Jan. 4, 1944. A. L. RICHE 2,338,667

WATER TREATMENT APPARATUS

Original Filed Sept. 13, 1935 2 Sheets-Sheet 1

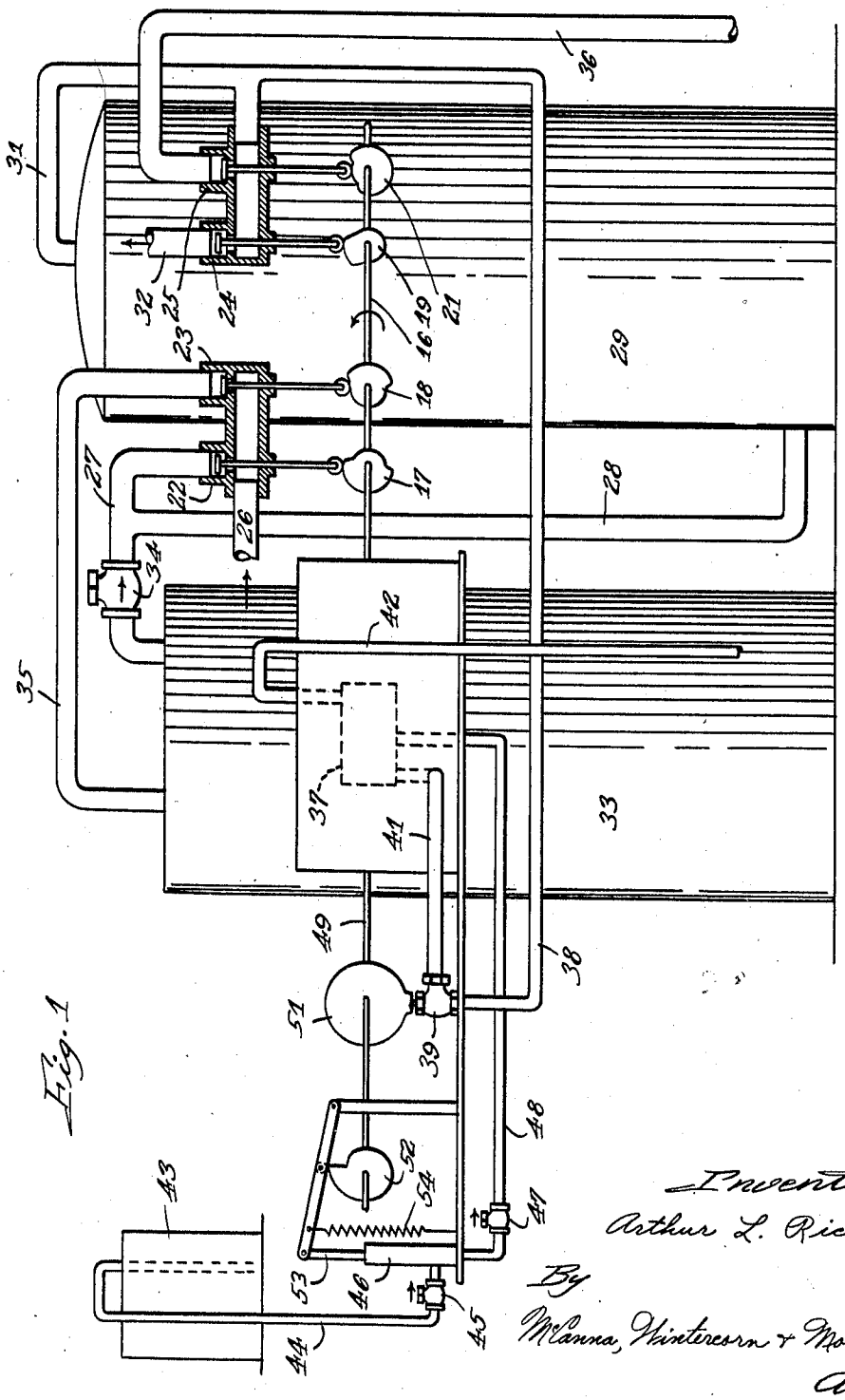


Fig. 1

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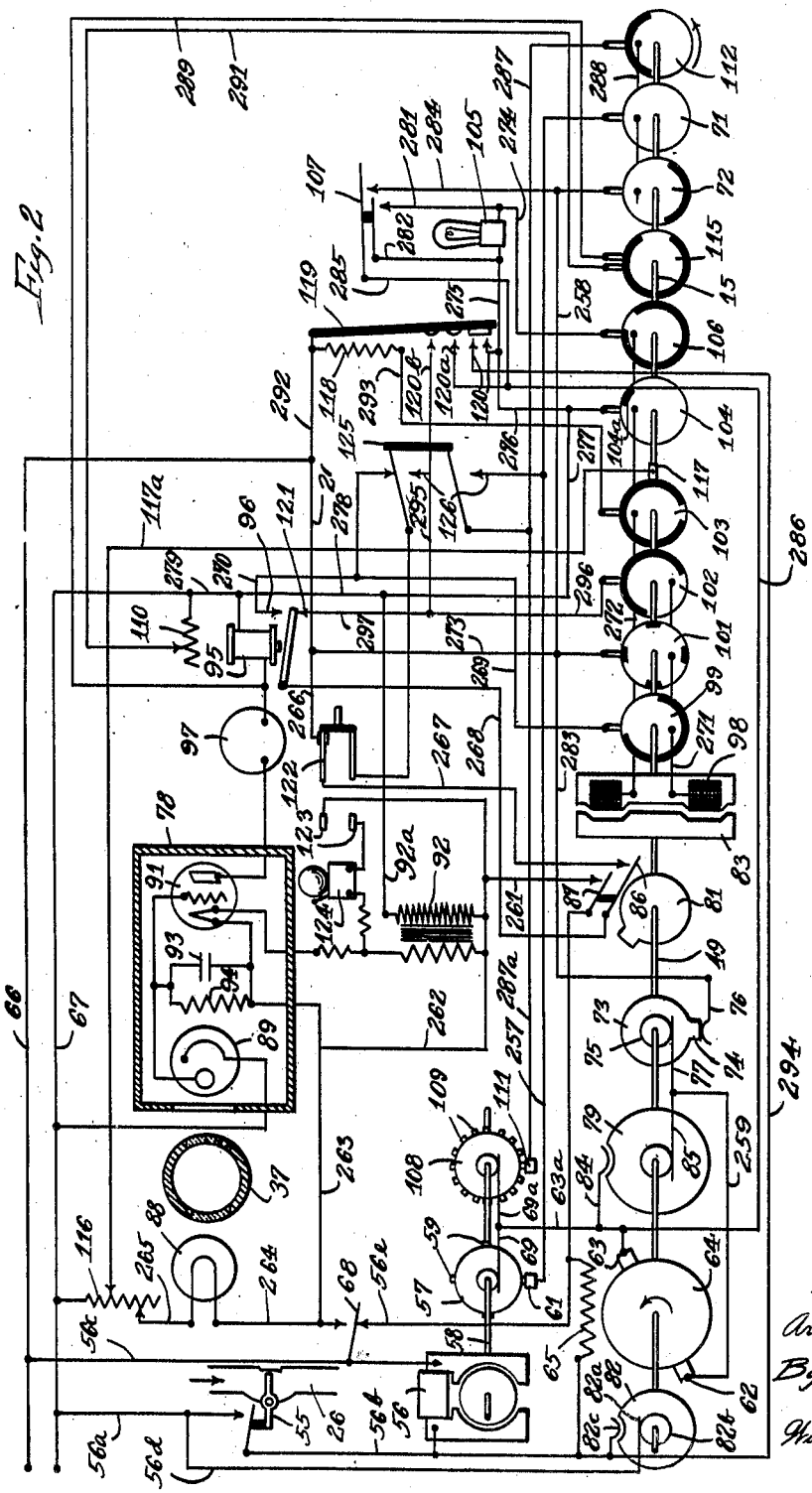
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WATER TREATMENT APPARATUS

Original Filed Sept. 13, 1935 2 Sheets-Sheet 2

Fig. 2



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UNITED STATES PATENT OFFICE

2,338,667

WATER TREATMENT APPARATUS

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Original application September 13, 1935, Serial No. 40,379. Divided and this application January 24, 1941, Serial No. 375,838

23 Claims. (Cl. 210—24)

This invention relates to water treatment devices and has special reference to automatic devices wherein the operation thereof is controlled in response to a photoelectric test on the effluent water.

