

Aug. 9, 1955

R. A. WHITLOCK, JR

2,715,098

BASE EXCHANGE WATER TREATMENT APPARATUS

Original Filed Dec. 23, 1949

3 Sheets-Sheet 1

Fig. 1

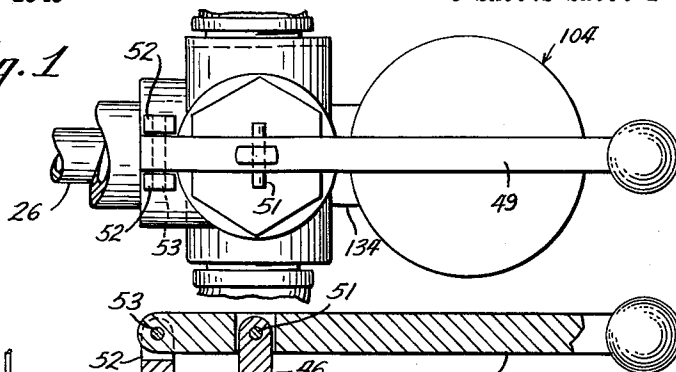
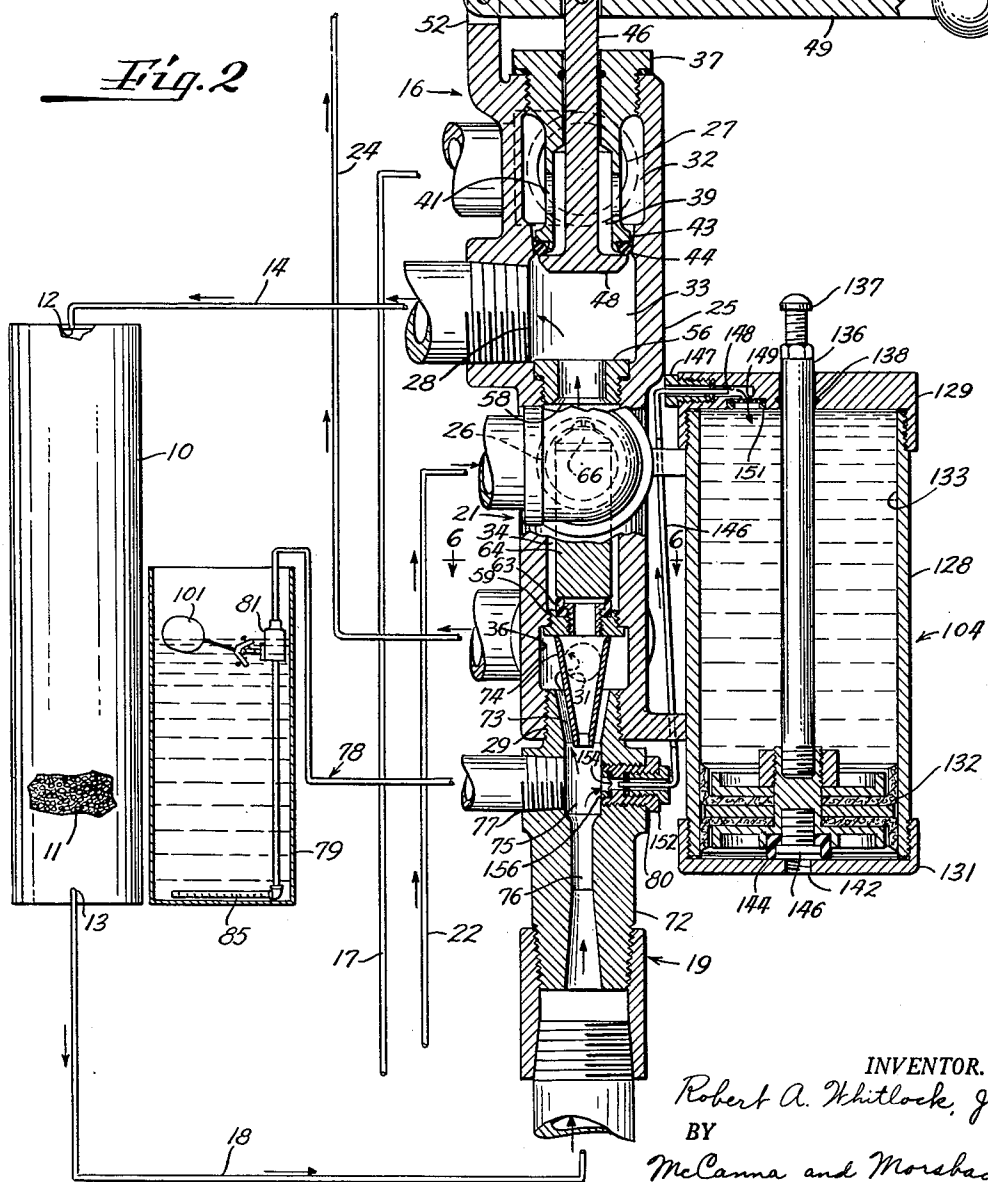


Fig. 2



INVENTOR.

Robert A. Whitlock, Jr.

BY

McCanna and Morebach

ATTYS.

