

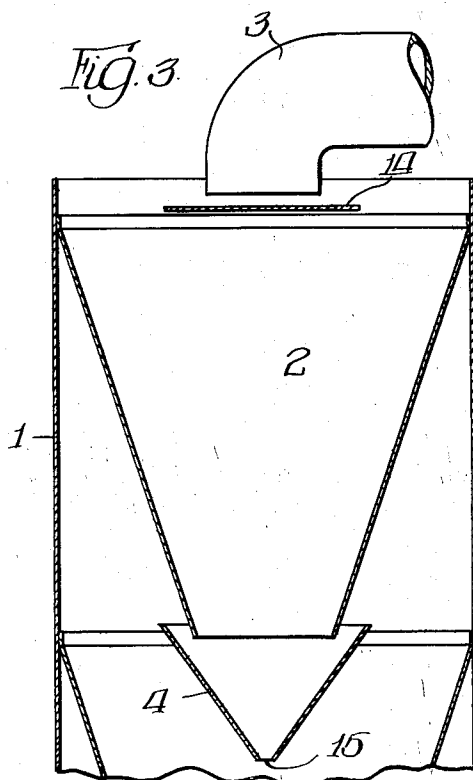
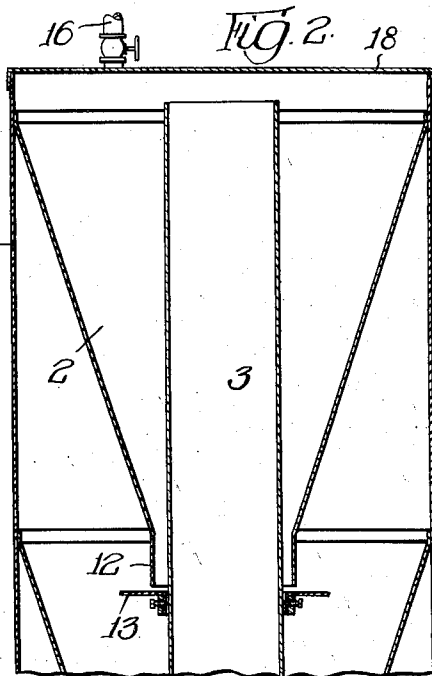
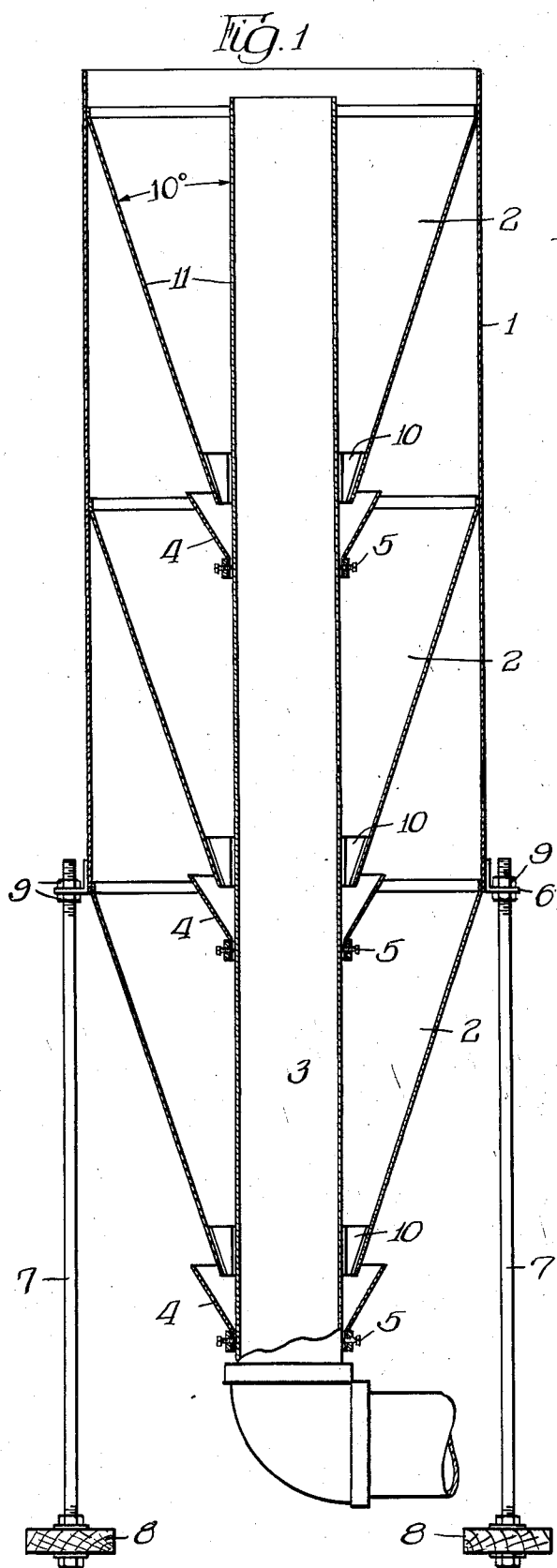
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APPARATUS FOR AERATING LIQUIDS