An object of the invention is the provision of generally improved means for testing a stream of changing fluid and the actuation of control mechanism in response to the tests.

A further and more specific object is the provision of a zeolite water softener wherein all steps of the regeneration which involve a flow of liquid through the softener are automatically controlled in response to tests on the effluent water.

Another object is the provision of testing means wherein the frequency of the tests is proportional to the flow of the fluid to be tested.

Other objects and attendant advantages will be apparent from the following description and the accompanying drawings, in which—

Figure 1 is a diagrammatic view showing a water softener embodying my invention, and

Fig. 2 is a diagrammatic showing of the testing and actuating mechanisms.

The invention as herein shown contemplates an automatic water treatment apparatus including water treatment mechanism, valve mechanism for controlling the flow through the apparatus, and testing mechanism for testing the effluent from said apparatus to actuate the control mechanism in response to changes in the effluent therefrom. This is a division of my copending application, Pat. No. 2,254,782, issued September 2, 1941.

In Figs. 1 and 2 I have shown in diagrammatic form the apparatus for testing and controlling the operation of a zeolite water softener which is so arranged that it may be used either for operating the softener in a completely automatic manner, or to perform the tests and emit signals to indicate when the operations should be performed manually. The control mechanism has a driven shaft diagrammatically shown at 15 adapted to be integral with or connected to a shaft 16 (Figure 1) when the control device is used for automatic actuation of a softener. The shaft 16 carries cams 17, 18, 19 and 21 adapted to actuate valves 22, 23, 24 and 25, respectively. In the particular valve arrangement shown in Figure 1, the valves 22 and 23 are interconnected and the valves 24 and 25 are interconnected, though this particular arrangement is shown merely by way of illustration, and numerous other suitable valve arrangements are well known in the art. A pipe 26 is connected to a supply of hard water which during normal softening operation passes through pipes 27 and 28 to the bottom of the softener tank indicated generally by the numeral 29. The softened water emerges from the softener through the pipe 31 and passes into the service line 32 by way of the valve 24, the valves in Figure 1 being shown in the service position. A regenerating solution tank 33 is connected to pipe 27 through check valve 34 and to valve 23 by line 35 in such manner that when hard water is passed into the line 35 through opening of the valve 23, solution will be forced out of the tank by way of the check valve 34 into the line 28 to the bottom of the softener. The valve 25 is connected to drain through a pipe 36.

The testing and control device has an observation cell 37 provided with a pair of glass windows through which light may be projected. This cell is connected to the outlet of the softener by means of a pipe 38, a valve 39 and a pipe 41 and to drain through a pipe 42. The observation cell is also connected to a source of reagent supply 43 through a pipe 44, a check valve 45, a pump 46, a check valve 47, and a pipe 48. A shaft 49 is driven from a motor shaft of the control mechanism in a manner which will presently appear so as to periodically make one complete revolution for the purpose of performing a test. During this rotation of the shaft a cam 51 allows the stem of the valve 39 to rise, shutting off the flow of water to the cell 37 and shortly thereafter a cam 52 on the shaft 49 releases the piston 53 of the reagent pump, a spring 54 causing the return of the piston and the simultaneous injection of a quantity of reagent into the cell 37. This reagent has the property of reacting chemically with the calcium and magnesium salts in the hard water to produce a precipitate, though it will be understood that where the device is used for a purpose other than the detecting of hardness or regenerating solution in the water, any other suitable reagent will be employed which will product a physically perceptible change in the solution in the cell 37. In the present instance a suitable reagent is a standard solution of potassium salts of non-volatile fatty acids (of which corn oil has been found preferable) held in solution by the addition of a sugar of glycerine and filtered at a low temperature.

The control mechanism shown in Fig. 2 is effective to make periodic tests on the effluent from the softener and in response to said tests rotate the shaft 16 a quarter turn when the effluent water becomes hard, thus initiating regeneration of

the softener. The mechanism is also effective to make periodic tests of the effluent from the softener when regenerating solution is being admitted thereto and upon the appearance of this solution in the effluent from the softener to again turn the shaft 16 through a quarter turn for the purpose of stopping the flow of regenerating solution. Thereafter the brine is allowed to stand in the softener tank for a predetermined period which is automatically measured by the control mechanism at the termination of which the control mechanism rotates the shaft 16 through a further quarter turn bringing the softener valves into the rinse position. Thereafter the test and control mechanism tests the effluent from the softener and when the spent regenerating solution has been completely washed from the softener automatically again turns the shaft 16 through a final quarter turn returning the valves to the service position.