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R. A. WHITLOCK, JR

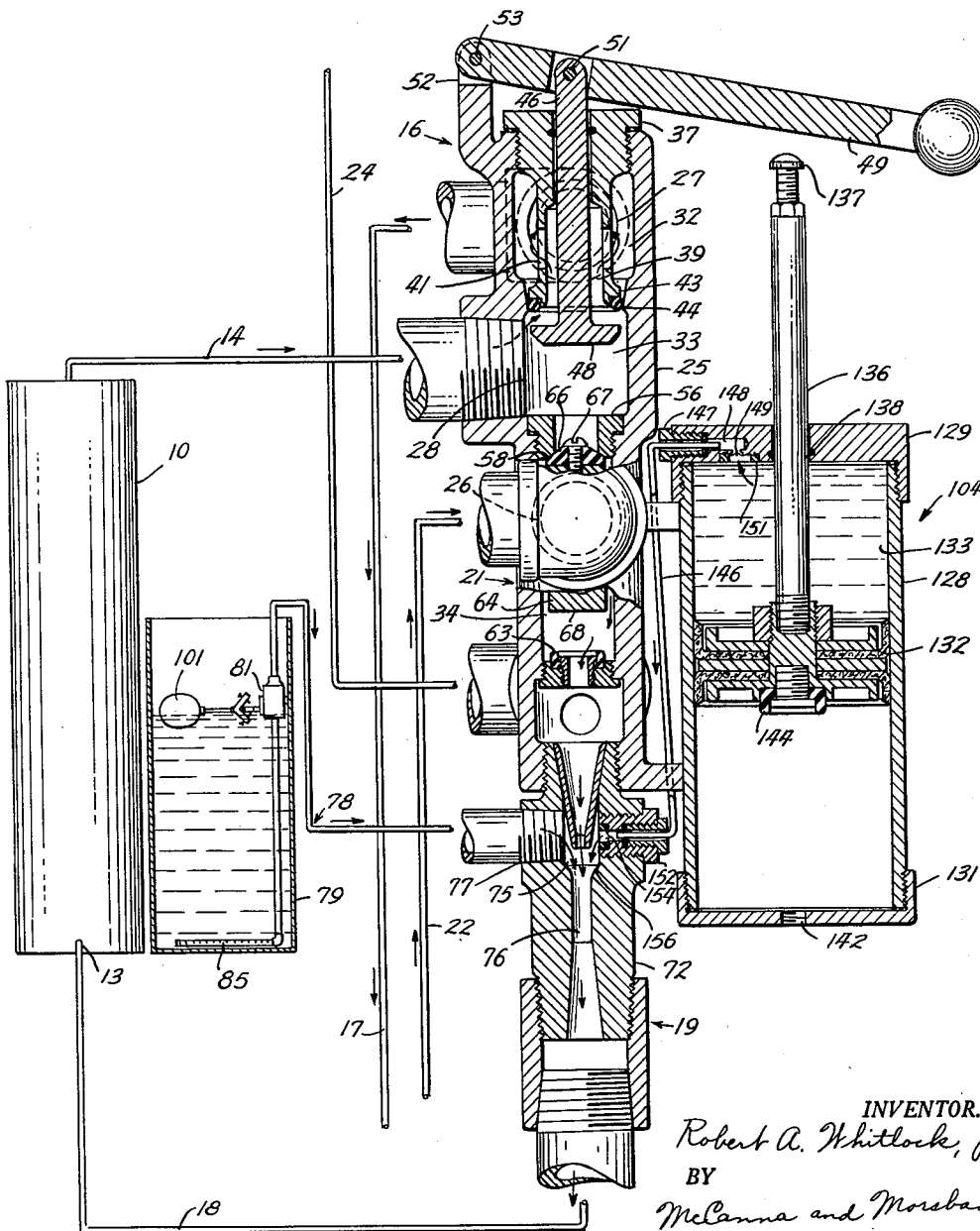
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3 Sheets-Sheet 2

Fig. 3



INVENTOR.
Robert A. Whitlock, Jr.
BY
McLanna and Morsbach

ATTYS.

Aug. 9, 1955

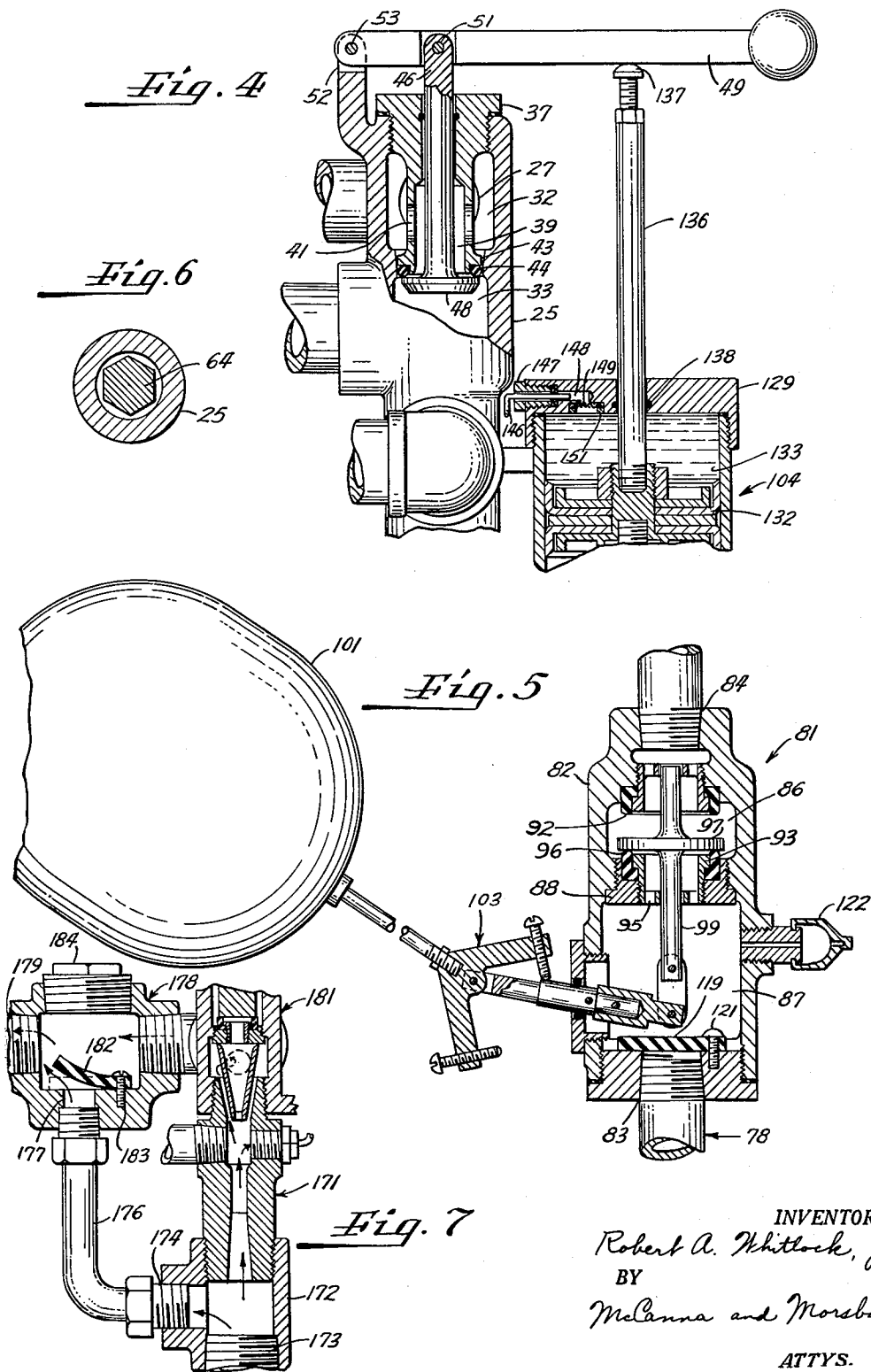
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2,715,098

BASE EXCHANGE WATER TREATMENT APPARATUS

Robert A. Whitlock, Jr., Rockford, Ill., assignor to Automatic Pump & Softener Corporation, Rockford, Ill., a corporation of Illinois

Continuation of application Serial No. 134,733, December 23, 1949. This application February 2, 1953, Serial No. 334,582

19 Claims. (Cl. 210—24)

This invention relates to liquid treating apparatus and more particularly to water treating apparatus.

