstructed and direct communication with the atmosphere and constructed for rotation around a horizontal axis extending transversely above the liquid path, said rotor member having a plurality of paddle-like blades extending generally parallel to and spaced around said axis, said blades having main rotor surfaces extending radially outwardly from said axis and transversely of said path for engaging the liquid and urging the liquid in a relative downstream direction along said path in response to rotation of the rotor, and said blades also having outer edge surfaces projecting forwardly, in the direction of rotor rotation, from said main rotor surfaces, said outer edge surfaces increasing the effective lifting and projection of liquid by the rotor both upwardly above the rotor and forwardly in an upstream direction along said path.

26. A liquid aerating rotor member according to claim 25 in which at least some of the main rotor surfaces have a plurality of openings therethrough surrounded by imperforate surface portions for delivery of some liquid portions from the main rotor surfaces of one blade through said openings and into engagement with a following blade.

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