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APPARATUS FOR TREATING WATER

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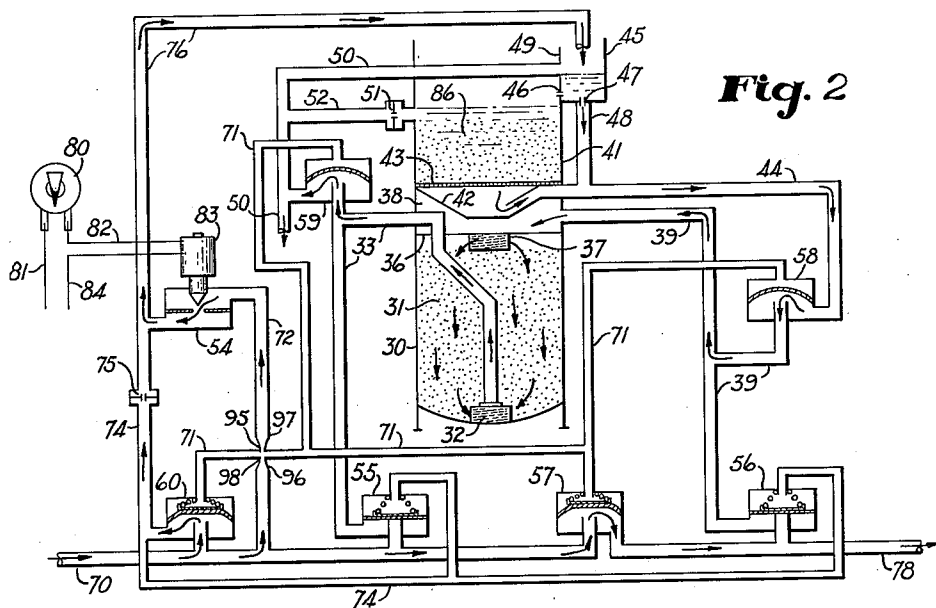


Fig. 2

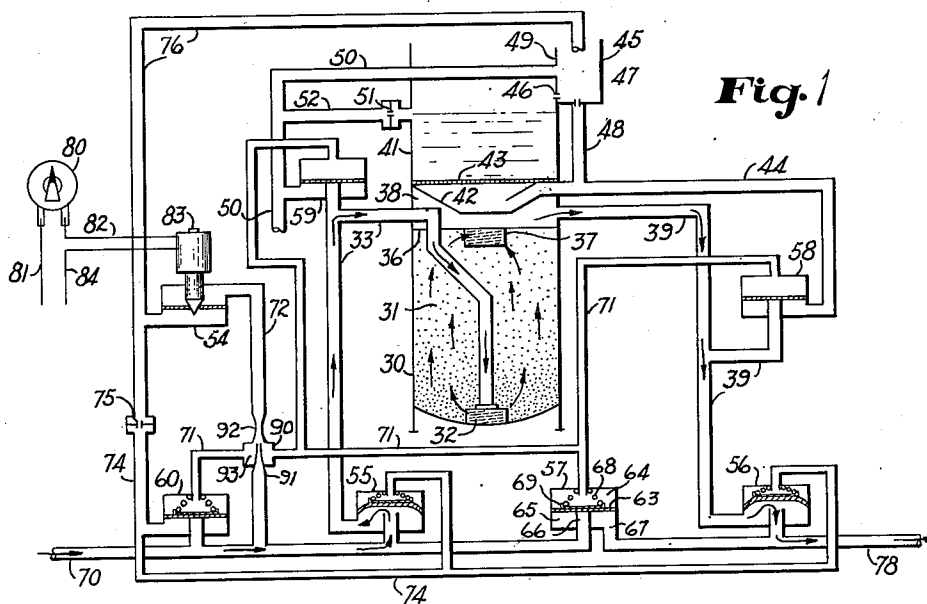


Fig. 1

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APPARATUS FOR TREATING WATER

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7 Claims. (Cl. 210—24)

1

This invention relates to apparatus for treating water or other aqueous solutions of electrolytes by ion exchange in general and especially suited for softening water by cation exchange, and is an improvement on my co-pending application Serial No. 40,528, filed July 24, 1948.