Heretofore liquid treating apparatus has not been entirely satisfactory in all respects. For example, in manually operated liquid treating apparatus, inherently requiring a large number of valves, the user has to manually pre-position all the valves to effect each of the different steps or phases of operation such as treating the raw liquid supply, rinsing, regenerating and backwashing. This is time-consuming, bothersome and in many instances the user neglects to or forgets to set the valves for the different phases of operation of the apparatus as soon as they should be set with the consequence the apparatus does not operate as intended or at its greatest efficiency. In semi-automatic apparatus the equipment used therein, such as electric controls, motors and clocks, in addition to conventional equipment makes such apparatus too complicated and costly for ordinary household use, both from an installation standpoint and a maintenance standpoint. For example, during the installation of such equipment requiring permanent type electrical wiring, both an electrician and plumber must be employed. This increases the installation cost. Also in the event that repairs are necessary on such apparatus both an electrician and a plumber may be required to service the existing equipment, thereby increasing service costs.

An object of this invention is the provision of liquid treating apparatus that may be manually operated or semi-automatic operated, as desired, that may be produced at a relatively low cost and that is operated by hydraulic means.

Another object of the invention is the provision of liquid treating apparatus of the above character having novel control means for controlling the operation of the apparatus.

Another object of the invention is the provision of apparatus of the above character having novel timing means for controlling the operation of the control means so that the apparatus may be returned to a liquid treating condition upon the lapse of a preselected period of time.

Another object of the invention is the provision of liquid treating apparatus having novel injector means defined by a nozzle movable between opposed positions in response to a change in the direction of flow of the liquid through the injector means and that defines, in one position, an injector and in the other position permits the unrestricted flow of liquid through the injector means.

Another object of the invention is the provision of liquid treating apparatus having novel control means that effects a complete cycle of operation of the apparatus in response to opening the drain line.

Other objects and advantages of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings, in which—

Figure 1 is a plan view of a drain valve, flow control

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valve, and timer utilized in the liquid treating apparatus embodying the present invention;

Fig. 2 is a diagrammatic view of liquid treating apparatus showing the drain valve, the flow control valve, the injector and timing means in the service positions;

Fig. 3 is a view similar to Fig. 2 with the components of the apparatus in a position for effecting regeneration, and rinsing of the exchange material;

Fig. 4 is a side elevational view of the drain valve and timing means showing the plunger of the timing means engaging the manually operated lever of the drain valve to effect closing of the drain line;

Fig. 5 is a sectional view of the valve mechanism in the reagent tank;

Fig. 6 is a sectional view taken substantially along the line 6—6 of Fig. 2; and

Fig. 7 is a fragmentary sectional view of a modification of the invention showing a bypass around the injector.

This is a continuation of my copending application Serial No. 134,733 filed December 23, 1949, now abandoned, entitled "Base Exchange Water Treatment Apparatus."

In general the liquid treatment apparatus comprises a treatment tank 10, a regenerant tank 79, and a novel flow control apparatus for controlling flows to and from the treatment tank. The tank 10 of conventional construction as shown in Fig. 2, contains a bed of base exchange material 11. At its top and bottom the tank 10 is provided with pipe connections 12 and 13. A circuit conduit 14 connects the top connection 12 with a drain valve 16 connected in a drain line 17. A circuit conduit 18 connects the bottom connection 13 with an injector 19 while inlet valve 21 connected in a raw water supply line 22 is disposed between the drain valve 16 and the injector 19 for alternately directing the flow of water between the opposite ends of the reaction tank. While it is to be understood that the drain valve, the inlet valve, and the injector may be spaced apart as separate units and interconnected by suitable conduit, for purposes of illustrating one embodiment of the invention, they are connected together as a single compact multiport control valve as disclosed and claimed in my copending application, Serial No. 134,732, filed December 23, 1949.

In general the control valve includes a body 25 having an inlet port 26 connected to the raw water supply line 22 attached to a source of liquid under pressure such, for example, as a municipal water supply system, a drain port 27 adjacent the upper end of the body as shown in Fig. 2, connected with the drain line 17, a top port 28 between the inlet port 26 and the drain port 27 and arranged to be connected to the conduit 14, a bottom port 29 and a service port 31 between the inlet port 26 and the bottom port 29, in communication with a service line 24. The body is formed with a central passage extending lengthwise of the body divided into a plurality of chambers 32, 33, 34 and 36. The chamber 32, constituting a part of the drain valve 16, is at the upper end of the body in communication with the drain port 27 and is formed by an annular groove on a stem guide insert 37 threaded in the upper end of the body and an annular groove formed in the side walls of the body. An O-ring 44 is secured to the lower end of the insert 37 to define a valve seat facing the chamber 33 while an axially extending passageway 39 encircled by the valve seat effects communication between the chamber 33 and the chamber 32 through apertures 41 in the insert. A stem 46 extends through the stem guide insert 37 and is formed with a disc or valve element 48 shaped to seat against the valve seat 44. A lever 49 is pivotally connected, inter-

mediate its ends, with the outer end of the stem by a pin 51 and one end of the lever 49 is pivotally mounted, by a pin 53, on an upstanding bracket 52 at one side of the body 25. The opposite end of the lever extends outwardly from the other side of the body and terminates in a handle portion shaped to be conveniently grasped by an operator. The lever 49 is arranged so that when the free end of the lever as shown in Fig. 2 is pushed downward, the valve element 48 is moved rapidly away from the valve seat 44 as shown in Fig. 3 thereby placing the drain port 27 in communication with the port 28 and when the lever 49 is pulled upwardly the valve element 48 seats on the valve seat 44 to close communication therebetween.

The chamber 33 is defined by the inner end of the insert 37 and a ported insert 56 spaced from the insert 37 and threaded into the body passageway at a position between the top port 28 and the inlet port 26. The end of the insert adjacent the chamber 34 is preshaped to define a valve seat 58. The chamber 34 of the inlet valve is defined by the insert 56, and a ported insert 59 spaced from the insert 56 and threadably received in the body passageway at a position between the inlet port 26 and the ports 29 and 31. The inlet port 26 communicates with the valve chamber 34 between the inserts 56 and 59 and the ports in these inserts define outlet ports at the opposite ends of the valve chamber. A gasket is secured to the insert 59 to have an annular shoulder 63 extend inwardly of the chamber 34 to define a valve seat. Disposed within the chamber 34 is a valve member comprising spindle or plunger 64 having a generally hexagonal shape (Fig. 6) and shorter than the distance between the valve seats 58 and 63. A gasket 66 is attached to the upper end of the plunger as by a screw 67 while the lower end 68 of the plunger is substantially flat. The plunger is normally biased to a position closing one of the outlet ports, referred to as the normally closed outlet port, and opening the other of the outlet ports, referred to as the normally open outlet port. In the illustrated form of the invention, the valve member has a weight to normally gravitate through the liquid in the valve chamber to a position closing the lower outlet port and opening the upper outlet port. The plunger 64 is constructed so that it can be moved from a position closing the normally closed port, as shown in Fig. 2, to a position closing the normally open port, as shown in Fig. 3, in response to a pressure differential existing between the inlet port 26 and the ports 29 and 31, or between the chamber 33 and the chamber 34 while at the same time being heavy enough to return to the position shown in Fig. 2 when the pressure heads in the chambers 33 and 34 are substantially equal.