I will now describe in detail the structure by which this automatic actuation of the valves is accomplished.

A flow switch 55 is positioned in the water line 26 carrying hard water to the softener so that the contacts thereof are closed only when water is flowing in the pipe 26 in quantity greater than that required for test purposes. The switch 55 is connected into a circuit 56*a*, 56*b* and 56*c* of a synchronous self-starting timing motor 56 of the type used in clocks so that the timing motor only runs when water is flowing in the pipe 26, except to open the contacts during a test, the purpose being to test the water at certain intervals based on the time the water flows. A contact disk 57 is carried on a shaft 58 driven by the timing motor 56 and carries a plurality of contacts 59 adapted to engage a fixed contact 61 at spaced intervals, dependent upon the relationship between the shaft 58 and the motor, to initiate a test. In this particular construction the shaft makes a complete revolution each hour of running time so that tests are initiated each time water has flowed in the pipe 26 for a total of fifteen minutes. The interval can, of course, be regulated to suit requirements.

When contacts 59 and 61 are closed, the circuit is closed between the poles 62 and 63 of a repulsion motor 64, the field 65 of which is energized by current flowing from electrical supply lines 66 and 67 by way of lead 56*a*, flow switch 55, wire 56*b*, a wire 56*e*, a manually operated switch 68 and wire 56*c*. The circuit through the poles of the motor is closed through a wire 62*a*, brush 69 on a wire 257, contact disk 57, the contacts 59 and 61, contact disks 71 and 72 which are electrically interconnected, leads 258 and 263, a disk 73 having contacts 74 and 75 and brushes 76 and 77, and a wire 259. Upon the closing of this circuit the drive motor 64 begins to rotate, turning shaft 49 to which it is geared by suitable gearing not shown.

The contact disk 73 together with contact disks 79, 81 and 82, cams 51 and 52, and a clutch member 83 are carried on the shaft 49 and rotate with it. A brush 84 is connected to the motor pole 63 and is positioned to be out of contact with disk 79 when the drive motor is stopped but to engage the disk upon slight rotation thereof to complete the circuit between the poles by way of the disk 79, a brush 85 associated therewith and wire 259. Shortly thereafter the contact 74 leaves the brush 76 breaking the starting circuit at this point. A wire 56*d* shunts around the flow switch 55 and connects with a brush 82*a* engaging a contact ring 82*b* on the disk 82 and a brush 82*c* connected into the circuit including the wire 56*b* engages the disk 82 at all points except the starting point to insure continuous supply of current to the field 65 through a complete revolution of the shaft 49.

When the motor 64 starts, cam 51 on the shaft 49 cuts off the flow of water through observation cell 37, whereupon cam 52 causes reagent to be injected into the sample of water retained in the observation cell. A delay ensues while shaft 49 continues its rotation to the point where disk 81 engages interconnected switches 86 and 87. Thereupon switch 87 closes, the contacts therein being closer spaced than the contacts of switch 86, causing current to flow through a lamp 88 by way of wires 56*c*, switch 68, wire 56*e*, wires 261, 262, 263, 264, 265, and resistance 110, and projecting a beam of light through the observation cell 37 onto a light sensitive cell 89 connected to an amplifying tube 91 in such manner that a decrease of illumination on the light sensitive cell causes an increase of tube output. The light sensitive cell and amplifying unit are advantageously enclosed as shown at 78 to exclude extraneous light.

The power supply is alternating from a transformer 92 which is energized by way of wire 56*c*, switch 68, wire 56*e*, switch 87, wire 261, wire 92*a*, and wires 278 and 279, but both the photoelectric cell and the amplifying triode act as half-valve rectifiers on opposite sides of the cycle. A condenser 93 serves to bring the two sufficiently into phase so that the potential drop over a resistance 94 puts the negative bias on the grid of the tube which reduces the plate current to zero, when the intensity of light from the lamp 88 is properly adjusted.