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APPARATUS FOR AERATING LIQUIDS

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Our invention relates to the treatment of liquids and more especially to a treatment wherein the liquid is contacted with a gas or vapor. It is directed to providing an improved apparatus for such treatment. An object of our invention is to provide such an apparatus whereby large quantities of liquid may be treated in an apparatus that is simple and compact, occupying little space. Another object is to provide for such treatment in an apparatus that may be totally enclosed whereby splashing is overcome and also interference by a surrounding atmosphere avoided. Another object is to prolong the period of treatment by the provision of retention pools wherein the liquid is held following exposure to the gas. Another object is to provide such an apparatus wherein the liquid is repeatedly and alternately brought together in a body and separated as a spray or sheet, whereby most thorough and complete treatment may be received. Another purpose is to improve such treatment by providing a process wherein contact and interaction between the liquid and gas is secured by repeatedly varying the nature of the flow of the liquid during its passage and to provide an apparatus wherein a variety of suitable forms of flow are secured.

Other objects will become apparent from consideration of the following disclosure. It will be apparent also that instead of being looked at from the aspect of liquid treatment it may be regarded also as providing an excellent means for the treatment of a gas.

Since the most common such liquid treatment and that carried out on the most extensive scale is the aeration of water, our invention will be described in connection therewith and from this description its utility and how it may be employed for other treatments will be apparent.

A great variety of methods and equipment have hitherto been used for the aeration of water. In some cases the water is sprayed out into the air through a nozzle under pressure and allowed to fall back into a pan. This is an effective method but requires much area as the water is usually projected several feet vertically and horizontally. Thus a common type of nozzle throwing 150 gallons per minute will cover an area about 15 feet in diameter. In another method the water is trickled down over pieces of coke, stone or other hard substance held in a frame or tray. In the best construction, the coke or other material is divided into several shallow beds spaced apart vertically so that the water will drip from one tray to the next, as well as

trickle over the coke. With a proper number, depth and spacing of trays, the flow may be of the order of 10 gallons per sq. ft. per minute. A third method is to flow the water over a series of vertically spaced trays. Usually these are circular with a smaller diameter tray at the top, the diameter increasing downward. With such construction the bottom tray may be about 5 feet in diameter for a capacity of 150 gallons per minute. These are the accepted and commonly used forms or methods, there being considerable variation in details of construction and arrangement. Occasionally some mechanical means such as compressed air or paddles is used but these cost more for operation and are only adopted when some special condition is to be met, such as lack of head. The simplicity and small space required by our improved method and apparatus and other advantages thereof as compared with means such as those referred to will be apparent from what follows, it being noted that we have satisfactorily handled capacities up to 400 gallons per minute in an apparatus only 24 inches in diameter.