The injector 19, in this embodiment of the invention, is connected to the body 25 as by having a sleeve 72 threaded into the port 29 to define with the insert 59, the chamber 36 at the lower end of the body. The end of the sleeve threaded into the body 25 is formed with a frusto-conical shaped seat 73 with the larger end of the recess adjacent the chamber 36 and in effect defining a continuation thereof. A frusto-conical shaped nozzle 74 shaped to seat snugly in the seat 73 is disposed in and "floats" in the chamber 36 and is movable between a position in which the enlarged end of the nozzle 74 abuts against the insert 59 and a position in which the nozzle 74 is disposed in the seat 73 as shown in Fig. 3. When the nozzle is in the latter position, it defines an injector and when it is in the former position the nozzle is disposed so that liquid flowing through the sleeve 72 passes into the chamber 36 in a relatively unimpeded manner. Thus in the latter position of the nozzle the sidewalls defining the seat 73 and the outer surface of the nozzle 74 are spaced to define an annular passageway having a larger area than the discharge orifice or opening in the nozzle. A chamber 75 is formed in the central portion of the

sleeve while the outer end of the sleeve has a passageway 76 shaped to define a throat portion and an outwardly flaring portion. A port 77 for connection with a brine supply line 78, in communication with a regenerant tank 79, and a port 80 are formed in the sleeve to be in communication with the chamber 75.

The regenerant tank 79 may be of any conventional construction. As shown the regenerant line 78 enters the tank 79 through its open upper end and terminates in a horizontally disposed intake 85 at the bottom of the tank. A float operated valve 81, of the type disclosed and claimed in Patent No. 2,558,471 is connected in the regenerant line 78 as shown in Figs. 2 and 3 to control the flow of liquid therethrough. The valve is best shown in Fig. 5 and in general includes a body 82 having a lower port 83 in communication with the bottom of the tank 79 and an upper port 84 in communication with the injector 19 through the line 78. Disposed within the body are two chambers 86 and 87 defined by the ends of the body and an insert 88 between the ports 83 and 84. The top of the chamber 86 is formed with an upper valve seat 92 while the bottom of the chamber 86 is formed with a lower valve seat 96 encircling a passageway 95 in the insert 88 effecting communication between the chambers 86 and 87. A valve disc 97, movable between the valve seats 92 and 96, is controlled by a float 101 disposed in the tank 79 through a suitable lost motion linkage 103 including a spindle 99 attached to the valve element 97.

A flexible valve disc 119 is secured to the bottom of the chamber 87, as by a screw 121, to cover the port 83 and form a flap type check valve. A check valve 122 is also provided between the chamber 87 and atmosphere.

A timing mechanism 104 for controlling the closing of the drain valve 16 is shown in Figs. 2 and 3 and in this embodiment of the invention includes a cylindrical housing 123 attached to the body 25 as by spaced brackets 134 (see Fig. 1) and having end caps 129 and 131 at opposite ends. Disposed within the housing is a piston 132 arranged to move between opposite ends of the chamber 133 formed in the housing 128. A piston rod 136 rigid with the piston 132 projects through an aperture in the cap 129 and at the outer end of the piston rod is a screw 137 shaped to engage the handle portion of the lever 49. An O-ring packing 138, acting between the cap 129 and the piston rod 136, prevents leakage of fluid along the piston rod. The cap 131 is formed with an aperture 142 open to atmosphere and on the lower side of the piston 132 is a gasket having an annular shoulder 144 shaped to engage the inner surface of the end cap 131 and to define a valve for preventing communication between the chamber 133 and atmosphere through the aperture 142 when the piston is in the position shown in Fig. 2. The gasket 144 is secured to the piston 132 by a screw 146.

The chamber 133 is in communication with the injector 19 through a conduit 146. At one end the conduit 146 is received in a fitting 147 threaded into a recess 148 in the end cap 129 and in communication with the chamber 133. A screen 149 is disposed between the recess 148 and the chamber 133 and is retained in position, as by a ring 151, to prevent the passage of particles between the conduit and the chamber. The opposite end of the conduit 146 is received in a fitting 152 threaded into the port 80 in the sleeve 72. The inner end of the fitting 152 is formed with a recess shaped to receive a screen 154 held in the recess by a ring 156. Suitable gaskets at opposite ends of the conduit 146 prevent leakage in a conventional manner.

In Fig. 7 there is shown a modification of the invention in which provision is made for bypassing fluid around an injector 171 connected in a liquid treating system as described hereinbefore. To this end a fitting 172 is connected in the line 18, having an outlet port 174 in communication with a conduit 176. The opposite end of the

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conduit is connected with a port 177 in a fitting 178, connected in the service line 24 adjacent the body 25. A flap type check valve 182 is mounted in the fitting 178 as by a screw 183 to cover the port 177 so that liquid may flow only from the line 173 to the service line 24 and not from the service line 24 to the line 173. Access to the valve 182 may be had through an opening in the fitting 178 receiving a plug 184.

The operation of the foregoing apparatus is best seen by referring to Figs. 2 and 3. For purposes of illustration it will be assumed that the components of the system are in the position shown in Fig. 2 so that liquid flowing through the tank 10 is being treated and delivered to service. Thus the valve element 48 is seated against the seat 44, the plunger 64 is in its lower position so that the end 68 seats on the valve seat 63 and the valve element 66 is spaced from the seat 58. Under these conditions, water flows from the liquid supply line 22, through port 26 into the chamber 34 and from the chamber 34 through chamber 33 and port 28 into one end of the hydraulic circuit including conduit 14, tank 10, conduit 18 and injector means 19. The fluid flowing from the hydraulic circuit passes into chamber 36 and through port 31 to the service line 24. In the structure of Fig. 7 the flow from the tank is through the conduit 18, the fitting 172, the conduit 176, the port 177 to the service line 24 so as to bypass the injector 171. Under these conditions the pressure at the inlet port 26 or in the chamber 34 is greater than the pressure at the ports 29 and 31 or in the chamber 36 by reason of the pressure drop in the fluid flowing through the external hydraulic circuit and this produces a pressure unbalance on the plunger 64 which maintains the latter seated against the seat 63. The flow through the injector 19 is such that the nozzle 74 is moved to an inner position in which the large end of the nozzle abuts against the insert 59. In this position of the nozzle the latter defines with the seat 73 an annular passageway of greater area than the throat portion of the injector 19.

The chamber 133 of the timing mechanism 104 is filled with fluid and the piston 132 is in its lowermost position so that the valve element 144 seats against the end cap 131 to prevent leakage from the chamber 133 to atmosphere through the aperture 142. The regenerant tank 79 is filled and the valve element 97 engages the seat 96 so that the regenerant supply line 78 is closed. Similarly the check valves 119 and 122 are in the closed positions as shown in Fig. 5 so that fluid cannot flow to or from the tank 79.