If soft water is flowing in the observation cell 37 when the flow of water is cut off, the injection of reagent therein has no effect upon the light absorption characteristics of the fluid and the drive motor 64 continues its operation until the shaft 49 has been driven through a complete revolution without the remainder of the mechanism being actuated. However, when hard water begins to appear in the effluent from the softener, the observation cell 37 will necessarily contain water having a certain degree of hardness so that when the reagent is injected it will react with the hardness producing constituents of the water such as the calcium and magnesium salts, causing a precipitation within the observation cell which interferes with the passage of light therethrough. When this precipitate becomes sufficient to block the light to a predetermined degree, the output from the tube 91 will reach a point sufficient to actuate a relay 95 causing it to pick up and close a contact 96, the current concurrently passing through a milliammeter 97 which gives a visual indication to the operator. The cam 81 which has continued its rotation, as previously described, closing the contact 87, now closes the contact 86. Upon closing of the contact 86 nothing happens unless the relay 95 has picked up, in which case current will flow through a magnetic clutch 98 by way of a wire 266, a switch 122, a wire 267, the contact 86, a wire 268, the relay contact 96, wires 279 and 269, a contact disk 99, conductor 271, a conductor 272, contact disk 104, wires 277, 278 and 279 causing the magnetic clutch to engage and rotate the shaft 15 until the circuit is broken at contact disk 104, whereupon the clutch will release and the shaft

49 will complete its revolution independently. Thereupon a lamp 105 is in circuit with the clutch 98 through a wire 266, a wire 273, a contact disk 101, wire 271, clutch 98, wire 272, wire 274, lamp 105, and wires 275, 276, 277, 278 and 279, the burning of the lamp 105 indicating to the operator that the softener is in need of regeneration. While the lamp 105 is in series with the clutch, it does not permit enough current to pass to hold the clutch in engagement. The operator then depresses switch 107 shunting out the lamp 105 and closing the circuit through the clutch by way of wires 266 and 273, disk 101, wire 271, clutch 98, wire 272, disk 106, wire 274, a wire 281, switch 107, a wire 282, and wires 275, 276, 277, 278 and 279, and holds switch 107 closed until insulator 104a of contact disk 104 has moved beyond its brush to establish the circuit direct from wire 272 to 277. The closing of the switch 107 simultaneously closes the circuit between the poles 62 and 63 of the drive motor by way of wire 259, brush 77, contact 74, brush 76, wires 283, 258 and 284, switch 107 and wires 285 and 286, thus causing this shaft 49 to again rotate through one revolution. During this rotation of the shaft 49 the clutch 98 will remain engaged until the circuit is broken at contact disk 101, causing the shaft 15 to be rotated a sufficient distance to complete a quarter turn thereof and moving the valves (Figure 1) into a position to close the valve 22, open the valve 23, close the valve 24 and open the valve 25, thereby placing the valves in a position to admit regenerating solution from the tank 33 into the softener tank 29. Where it is desired to operate the softener in a completely automatic manner, the switch 107 is maintained closed at all times so that when the relay 95 picks up, the shaft 15 will not be stopped by operation of the contact disk 104 but will pass completely through a quarter turn into the regenerating position.

In this position of the shaft 15 and of the softener valves, regenerating solution is being fed into the softener and tests are performed to determine when this solution has completely displaced the water in the softener. For this purpose a contact disk 108 is carried on the shaft 58 of the timing motor and has a plurality of contacts 109 adapted to make contact with an opposed contact 111 at more frequent intervals. When regenerating solution has begun to come through the softener it will appear in the observation cell 37 at one of the successive tests causing the relay 95 to pick up upon closing of the contact 87, the contact 111 being connected to a contact disk 112 by conductors 287a and 287, the circuit between the poles 62 and 63 being closed through the wire 63a, a brush 69a, disk 108, contact 111, conductors 287a and 287, disk 112, a conductor 288, disk 72, wires 253 and 283, brush 76, contact 74, disk 73, contact 75, brush 77 and wire 259. With the relay 95 closed, the closing of the contact 86 completes the circuit through the magnetic clutch by way of the contact disks 99 and 104 as previously described and maintains the clutch closed for a quarter turn through the establishment of a circuit through the contact disk 101. This brings the valves of the softener to a position in which all of the valves except 25 are closed holding the regenerating solution quiescent in the softener for the completion of reaction between it and the zeolite.