The aeration of water to effect improvement therein is widely carried out, there being a large number of plants, large and small, employing this process, either alone or in connection with some other treatment. The improvement sought in a water may be any one or more of several kinds and may result from either a mechanical or a chemical effect had by aeration, or both. Thus the removal of dissolved carbon dioxide from water by aeration is probably purely mechanical while the changing of ferrous iron to ferric form to cause or aid precipitation thereof is, so far as such action is concerned, purely chemical. Aeration of water is widely used to overcome objectionable tastes or odors and in such cases the effect may be the result of either chemical or physical action, or both, depending upon the particular impurity or impurities present. In such cases there may be oxidation or mechanical separation, or both.

In some cases the amount of air required to treat a given volume of water may be very small indeed, as for instance to raise ferrous iron to ferric form. The amount of iron present in water is very small, usually only a few parts per million, and the amount of oxygen required proportionately small. Usually there is no objection to applying much more air than is needed to supply the required oxygen and it may be desirable to do so for other purposes; however where excess oxygen is to be avoided or where our method is used for some other treatment, our enclosed apparatus

where the amount of air admitted may be governed and where there is no large space within the apparatus for air to accumulate and where the air is carried through and discharged with the liquid, provides for excellent control. Also our method has advantages that are particularly apparent in cases that permit or require uniform treatment of a large volume of liquid with a small volume of gas or when the treatment requires very intimate and prolonged contact. These arise out of the characteristics of our method and apparatus wherein the gas is first thoroughly mingled with or beaten into the liquid, the two then being wholly or partially separated, these actions being repeated as often as is considered necessary, while periodically the water passes through what serve as retention chambers to delay its passage so that reaction time is provided for, and in a similar manner the gas is held so as to be fully utilized.

In the accompanying drawing, Fig. 1 is a vertical sectional view of one form of our apparatus.

Fig. 2 is a similar view of but a portion of an apparatus and serves to illustrate some of the elements of Fig. 1 in modified form.

Fig. 3 is a partial vertical sectional view similar to that of Fig. 2 and showing another form of construction and/or arrangement of parts.

In these figures, 1 designates an enclosing shell shown in the form of a cylinder and 2 the members of what may be a series of inverted, truncated cones or funnels mounted within the cylinder 1 and preferably sealed thereto around their upper edges. Below the open ends of cones 2 are positioned the smaller cones 4, the upper edges of which are spaced above the lower edges of cones 2, as hereinafter referred to. In Fig. 1, the cones 4 are shown mounted on the central riser pipe 3 and adjustable thereon by means of set screws 5 and ordinarily they should fit the pipe loosely or a drain hole may be provided so that they will empty when treating flow ceases. The rods 7, extending from the base 8 through lugs 6 support cylinder 1 and with it the cones 2, and by means of the nuts 9 these parts may be raised and lowered to space the lower ends of cones 2 from cones 4 as required. Spacers 10 are shown by means of which the lower ends of cones 2 are held concentric with pipe 3 but these are not an essential part of the apparatus.

In operation water flows through pipe 3 and in the form shown in Figs. 1 and 2 overflows at the top thereof. Some of the water may run down the outside of the pipe but at normal rates of operation the water mushrooms out at the top so that in greater part it strikes the walls of the upper cone near the top. The water then rushes down the wall of the cone, which, due to the restriction below, is partly filled with water. While the water is mushrooming across to the cone and as it flows down the latter, there is surface exposure to air but also a considerable amount of air becomes mingled with the water in the form of small bubbles. As this rushing flow of water down the steep sides of the cone strikes the surface of the pool of retained water, it entrains still more air and because of the considerable energy in the rapidly flowing water, sets up a very violent agitation or turbulence in the pool so that the bubbles of air are carried through the volume thereof and mostly retained so as to be carried down through the orifice opening into the next chamber. The water flowing downwardly out of cone 2 is diverted into a reverse direction by cone 4 and thrown upwardly and out-

wardly, striking the wall of cylinder 1 or that of the next cone 2 according to the volume of flow. In the second cone the actions as above described are repeated but normally the water is projected upwardly and outwardly with considerably more velocity and energy from cone 4 than from the top of entry pipe 3 and consequently there is a greater spraying and spattering action in the second and subsequent chambers, or if there be but one cone then the spraying into the air occurs on discharge therefrom.