To regenerate the exchange material in the tank 10 the operator presses downwardly on the handle 49 of the drain valve 16 to move the valve element 48 away from the seat 44. As a consequence liquid flows from the chamber 33 through the passageway 39, the apertures 41, and the chamber 32, out the drain port 27 to the drain line 17. As soon as the valve element 48 is moved away from the seat 44 the chamber 32 is opened to atmosphere and the pressure equilibrium of the system is upset so that a pressure differential exists between the chamber 34 and the chamber 36. For a short interval after the valve 48 is opened, the pressure in the chamber 36 remains substantially constant, while the pressure in chambers 33 and 34 immediately drops. Because of the higher pressure in the chamber 36 and due to the turbulence and the velocity of liquid passing from the chamber 34 through the ported insert 56 to the chamber 33 the plunger 64 is caused to move from the position shown in Fig. 2 to the position shown in Fig. 3 so that the valve element 66 seats against the seat 58. As soon as the valve element 66 seats, the liquid flowing through the inlet port 26 passes through chamber 34 to the chamber 36 so that the direction of flow through the hydraulic circuit is reversed. Liquid then flows from the inlet 22 through chamber 34 and from the chamber 34 downwardly through nozzle 74, conduit 18, upwardly through tank 10 and conduit 14 to

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the chamber 33 from which it passes to drain through the drain conduit 17. The pressure drop in the liquid, as it flows through the hydraulic circuit including the injector and the tank 10, produces a pressure unbalance on the plunger or valve member which retains the latter in its raised position with the valve element 68 seated against the seat 58. This change in the direction of flow forces the nozzle 74 to seat in the conical-shaped seat 73 as shown in Fig. 3. Under these conditions liquid passing into the chamber 36 flows through the nozzle 74 to the chamber 75. As the liquid passes through the chamber 75 to be discharged in the throat portion 76 a low pressure area or suction is created in the chamber 75 that effects unseating of the valve 97. Concurrently this suction causes the flap valve 119 in chamber 87 to open so that regenerant solution from the tank 79 is drawn into the line 78 from the intake 85 at the bottom of the tank 79. The regenerant solution mixes with the liquid discharged into the chamber and the mixture flows through the line 18, up through the tank 10, through the conduit 14, to the chamber 33 and thence to the drain line 17. When the float 101 gets to a preselected lower level it brings the valve 97 into engagement with seat 92 to stop the flow of regenerant.

The liquid from the nozzle continues to flow up through the tank 10 for a limited period of time to rinse the regenerant from the bed of exchange material 11. As shown in Fig. 2 the line 146 is in communication with the chamber 75 in the injector 19. Thus when liquid passes through the injector as described liquid is also drawn into the chamber 75 from the chamber 133. The size of the opening in the conduit 146 is relatively small, a suitable tubing having a bore on the order of .02 inch, so that it takes an appreciable length of time for the liquid to be withdrawn from the chamber 133. By selecting the proper conduit at 146 the rinsing time can be controlled. As the liquid is withdrawn from the chamber 133 the piston 132 is caused to move upwardly due to the fact that atmospheric pressure is greater than the pressure at the upper end of the chamber 133. Fluid is withdrawn from the chamber 133 until the piston 132 reaches the position shown in Fig. 4 in which the screw 137 engages the lever 49 and effects the seating of the valve element 48 on the seat 44. The time required to reseal the valve element 48 on the seat, and consequently the duration of the brining and rinsing, 44 can be varied by adjusting the screw 137, or varying the length of the conduit 146. It is to be understood that the period of time that it takes for the piston 132 to move upwardly to close the drain valve 16 must be coordinated with the period of time that it takes to effect regeneration and rinsing of the bed of exchange materials so that the various steps have a definite sequence and time relationship.

As soon as the valve element 48 is seated, the pressure in chamber 33 builds up and there is no longer a pressure differential between the chamber 33 and the chamber 34 or between the conduits 14 and 18 and the line 22 and consequently there is no force urging or holding the plunger 64 in its upper position. The plunger 64, therefore, settles downwardly in the chamber 34, moving the valve element 66 away from the seat 58. As the plunger 64 moves downwardly in the chamber 34 the valve element 68 seats on the seat 63 thereby preventing the flow of water between chambers 34 and 36 and causing liquid to flow between the chambers 34 and 33 when the liquid is drawn from the service line.

When the flow of water reverses its direction through the injector 19 the nozzle 74 is forced away from the seat 73 so that the liquid may flow through the annular chamber defined by the walls of the seat and the peripheral surface of the nozzle 74. When line pressure is reestablished to chamber 75 liquid flows through the supply line 78 forcing the disc 97 away from the seat 92 to permit entrance of fluid into the chamber 86 and thence into the chamber 87 through the aperture 95. The liquid is pre-

vented from flowing out of the chamber 87 through the supply line leading to the intake 85 by the check valve 119 but flows into the tank 79 through the check valve 122. Thus, untreated fluid always flows in at the top of the tank and regenerant solution is removed from the bottom of the tank. With this construction salt creepage up over the top of the tank is minimized, if not entirely eliminated. When the liquid reaches a preselected level the float 101 causes the valve 97 to seat against the seat 96, thus preventing the entrance of further fluid into the tank 79.

Concurrently with the filling of the regenerant tank 79 liquid flows into the chamber 133 through the conduit 146. As liquid flows into the top of the chamber 133 the piston 132 is moved downwardly in the chamber 133 until the shoulder 144 seats against the inner surface of the cap 131 to return the parts to the starting or service position.

It will be observed that at the conclusion of the rinsing step the lower portion of the tank 10 is filled with untreated liquid. In the normal operation of the apparatus this untreated liquid in the tank is used in refilling the regenerant tank 79 and also fills the chamber 133 so that treated liquid can be obtained from the system immediately after the regenerant tank 79 is filled.

The advantages of this construction are readily apparent. The foregoing apparatus provides a construction wherein the apparatus, once initiated, passes through the regeneration, and rinsing steps of operation and returns to the service position without further attention. The control unit may be made extremely compact and fully enclosed. The operation is simple. This control assembly is rugged and requires a minimum of maintenance during its service life. Liquid also flows to service during the regenerating and rinsing steps. Another advantage is that the only manual manipulation required to effect a complete cycle of operation is to open the drain line valve. After the initial opening of the drain valve, all phases of operation are hydraulically controlled. Consequently there are no electric motors, meters, clocks or drop buckets and the like to get out of order.