One of the objects of the present invention is to provide a novel apparatus which is so constructed as not to require a multiplicity of manual valve actuations in its operation and use and which at the same time is compact, efficient and inexpensive to manufacture.

Another object is to provide for such apparatus diaphragm valves to control the various flows, and pilot valve means to control the operation of said diaphragm valves.

Still another object is to provide a hydraulic suction producing device to control the operation of diaphragm valves.

The manner in which the above and further objects and novel features of this invention are achieved will appear more fully from the accompanying drawings and the following detailed description.

In the drawings, in which similar reference numerals refer to similar parts throughout the several views:

Fig. 1 is a diagrammatic view, partly in cross section, of one form of my invention showing an ion exchange apparatus in service position; and

Fig. 2 is a view similar to Fig. 1, but showing a modified apparatus in regenerating position.

Referring now to Fig. 1 diagrammatically showing an apparatus in accordance with my invention in service position, a tank 30 contains a bed 31 of granular ion exchange material or zeolite and is provided with a bottom distributor 32 the inside of which is in communication with a pipe 33 leading to the outside of the tank. On top of the tank 30 is mounted a regenerant chamber 41 having a bottom 42. Within the tank 30 below the regenerant chamber 41 is a separating plate 36 carrying a collector 37 which is in communication with a compartment 38 formed between the plate 36 and the bottom 42. To the compartment 38 is connected a pipe 39. Over the frusto-conical bottom 42 is placed a screen 43, and a pipe 44 leads from the lowest part of the chamber 41. Adjacent to the regenerant chamber 41 is a head box 45 which is provided with an orifice 46 adapted to discharge into the chamber 41 and another orifice 47 adapted to discharge into a pipe 48 which is connected to the pipe 44. A common wall 49 between the chamber 41 and the head box 45 is lower than their other walls so as to form an

2

overflow weir. From the head box 45 a pipe 50 leads to waste. At a level somewhat below the level of orifice 46 and connecting the chamber 41 with the pipe 50 is a pipe 52 which is fitted with a small orifice or weep hole 51.

Flow through the apparatus is controlled by a solenoid valve 54 which in turn, directly or indirectly, controls six diaphragm valves 55, 56, 57, 58, 59 and 60. Referring specifically to the reference numerals on valve 57 of Fig. 1, each of these diaphragm valves has a diaphragm 63 separating a pressure chamber 64 from a valve chamber 65. In the valve chamber 65 is a central port 66 adapted to be opened and closed by the diaphragm 63, and a lateral port 67 which is always open. A spring 68 is provided in valves 55, 56, 57 and 60, which through a plate 69 presses against the diaphragm 63, tending to force the diaphragm 63 against the central port 66 to close it.

A supply pipe 70 has branches connected with the central ports of diaphragm valves 55, 57 and 60 as well as with an ejector 90 having an inlet nozzle 91, an outlet nozzle 92, and a suction chamber 93. The outlet nozzle 92 is adapted to discharge into a pipe 72 in communication with the solenoid valve 54, and the suction chamber 93 is connected with a branched control pipe system 71 which is in communication with the pressure chambers of the diaphragm valves 57, 58, 59 and 60. Another control pipe 74 has branches connected with the lateral port of diaphragm valve 60, with the pressure chambers of diaphragm valves 55 and 56 and with an orifice 75 which is arranged to discharge into a pipe 76 having a branch connection with the solenoid valve 54 and leading to the head box 45. The pipe 33 leading from the distributor 32 has branches connected with the lateral port of diaphragm valve 55 and the central port of diaphragm valve 59. The pipe 39 leading from the compartment 38 has two branches, one connected with the lateral port of valve 56 and the other with the central port of valve 58. The pipe 44 leads from the chamber 41 to the lateral port of valve 58. The waste pipe 50 has a branch in communication with the lateral port of valve 59. A service pipe 78 leading to a point of use has branches connected with the lateral port of valve 57 and the central port of valve 56.