It will be apparent that during the passage of the water through the path referred to it is continually in contact with the air, and also that this contact is had in several different ways. Thus the water is first sprayed through the air, then it flows down the walls of the cone, there is the turbulent body of mixed water and air in the lower end of the cone and from here it is finally sprayed out again. These variations in conditions of flow may not affect the chemical reactions directly in the sense of changing the kind of reaction had but because of the repeated breaking up and remingling of the body of water they secure not only excellent opportunity for contact and absorption but provide for thorough diffusion. Furthermore time for reaction is provided by the retention period and this under conditions such that more oxygen is at hand for absorption if needed. If the result sought be not oxidation as just spoken of but a mechanical effect such as removal of a dissolved gas, the facilities provided are equally good. In such a case the result obtained is ultimately dependent upon partial vapor or gas pressures, but the degree of contact and thoroughness of mingling of the water and washing gas and also the time element are very important and these are all provided for in an excellent manner, it being kept in mind that large volumes of air will be drawn through.

It will be understood, of course, that the number of cones may be more or less than the three shown in the drawing for purpose of illustration, and also that the size of the cones will be dependent upon the amount of water to be treated. While the number of cones may be so varied, we have so far not found any appreciable benefit by using more than three. Thus in treating a water taken from a small lake that had abundant algae growth, the water having pronounced and objectionable taste and odor, we found improvement using up to three cones but not beyond that number and our observations lead us to believe that in the great majority of cases this is the optimum number. We found also that the form or proportions of the cones have some importance, probably from some effect on the kind or degree of mixing or agitation obtained and the amount of air entrained and carried along. While we tried cones of various angles and a certain range is permissible, our best results were had when the walls of the large cones 2 were at an angle of about 10° from the vertical, that is, when the included angle was about 20°.

The size of the cones will of course depend upon the quantity of liquid to be treated and only general information can be given. The diameter of conduit 3 will be chosen according to the flow and the top of it should be at or a little above the level of the top of the upper cone. The diameter of the cone 2 at the top should be such that the water mushrooming out from the pipe will strike it near the top at the maximum rated flow. The annular space or orifice between the pipe and the cone at the bottom thereof should be such that

at the maximum water flow the cone will not become more than about half full. The angle and other proportions of the cones 4 are not so important, although we have used satisfactorily an included angle of about 30°. They should be spaced upon this pipe 3 so that each will be vertically in the same relation to its cone 2. These cones 4 serve a double purpose. They not only spray the water upward and outwardly as previously referred to, but also when the part 1 carrying the cones 2 is raised or lowered by means of the nuts 9, they may serve to vary the restriction at the bottom of the cones 2 and so to adjust for varying flows of water. The top of cones 4 should not extend too far above the bottom of cones 2 or too much liquid may be held back in 2 and also proper spraying effect may not be secured. While great exactness here is not required, yet at the normal rated flow the distance from the bottom of a cone 2 to the top edge of its associated cone 4 may well be of the order of about one inch. In general, flows over the range of 2-1 may be taken care of without such vertical adjustment of cones 2 but additional restriction is usually desirable at lower flows. This is partly to secure proper spraying out but also to secure proper retention in the cone 2. While for the reasons given and others that are apparent complete specific data cannot be given, yet it may be said that the apparatus shown in Fig. 1 is quite closely to scale for an apparatus now in use handling from 200 to 400 gallons per minute, the diameter of the cones 2 at the top being in this case 24 inches and the diameter of pipe 3 being 6 inches.

In Fig. 2 the cone 2 is provided with a straight section or skirt 12 at the bottom and instead of the cones 4 of Fig. 1 a flat plate 13 is indicated. These forms may be sometimes used either singly or in combination, as where conditions are otherwise favorable to ease of treatment, but they have not been found as satisfactory as the form of Fig. 1. The part 12 by providing a downdraft or so-called negative head effect secures a greater flow without causing too deep a pool or so large a volume to be held in 2.