I claim:

1. Base exchange liquid treatment apparatus comprising a regenerant tank, a reaction tank having an untreated liquid inlet and a treated liquid outlet, inlet valve mechanism, a supply line connecting said valve mechanism to a supply of untreated liquid under pressure, conduits from said valve mechanism to said untreated liquid inlet and said treated liquid outlet, a service pipe connected with the conduit which extends between the inlet valve mechanism and the treated liquid outlet, said inlet valve including a chamber in constant communication with said supply line, and a valve member in said chamber selectively movable in said chamber in response to differences in pressure in said conduits between a service position closing the conduit to the treated liquid outlet and opening the conduit to the untreated liquid inlet to direct untreated liquid to the untreated liquid inlet and a regeneration position closing the conduit to the untreated liquid inlet and opening the conduit to the treated liquid outlet, an injector interposed in the conduit which extends between the inlet valve mechanism and the treated liquid outlet positioned to receive untreated liquid from the inlet valve and deliver untreated liquid and regeneration liquid to the treated liquid outlet when the valve member occupies the regeneration position, a regenerant line connecting the injector with the regenerant tank, a drain line communicating with the conduit between the untreated liquid inlet and the inlet valve, and a drain valve in the drain line movable between a closed position maintaining line pressure in the last mentioned conduit and an open position opening said conduit to drain and thereby producing a pressure differential on said valve member to move the same to the regeneration position and reverse the direction of flow through the reaction tank.

2. Base exchange liquid treatment apparatus comprising a regenerant tank, a reaction tank having an untreated liquid inlet and a treated liquid outlet, inlet valve mechanism, a supply line connecting said valve mechanism to a supply of untreated liquid under pressure, conduits from said valve mechanism to said untreated liquid inlet and said treated liquid outlet, a service pipe connected with the conduit which extends between the inlet valve mechanism and the treated liquid outlet, said inlet valve including a chamber in constant communication with said supply line, and a valve member in said chamber selectively movable in said chamber in response to differences in pressure in said conduits between a service position closing the conduit to the treated liquid outlet and opening the conduit to the untreated liquid inlet to direct untreated liquid to the untreated liquid inlet and a regeneration position closing the conduit to the untreated liquid inlet and opening the conduit to the treated liquid outlet to direct untreated liquid to the treated liquid outlet, an injector interposed in the conduit which extends between the inlet valve mechanism and the treated liquid outlet positioned to receive untreated liquid from the inlet valve and deliver untreated liquid and regeneration liquid to the treated liquid outlet when the valve member occupies the regeneration position, a regenerant line connecting the injector with the regenerant tank, a drain line communicating with the conduit between the untreated liquid inlet and the inlet valve, a drain valve in the drain line movable between a closed position maintaining line pressure in the last mentioned conduit and an open position opening said conduit to drain and thereby producing a pressure differential on said valve member to move the same to the regeneration position and reverse the direction of flow through the reaction tank, and timing means arranged to close the drain valve a predetermined time interval following opening of the drain valve.

3. Base exchange liquid treatment apparatus comprising a regenerant tank, a reaction tank having an untreated liquid inlet and a treated liquid outlet, inlet valve mechanism, a supply line connecting said valve mechanism to a supply of untreated liquid under pressure, conduits from said valve mechanism to said untreated liquid inlet and said treated liquid outlet, a service pipe connected with the conduit which extends between the inlet valve mechanism and the treated liquid outlet, said inlet valve including a chamber in constant communication with said supply line, and a valve member in said chamber selectively movable in said chamber in response to differences in pressure in said conduits between a service position closing the conduit to the treated liquid outlet and opening the conduit to the untreated liquid inlet to direct untreated liquid to the untreated liquid inlet and a regeneration position closing the conduit to the untreated liquid inlet and opening the conduit to the treated liquid outlet to direct untreated liquid to the treated liquid outlet, an injector interposed in the conduit which extends between the inlet valve mechanism and the treated liquid outlet positioned to receive untreated liquid from the inlet valve and deliver untreated liquid and regeneration liquid to the treated liquid outlet when the valve member occupies the regeneration position, a regenerant line connecting the injector with the regenerant tank, a drain line communicating with the conduit between the untreated liquid inlet and the inlet valve, a drain valve in the drain line movable between a closed position maintaining line pressure in the last mentioned conduit and an open position opening said conduit to drain and thereby producing a pressure differential on said valve member to move the same to the regeneration position and reverse the direction of flow through the reaction tank, means for rapidly opening the drain valve to produce a pressure surge in said chamber and thereby effect movement of the valve member to the regeneration position, and timing means arranged to close the drain valve a predetermined time interval following opening of

the drain valve and thereby effect movement of the valve member to the service position.

4. The combination recited in claim 1 including a timing chamber, a conduit between the timing chamber and the injector for supplying liquid to the chamber when the valve member occupies the service position and for withdrawing of liquid by the injector in the regeneration position of the valve member, and a member operated in response to removal of liquid from the timing chamber for closing the drain valve to return the valve member to service position.

5. Base exchange liquid treatment apparatus comprising a regenerant tank, a reaction tank having an untreated liquid inlet and a treated liquid outlet, inlet valve mechanism, a supply line connecting said valve mechanism to a supply of untreated liquid under pressure, conduits from said valve mechanism to said untreated liquid inlet and said treated liquid outlet, a service pipe connected with the conduit which extends between the inlet valve mechanism and the treated liquid outlet, said inlet valve including a chamber in constant communication with said supply line, and a valve member in said chamber selectively movable in said chamber in response to differences in pressure in said conduits between a service position closing the conduit to the treated liquid outlet and opening the conduit to the untreated liquid inlet to direct untreated liquid to the untreated liquid inlet and a regeneration position closing the conduit to the untreated liquid inlet and opening the conduit to the treated liquid outlet to direct untreated liquid to the treated liquid outlet, an injector interposed in the conduit which extends between the inlet valve mechanism and the treated liquid outlet positioned to receive untreated liquid from the inlet valve and deliver untreated liquid and regeneration liquid to the treated liquid outlet when the valve member occupies the regeneration position, a regenerant line connecting the injector with the regenerant tank, a drain line communicating with the conduit between the untreated liquid inlet and the inlet valve, a drain valve in the drain line movable between a closed position maintaining line pressure in the last mentioned conduit and an open position opening said conduit to drain and thereby producing a pressure differential on said valve member to move the same to the regeneration position and reverse the direction of flow through the reaction tank, a regenerant valve in the regenerant line operative to open upon reduction in pressure in the regenerant line in response to operation of the injector for the passage of regenerant to the injector, closing means for closing the regenerant valve at preselected upper and lower liquid levels in the regenerant tank, and means for opening the drain valve to thereby effect movement of the valve member to the regeneration position to direct untreated liquid through the injector to the treated liquid outlet and withdraw regenerant from the regenerant tank to mix with the liquid in the injector until terminated by the closing means and to thereafter supply liquid free of regenerant.