A time switch 80 is provided to control the operation of the solenoid valve 54. This time switch 80 is advantageously of the type that is normally open and in which a manual turning of the handle closes the switch and at the same time winds the main spring so that the timing mechanism

3

is thereby placed in operation, and, after running for a predetermined interval of time, opens the switch and stops. Such time switches are well known and have in recent years come into wide use on a variety of appliances. A wire 81 leads from a supply of electric energy to the time switch 80, a wire 82 connects the time switch 80 with the coil 83 of the solenoid valve 54, and a wire 84 leads from the coil 83 back to the supply of electric energy.

In Fig. 2, illustrating the apparatus in regenerating position, another hydraulic suction producing device is shown in place of the ejector 90 of Fig. 1. There is, instead, provided a Venturi tube 95 having an inlet portion 96 connected with the supply pipe 70, an outlet portion 97 connected with pipe 72 leading to the solenoid valve 54, and a throat 98 to which the control pipe system 71 is connected. The ejector 90 of Fig. 1 and the Venturi tube 95 of Fig. 2 are equivalent suction producing devices which operate in the same way and produce the same result.

In normal operation of the apparatus, as shown in Fig. 1, the time switch 80 is in its normal or open position, the coil 83 is de-energized and the solenoid valve 54 is closed. The water entering from the supply pipe 70 into the injector 99 (or the Venturi tube 95) therefore finds no outlet through pipe 72 so that the full supply pressure is communicated through the suction chambers 93 (or the throat 98) to the control pipe system 71 and thence to the pressure chambers of diaphragm valves 57, 58, 59 and 60 whereby the diaphragms are forced down, thus closing the central ports. At the same time any pressure previously existing within the control pipe 74 is relieved through the orifice 75, which in turn relieves the pressure from the pressure chambers of diaphragm valves 55 and 56, while the full pressure existing in the supply pipe 70 is communicated to their valve chambers. This causes the diaphragms of valves 55 and 56 to lift and open the central ports. Consequently, as shown by arrows in Fig. 1, flow of water takes place from the supply pipe 70 through diaphragm valve 55 and pipe 33 to distributor 32, then upwardly through the bed 31 of ion exchange material, thence through the collector 37 into the compartment 38, and via pipe 39, valve 56 and service pipe 78 to a point of use.

When the apparatus is used to soften water, the bed 31 consists of cation exchange material charged with sodium ions. As the water passes through the bed 31 it is softened. The bed 31 expands during this upward flow to an extent which depends upon the rate of flow. At high rates of flow the escape of granules of ion exchange material is prevented by the collector 37 which has slots narrower than the diameter of the smallest granules.

When the capacity of the bed 31 to exchange ions has been exhausted it is restored by a process known as regeneration. In order to effect regeneration the user has to do but two things: He places a suitable quantity of regenerant 86 into the chamber 41 and he turns the handle of time switch 80, thereby closing the switch and winding its main spring. In the case of a water softener the regenerant 86 is sodium chloride or common salt which comes to rest on the screen 43, as shown in Fig. 2.

The closing of the time switch 80 energizes coil 83 by establishing an electrical circuit through wires 81, 82 and 84, thereby opening the solenoid valve 54. This opening of valve 54 initiates a

4

flow of water from the supply pipe 70 through the Venturi tube 95 (or injector 90) into the pipe 72, creating sub-atmospheric pressure in the throat 98 (or suction chamber 93) which is communicated to the control pipe system 71. Consequently, the pressure of the supply previously prevailing in the pressure chambers of valves 57, 58, 59 and 60 is reduced to sub-atmospheric pressure and the diaphragms of these valves lift and thus open their central ports. The opening of valve 60 admits water from the supply pipe 70 into the control pipe 74 and since the orifice 75 is substantially smaller than the ports and passages of valve 60 the pressure within control pipe 74 rises to substantially the pressure existing in the supply pipe 70 and is communicated to the pressure chambers of diaphragm valves 55 and 56, forcing their diaphragms down to close the central ports. This interrupts the flow of water through the bed 31 to use.