In Fig. 3 is shown another modification that may be used when the supply is from above. In this form the pipe 3 discharges onto plate 14. The discharge from 2 is through a circular orifice instead of an annular orifice at the bottom thereof, into cone 4. Cone 4 is provided with a drain hole 15 and may be supported by straps not shown from cones 2, or from enclosure 1 if adjustment is not required. Where adjustment is desirable, a central rod or column extending from the floor or from plate 14 corresponding to pipe 3 of Fig. 1, will carry parts 4. The manner of securing such support will be readily understood without further explanation.

Very considerable quantities of air are carried through the apparatus with or by the water so that ample opportunity for aerating effect is provided. In general we prefer that part 1 form a tight enclosure and we have so far for some reason had the best results with that construction, but we do not doubt that in some cases this will not prove necessary. If only a limited quantity of air or other gas is to be drawn through, a cover 18 having the inlet 17 containing the adjustment 16 may be provided, as indicated in Fig. 2.

It will be apparent from the preceding description taken with the drawing, that our invention provides a novel and useful method of treating

a liquid with a gas that is very simple and effective, the liquid and gas being contacted and the contact prolonged under varying and always favoring conditions while at the same time the liquid is violently agitated and thoroughly mixed, also that we have provided a very simple and compact apparatus whereby our improved treatment may be carried out and the objects sought secured.

We claim:

1. In apparatus of the character described, the combination of a water supply pipe, a series of vertically spaced hydraulic head providing and water retaining basins each of which has a submerged discharge opening in the lower portion thereof, said openings being so restricted in area as to cause water to be retained in said basins to build up a head therein over said openings, and means that include a basin wall whereby the water is caused to flow radially outward and then radially inward during passage from the discharge opening of an upper basin to that of the next lower basin.

2. Apparatus of the character described comprising a vertically disposed fluid inlet pipe, a plurality of relatively large vertically spaced liquid retaining basins each having a submerged liquid discharge opening in the lower part thereof, said openings being of such restricted area as will at normal flow retain a substantial depth of liquid in said basin, and a relatively small flow guiding and directing member intermediate upper and lower discharge openings, said member being closed at the bottom, said basins and said members being symmetrically disposed circumferentially of said pipe.

3. In apparatus of the class described, the combination of a water supply pipe, a series of vertically spaced hydraulic head providing basins each having a submerged discharge opening in the lower portion thereof, the upper of said basins being so placed as to receive the discharge from said pipe, a substantially smaller and shallower intermediate basin below each of said discharge openings to receive discharge therefrom, said intermediate basins being closed at the lower portion and so shaped at the sides as to direct upwardly the flowing water.

4. In apparatus of the character described, the combination of a liquid inlet pipe and a series of regularly vertically spaced, alternately larger and smaller basin members mounted below the discharge end of said inlet, said larger members being of substantial liquid holding depth to serve as liquid retention basins and being provided in their lower part with a submerged discharge opening of such restricted area as to require a head thereover equal to at least about one half the basin depth to effect normal flow discharge therethrough, there being a smaller member under each such opening to receive the discharge therethrough, said smaller members being closed at their lower portion and discharging over their upper edges.

5. In apparatus of the character described, a vertical cylindrical enclosing member, a plurality of inverted truncated conical members mounted concentrically therein and attached thereto, an inlet conduit concentric therewith and having its discharge end adjacent the upper part of the upper cone, and a plurality of inverted truncated conical members mounted on said conduit, each in such vertical spaced relationship with one of the first named conical members as to restrict discharge therefrom.

6. The combination with the apparatus of claim 5 of adjusting means for varying the spacing between the two described sets of conical members.

7. An aerating apparatus comprising in combination a central vertical inlet conduit, an outwardly and upwardly flaring ring mounted thereon, a cylindrical enclosing ring surrounding said conduit, said enclosing ring being of substantially greater diameter than the conduit, an inwardly and downwardly flaring ring mounted on said enclosing ring, and mounting means for holding

said enclosing ring in position such that the lower end of the inwardly and downwardly flaring ring is within and below the upper edge of the first named ring.

8. The apparatus of claim 7 wherein the mounting means is provided with adjusting means for varying the vertical spacing of said inwardly and outwardly flaring rings.

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