6. Base exchange liquid treatment apparatus comprising a regenerant tank, a reaction tank having an untreated liquid inlet and a treated liquid outlet, inlet valve mechanism, a supply line connecting said valve mechanism to a supply of untreated liquid under pressure, conduits from said valve mechanism to said untreated liquid inlet and said treated liquid outlet, a service pipe connected with the conduit which extends between the inlet valve mechanism and the treated liquid outlet, said inlet valve including a chamber in constant communication with said supply line, and a valve member in said chamber selectively movable in said chamber in response to differences in pressure in said conduits between a service position closing the conduit to the treated liquid outlet and opening the conduit to the untreated liquid inlet to direct untreated liquid to the untreated liquid inlet and a regeneration position closing the conduit to the untreated liquid inlet and opening the conduit to the treated liquid

outlet to direct untreated liquid to the treated liquid outlet, an injector interposed in the conduit which extends between the inlet valve mechanism and the treated liquid outlet positioned to receive untreated liquid from the inlet valve and deliver untreated liquid and regeneration liquid to the treated liquid outlet when the valve member occupies the regeneration position, a regenerant line connecting the injector with the regenerant tank, a drain line communicating with the conduit between the untreated liquid inlet and the inlet valve, a drain valve in the drain line movable between a closed position maintaining line pressure in the last mentioned conduit and an open position opening said conduit to drain and thereby producing a pressure differential on said valve member to move the same to the regeneration position and reverse the direction of flow through the reaction tank, a regenerant valve in the regenerant line operative to open upon reduction in pressure in the regenerant line in response to flow of untreated liquid in one direction through the injector for the passage of regenerant to the injector, and to open upon elevated pressure in the regenerant line in response to reverse flow through the injector for the passage of liquid to the regenerant tank from the injector, closing means for closing the regenerant valve at preselected upper and lower liquid levels in the regenerant tank, means for opening the drain valve to thereby effect movement of the valve member to the regeneration position to direct untreated liquid through the injector to the treated liquid outlet and withdraw regenerant from the regenerant tank to mix with the liquid in the injector until terminated by the closing means and to thereafter supply liquid free of regenerant, and timing means for closing the drain valve a predetermined time after the opening thereof to reverse flow through the reaction tank and the injector to thereby produce an elevated pressure in the regenerant line and refill the regenerant tank.

7. Base exchange liquid treatment apparatus comprising a regenerant tank, a reaction tank having an untreated liquid inlet and a treated liquid outlet, inlet valve mechanism, a supply line connecting said valve mechanism to a supply of untreated liquid under pressure, conduits from said valve mechanism to said untreated liquid inlet and said treated liquid outlet, a service pipe connected with the conduit which extends between the inlet valve mechanism and the treated liquid outlet, said inlet valve including a chamber in constant communication with said supply line, and a valve member in said chamber selectively movable in said chamber in response to differences in pressure in said conduits between a service position closing the conduit to the treated liquid outlet and opening the conduit to the untreated liquid inlet to direct untreated liquid to the untreated liquid inlet and a regeneration position closing the conduit to the untreated liquid inlet and opening the conduit to the treated liquid outlet to direct untreated liquid to the treated liquid outlet, an injector interposed in the conduit which extends between the inlet valve mechanism and the treated liquid outlet positioned to receive untreated liquid from the inlet valve and deliver untreated liquid and regeneration liquid to the treated liquid outlet when the valve member occupies the regeneration position, a regenerant line connecting the injector with the regenerant tank, a drain line communicating with the conduit between the untreated liquid inlet and the inlet valve, a drain valve in the drain line movable between a closed position maintaining line pressure in the last mentioned conduit and an open position opening said conduit to drain and thereby producing a pressure differential on said valve member to move the same to the regeneration position and reverse the direction of flow through the reaction tank, a timing chamber, a member in said timing chamber movable in response to the flow of liquid into and out of the chamber, said member having means for closing the drain valve in response to movement to a preselected position, and a conduit between the timing chamber and the injector for supplying liquid there-

to under pressure when the valve member occupies the service position and for withdrawing liquid therefrom in response to operation of the injector when the valve member occupies the regeneration position.

8. The combination recited in claim 7 wherein the last mentioned conduit comprises a small diameter tubing and a fine mesh screen is provided at each end thereof to prevent the entrance of solid particles.

9. The combination recited in claim 1 wherein the service pipe is connected intermediate the injector and the inlet valve and the injector comprises a portion having a nozzle seat, a floating nozzle separate from but shaped to seat on said nozzle seat in response to movement of untreated liquid from the inlet valve to the treated liquid outlet connection at the reaction tank and to move away from said seat in response to movement of the liquid in the opposite direction for the passage of liquid around the nozzle to the service port.

10. The combination recited in claim 1 wherein a by-pass is provided in the conduit between the inlet valve and the treated liquid outlet, the by-pass extending around the injector, the by-pass having a check valve positioned to prevent flow therethrough toward the treated water outlet and wherein the service pipe is connected between the check valve and the inlet valve.

11. Base exchange liquid treatment apparatus comprising a reaction tank having an untreated liquid inlet and a treated liquid outlet, inlet valve mechanism, a supply line connecting said valve mechanism to a supply of untreated liquid under pressure, conduits from said valve mechanism to said untreated liquid inlet and said treated liquid outlet, a service pipe connected with the conduit which extends between the inlet valve mechanism and the treated liquid outlet, said inlet valve including a chamber in constant communication with said supply line, and a valve member in said chamber selectively movable in said chamber in response to differences in pressure in said conduits between a service position closing the conduit to the treated liquid outlet and opening the conduit to the untreated liquid inlet to direct untreated liquid to the untreated liquid inlet and a regeneration position closing the conduit to the untreated liquid inlet and opening the conduit to the untreated liquid outlet to direct untreated liquid to the treated liquid outlet, a restriction element in the path of liquid flow from said chamber through the conduit to said treated liquid outlet interposed between said chamber and said service pipe connection for restricting the flow of liquid from said chamber through the last-mentioned conduit and thereby producing a pressure differential therebetween, a drain line communicating with the conduit between the untreated liquid inlet and the inlet valve, and a drain valve in the drain line movable between a closed position maintaining line pressure in the last mentioned conduit and an open position opening said conduit to drain and thereby producing a pressure differential on said valve member to move the same to the regeneration position and reverse the direction of flow through the reaction tank.

12. Liquid treatment apparatus comprising a reaction tank for treating liquid, a regenerant tank, means for passing regenerant from said regenerant tank to said reaction tank and including an ejector for drawing regenerant from said regenerant tank for passage to the reaction tank in response to the flow of liquid in one direction through the ejector and for passing rinse liquid to the reaction tank following termination of the flow of regenerant from the regenerant tank to the reaction tank, valve means controlling the flow of liquid to and from said reaction tank and including a movable member for selectively establishing or terminating the flow of liquid in said one direction through the ejector to the reaction tank, a timing chamber defining a fluid storage compartment for holding timing fluid, a small diameter tubing extending from said timing chamber to the throat of the ejector for passing fluid from said timing chamber in response to the flow of liquid in said one direction through the ejector, said tubing having

a diameter and length selected to withdraw a timing fluid from the chamber at a rate proportional to the flow of regenerant and rinse to the reaction tank, means operative in response to the passage of a predetermined amount of fluid from said timing chamber through said tubing for actuating said movable member to terminate the rinse flow of liquid in said one direction through the ejector.