A stream of water is now discharged through pipe 76 into the head box 45, one part coming through Venturi tube 95 (or injector 90), pipe 72 and solenoid valve 54, and the other through diaphragm valve 60, control pipe 74 and orifice 75. The head box 45 fills up until the level therein reaches that of pipe 50, any further rise in level being prevented by overflow through pipe 50 to waste. From the head box 45 two streams of water are discharged; one through the orifice 46 into the chamber 41 and the other through orifice 47 into pipe 48. The stream flowing through orifice 46 percolates through and dissolves the regenerant 86 resting on screen 43 within chamber 41, and the practically concentrated regenerating solution thus formed flows into the pipe 44 where it is mixed with the second stream entering through orifice 47 and pipe 48. The solution is thus diluted in a predetermined proportion depending upon the relative sizes of orifices 46 and 47. The dilute regenerating solution flows by gravity via pipe 44, diaphragm valve 58 and pipe 39 into compartment 38, thence through the collector 37 and downward through the bed of ion exchange material 31, regenerating it. It then enters the distributor 32 and flows via pipe 33, diaphragm valve 59 and pipe 50 to waste.

After all regenerant 86 within chamber 41 has been dissolved, water continues to flow from orifice 46 through chamber 41. The combined streams of water discharged by orifices 46 and 47 follow the same path that had previously been taken by dilute regenerating solution, rinsing spent and excess regenerant from the bed 31.

While regeneration including rinsing of the bed 31 thus proceeds, hard water is available to the point of use through the open diaphragm valve 57 which establishes a direct bypass connection from the supply pipe 70 to the outlet pipe 78. The diaphragm valve 57 may, of course, be omitted when flow of untreated water to the point of use during regeneration is not desired. In many cases in which the installation of two units or the storage of treated water for use during regeneration is impractical, especially in household installations, such bypass, however, is desirable since the availability of hard water in the event of fire, for flushing toilets, etc., is preferable to having no water available at all.

After an interval of time which has been predetermined to allow for complete regeneration and rinsing of the bed 31, the time switch 80 returns to and stops in its normal or open position, de-energizing the coil 83 and thus closing

the solenoid valve 54. This restores the apparatus to the service position as shown in Fig. 1.

It should be noted that in order to assure reliable closing of the diaphragm valves 55, 56, 57 and 60 it is desirable to use springs 68, as shown, to aid the water pressure in closing these diaphragm valves, since their diaphragms encounter the full pressure of the water supply in the valve chambers 65 at the time they are called upon to close the valves. No springs are required for diaphragm valves 58 and 59, however, since there is at no time any substantial pressure in their valve chambers 65 both of which have their lateral ports 67 in permanent communication with points under atmospheric pressure. The alternate application of supply pressure and of sub-atmospheric pressure created by the hydraulic suction producing device provides adequate forces for the respective closing and opening of these two valves.

The injector inlet nozzle 91 (or Venturi throat 98) and orifice 75 are so dimensioned that their joint discharge is sufficient throughout the range of water supply pressures normally encountered to supply at least sufficient water to the head box 45 to effect regeneration and rinsing of the bed 31 within the allotted time. Water entering the head box 45 in excess of the discharge through orifices 46 and 47 flows via pipe 50 to waste without appreciably changing the level in the head box 45, so that the discharges through orifices 46 and 47 are constant regardless of variations in the supply pressure. Thus, the rates of flow of water used to make up regenerant solution and to dilute such solution and later to rinse out spent and excess regenerant remain constant so that regenerant concentration and regenerant contact time are maintained at the values predetermined for greatest effectiveness, in spite of changing operating pressures. The sizes of the orifices depend, of course, on the size of the apparatus. The diameter of the injector inlet nozzle 91 and the Venturi throat 98 is advantageously made between $\frac{1}{3}$ % and $1\frac{1}{2}$ % of the diameter of tank 30. Thus an injector inlet nozzle $\frac{1}{8}$ inch in diameter was found satisfactory for household type water softeners 9 to 12 inches in diameter, the passage in the injector outlet nozzle being twice as large, and the passages in and leading from the pipe 72, including those through the solenoid valve 54, being at least 3 and preferably 4 times greater in diameter. With such arrangement and a water supply pressure of 50 pounds per square inch the pressure within the control pipe 71 is reduced during regeneration to the order of 15 inches Hg below atmospheric pressure which insures reliable and quick opening of the diaphragm valves controlled by the control pipe 71. The diameter of orifice 75 is advantageously between 1% and 4% of the diameter of the diaphragms which it controls, an orifice diameter of 0.04 inch having been found satisfactory in conjunction with a diameter of 2 inches of the diaphragms of valves 55 and 56. With such an arrangement the closing of the diaphragm valve 60 when the apparatus is returned to service position after regeneration causes the pressure from the pressure chambers of diaphragm valves 55 and 56 to be dissipated so slowly through the orifice 75 that a measurable interval of time elapses, usually several seconds, before the valves 55 and 56 open. This is important in order to insure reliable previous closing of the diaphragm valves 58 and 59, and to avoid flooding of the chamber 41. The slow opening of valves

55 and 56 also avoids severe water hammer in the supply pipe 70 and the service pipe 78 on return of the apparatus to the service position.

The sizes of orifices 46 and 47 will vary not only with the size of tank 30, but also with the head for which the head box 45 is designed, with the time allotted to regeneration, the desired rates of flow and the quantity of regenerant and its desired concentration. As an illustrative example, with a head of 2 inches a diameter of $\frac{3}{8}$ inch for orifice 46 and $\frac{1}{8}$ inch for orifice 47 gave satisfactory results in an apparatus which employed a tank 9 inches in diameter and containing one cubic foot of resinous cation exchange material, and which was provided with a one and one-half hour time switch. When it is desired to regenerate the ion exchange material with concentrated regenerant, which is advantageous with certain types of ion exchangers, the orifice 47 may be omitted so that there is no dilution of the regenerating solution flowing from chamber 41.

When the water supplied to pipe 70 is likely to contain impurities of a size that might clog the injector 90 or Venturi tube 95 and the orifice 75 it is advantageous to provide on the upstream sides of these devices strainers that will retain such impurities.

If, on return to service, the level within chamber 41 is above the pipe 52, the water above this level slowly seeps away to waste through the orifice 51, thereby lowering the level sufficiently to avoid an overflow of the chamber 41 when regenerant is introduced for the next following regeneration. If the water in chamber 41 should unduly rise for any reason, it will overflow over the weir formed by the upper end of the wall 49 to be discharged to waste via pipe 50.

The arrangement illustrated diagrammatically in Figs. 1 and 2 may advantageously be embodied in a construction such as that shown in Figs. 9 to 23 of said Pick application Ser. No. 40,528, and the apparatus can be used for ion exchange treatment other than softening, such as cation exchange on the hydrogen cycle, or anion exchange.

The switch for energizing the solenoid valve 54 need, of course, not be of the type shown and described. Instead, other types of switches can be used, operated either manually or automatically. In fact, the solenoid valve 54 may, if desired, be replaced by a pilot valve which is opened manually when regeneration is needed and closed when regeneration is completed, either manually or by a spring under control of a mechanical timing device.

In place of the diaphragm valves controlled by the suction producing device other types of pressure operated valves may be used, such as the type operated by a piston moving in a cylinder.