13. Liquid treatment apparatus comprising a reaction tank for treating liquid, an ejector having a throat, a conduit connecting the ejector throat to said reaction tank for passing liquid thereto, valve means controlling the flow of liquid to and from said reaction tank and including a movable member movable between a first position controlling the flow of liquid in said one direction through the ejector throat and a second position controlling the flow of liquid in said opposite direction through the ejector throat, a regenerant tank, a conduit extending between said regenerant tank and the throat of the ejector for passing regenerant from the regenerant tank to the reaction tank in response to the flow of liquid in said one direction through the ejector, a timing chamber defining a liquid storage compartment containing timing liquid, a small diameter tubing extending from said timing chamber to the throat of the ejector for passing liquid from said timing chamber in response to the flow of liquid in said one direction through the ejector and for passing liquid back to said timing chamber to refill said timing chamber in response to the flow of liquid in said opposite direction through the ejector throat, and fluid pressure operated means in said timing chamber responsive to the passage of a predetermined amount of liquid from said timing chamber through said tubing for actuating said movable member from said first position to said second position to change the direction of flow of liquid through the ejector from said one direction to said opposite direction.

14. In a water treatment device or the like a flow control apparatus comprising a tubular body having spaced transverse partitions defining a valve chamber therebetween, an outlet port in each of said partitions, an inlet port in said body between said outlet ports, a valve member loosely disposed in said valve chamber movable between said outlet ports to alternately open one of the outlet ports and close the other outlet port and normally urged to a position closing one of the outlet ports, an hydraulic circuit connecting the outlet ports and providing continuous liquid communication therebetween, an outlet conduit extending from said hydraulic circuit adjacent each of said outlet ports, valves for controlling flow through said outlet conduits, and a restriction device for restricting the flow through said hydraulic circuit to provide an hydraulic impedance and being operative in response to liquid flow therethrough from said inlet port through the normally closed outlet port to produce a pressure unbalance on opposite ends of the valve member for retaining the valve member in a seated position closing the other outlet port and operative when flow therethrough is interrupted to equalize the pressures on opposite ends of the valve member.

15. In a water treatment device or the like a flow control apparatus for reversibly controlling liquid flow through an hydraulic circuit comprising, a vertically disposed valve chamber having a normally open outlet port and a normally closed outlet port, an inlet port in said chamber intermediate said outlet ports, an hydraulic circuit connecting said outlet ports including circuit conduits, said hydraulic circuit providing continuous liquid communication therebetween, a pressure relief conduit communicating with one of said circuit conduits, a pressure relief valve controlling liquid flow through said pressure relief conduit, a pressure responsive valve member in said valve chamber movable from a position blocking flow from said inlet port through said normally closed port to a position blocking flow from said inlet port through said normally open port in response to liquid flow produced by opening of said pressure relief valve,

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and a flow restricting element in said hydraulic circuit for restricting the flow therethrough from said normally closed outlet port, operative in response to flow therethrough from said inlet port through said normally closed port to produce a pressure unbalance on the top and bottom sides of the valve member for retaining the valve member in position blocking flow from the inlet port through the normally open port and operative when the flow through said hydraulic circuit is interrupted for equalizing the pressures on the top and bottom sides of the valve member whereby the valve member gravitates to a position blocking flow from the inlet port to the normally closed port.

16. In a water treatment apparatus including a water treatment tank, a flow control apparatus for reversibly controlling flow through said treatment tank comprising a vertically disposed body having spaced upper and lower outlet ports defining a valve chamber therebetween, an inlet port in said body intermediate said outlet ports, upper and lower flow chambers on opposite ends of said valve chamber in open communication with said upper and lower outlet ports respectively, an hydraulic circuit including said treatment tank communicating with said upper and lower flow chambers and providing continuous liquid communication therebetween, a drain conduit communicating with said upper flow chamber, a service conduit communicating with said lower flow chamber for passing liquid therefrom under pressure to service, an hydraulically operated valve member loosely disposed in said valve chamber for movement between said outlet ports and having a weight to gravitate to its lower position closing the lower outlet port whereby water flows from the inlet port through the upper outlet port and in one direction through the hydraulic circuit to the lower flow chamber from which the water flows to the service conduit as water is drawn from the latter, a drain valve adapted upon opening to pass liquid to drain from the upper flow chamber to produce a pressure unbalance on the valve member and effect raising of the latter to close the upper outlet port whereby water flows from the inlet port through the lower outlet port to the service conduit as water is drawn from the latter and in the other direction through the hydraulic circuit to the upper flow chamber from which the water flows through the drain conduit, and a flow restriction device in the hydraulic circuit to cause a pressure drop in the water flowing in said last mentioned direction through the hydraulic circuit thereby producing a pressure unbalance on the valve member for retaining the latter in its raised position, said hydraulic circuit substantially equalizing the pressures on opposite ends of the valve member upon closing of the drain valve whereby the valve member gravitates to its lower position opening the upper outlet port and re-establishing flow to service through the treatment tank.

17. Liquid treating apparatus comprising a reaction tank for treating liquid, an injector, a conduit connecting the injector to said tank for passing liquid in one direction from the injector to the tank and in the opposite

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direction from the tank to the injector, a second conduit connected to said tank, a supply pipe for connection to a liquid supply under pressure, valve means controlling the flow from the supply pipe through said conduits including a movable member selectively controlling the flow of liquid through the injector to the reaction tank, a timing chamber containing timing liquid, a small diameter tubing extending from said timing chamber to the injector for passing liquid from said timing chamber in response to the flow of liquid through the injector to the reaction tank, and means responsive to the passage of a predetermined amount of liquid from said timing chamber through said tubing for actuating said movable member to terminate the flow of liquid through the injector to the reaction tank and to reverse the direction of flow of liquid through the reaction tank and said conduit to refill said timing chamber through said tubing.

18. Liquid treating apparatus comprising a reaction tank for treating liquid, an injector, a conduit connecting the injector to said tank for passing liquid in one direction from the injector to the tank and in the opposite direction from the tank to the injector, a second conduit connected to said tank, a supply pipe for connection to a liquid supply under pressure, valve means controlling the flow from the supply pipe through said conduits including a movable valve operating member, a sealed timing chamber having a pressure responsive element movable in response to the flow of liquid into and out of the chamber, a small diameter tubing extending between said timing chamber and the injector for drawing liquid from the chamber in response to flow of liquid through the injector to the reaction tank and for refilling the chamber upon flow of liquid in the other direction from the reaction tank through said conduit, and means operated by the pressure responsive element in response to withdrawal of liquid from the chamber for moving the valve operating member to actuate the valve and change the direction of flow through the reaction tank.

19. The combination of claim 14 wherein said restriction device comprises a restriction element disposed between the valve chamber and the service pipe connection and an injector having its nozzle interposed in the conduit which extends between the valve mechanism and the treated liquid outlet at a point between the treated liquid outlet and the service pipe connection, restricting the flow from the valve mechanism to the treated liquid outlet in the regeneration position of the valve member.

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