While I have shown and described what I consider the preferred embodiments, modifications may be made without departing from the spirit of my invention and reference is, therefore, made to the appended claims for a definition of the scope of my invention.

What I claim is:

1. A water treating apparatus comprising a tank for ion exchange material, a flow connection leading to one end of said tank, another flow connection leading to the other end of said tank, a pressure operated valve in each of said flow connections, each of said valves including a pressure chamber, a hydraulic suction producing de-

7

vice having an inlet, an outlet and a suction connection, said inlet being adapted for permanent connection with a source of water under pressure, means establishing permanent communication between said suction connection and said pressure chambers, passage means leading from said outlet to a point of atmospheric pressure, a pilot valve in said passage means, and means for opening and closing said pilot valve.

2. The combination of claim 1, said pressure operated valves being diaphragm valves.

3. The combination of claim 1, said pilot valve being a normally closed solenoid valve adapted to open upon energization, and a time switch for energizing and de-energizing said solenoid valve.

4. A water treating apparatus comprising a tank for ion exchange material adapted to be operated in a cyclic sequence of steps including normal service and regeneration, a regenerant chamber, a supply connection leading from said tank to a source of water under pressure, a diaphragm valve in said supply connection, an outlet connection leading from said tank to a point of use, a diaphragm valve in said outlet connection, an inlet connection leading from said tank to said regenerant chamber, a diaphragm valve in said inlet connection, a waste connection leading from said tank to a point of disposal for waste water, a diaphragm valve in said waste connection, each of said diaphragm valves having a pressure chamber and being arranged to close on application of pressure to said pressure chamber, the two first named of said diaphragm valves controlling flow from said source through said tank to said point of use, control valve means for admitting water from said source to the pressure chambers of said two first named diaphragm valves, the pressure chambers of said two first named diaphragm valves having a permanent connection with a point of atmospheric pressure, a flow restriction in said permanent connection, the third and fourth named of said diaphragm valves controlling flow through said tank to said point of disposal during regeneration, a hydraulic section producing device having an inlet, an outlet and a suction connection, said inlet having a permanent connection with said source, the pressure chambers of said third and fourth named diaphragm valves having a permanent connection with said suction connection, passage means connecting said outlet with a point of atmospheric pressure, other control valve means in said passage means, and means for closing both said control valve means during normal service and for opening both said control valve means during regeneration.

5. The apparatus of claim 4, said other control valve means comprising a normally closed solenoid valve adapted to be opened upon energiza-

8

tion, and said first named control valve means comprising a diaphragm valve having a pressure chamber in permanent communication with the pressure chambers of said third and fourth named diaphragm valves, and a switch for energizing and de-energizing said solenoid valve.

6. A water treating apparatus comprising a tank for ion exchange material, a regenerant chamber, flow connections leading from said tank to a source of supply of water to be treated and to a point of use, a diaphragm valve in each of said flow connections and controlling flow from said source through said tank to said point of use, respectively, pressure chambers for said diaphragm valves, passage means connecting said source with said pressure chambers, a diaphragm control valve in said passage means and adapted to admit water from said source to said pressure chambers, a restricted flow passage leading from said pressure chambers to a point of atmospheric pressure, flow connections leading from said tank to said regenerant chamber and a point of disposal for waste, a group of other diaphragm valves, one in each of said last named flow connections and controlling flow from said regenerant chamber to said tank and from said tank to said waste connection, respectively, pressure chambers for said diaphragm control valve and said group of other diaphragm valves, a hydraulic suction producing device having an inlet, an outlet and a suction connection, said inlet being in permanent communication with said source and said suction connection being in permanent communication with said last named pressure chambers, passage means leading from said outlet to a point of atmospheric pressure, a pilot valve in said passage means, and means for opening and closing said pilot valve.

7. In the apparatus of claim 6, a head box constituting said points of atmospheric pressure, and a flow passage from said head box to said regenerant chamber.

ERIC PICK.

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