It will be observed that when the regenerating solution is being passed into the softener and emerges therefrom in the effluent line so as to reach the observation cell 37, this solution will come through the softener in high concentration. Furthermore, this effluent will be spent solution containing principally calcium and magnesium salts obtained from the zeolite bed. This high concentration of spent solution will produce a large amount of precipitate in the observation cell upon reaction with the reagent and will obscure most of the light from the lamp 68, thereby giving a very high tube output. In order to change the test range and protect the relay 95 its sensitivity is decreased during the tests when the valves occupy the brine intake position by the closing of an adjustable shunt around the relay coils which is accomplished by contact disk 115, wires 289 and 291, and resistance 116. Furthermore, for the best results from the tube its output should be held below a certain maximum which is accomplished by shunting a part of the control resistance 118 in series with the lamp by way of wires 279, 278, 277, disk 104, conductor 272, disk 103, a contact 117 and a conductor 117a thus increasing the illumination on the photoelectric cell 39 and decreasing the tube output.

As the shaft 15 moves into the last mentioned or soaking position, a circuit is closed between the power lines through contact disks 103 and 104, the current passing through the resistance 118 of a thermal timer designated generally by 119 by way of a wire 292, resistance 118, a wire 293, disk 103 and associated brush, conductor 272, disk 104 and associated brush, and wires 277, 278 and 279. Upon the lapse of a predetermined period of time, the blade of the thermal timer will cause contacts 120 to be made to close the circuit through the winding 65 of the motor 64 by way of wire 59c, switch 68, wire 59e, winding 65, a wire 294, contact 120, and wires 276, 277, 278 and 279. The blade also closes the circuit through the poles 62 and 63 of the drive motor through wire 286, contact 120a, the timer blade 119, wires 292, 266, 273, 283, contact brush 76, contact 74, disk 73, contact 75, brush 77 and wire 259, causing the shaft 49 to rotate through a complete turn, and simultaneously the circuit through the magnetic clutch will be closed by way of wire 292, the thermal timer blade 119, contact 120b, wires 295 and 296, contact disk 102, conductors 271 and 272, disk 104 and conductors 277, 278 and 279. Shortly after movements of valves begin a new circuit is set up by current flowing directly through wires 266, 273 and disk 101 to wire 271. The shaft 15 is then indexed an additional one-quarter turn so as to open valve 22, close valve 23, close valve 24 and open valve 25 so that water will flow through the softener and into drain by way of the pipe 36. As water flows through the softener, the timing motor 58 will periodically cause the closing of the contacts 109 and 111 to bring about periodic tests on the effluent. Since spent regenerating solution is passing through the observation cell 37 during the initial part of this test period, the relay 95 will be picked up upon each of the tests so that when the contact 86 is closed the circuit through the clutch 98 cannot be completed through the contact disk 102. However, when the spent regenerating solution is completely washed from the softener, no precipitation will occur in the observation cell and consequently the relay 95 will not pick up so that when the switch 86 is closed the circuit through the clutch 98 will be closed by way of wire 266, switch 122, wire 297, switch 86, wire 263, the relay, contact 121, a wire 297, wire 296, disk 102, conductors 271 and 272, disk 104, and wires 277, 278 and 279,

causing the shaft 15 to rotate through the final one-quarter turn, returning the valves to the service position shown in Figure 1 and completing the regeneration of the softener, disk 101 and wires 266, 273, maintaining the circuit closed after the opening of the relay. At this point the flow switch 55 and timing motor 56 again take up the duty of initiating periodic tests on the effluent soft water from the softener.

The switch 63 is provided to permit manual calibration and adjustment of the light sensitive testing mechanism as desired without in any wise affecting the actuating mechanism for the shafts 49 and 15. By closing this switch to complete circuit directly from wire 56c to wire 264 the lamp 88 is caused to come on, and the effect of this may be observed on the milliammeter 97.

Where the testing and actuating device is desired to be used as an alarm mechanism with the valves to be operated manually, a switch 122 is provided adapted to be thrown to the left facing Fig. 2 to close contacts 123 to a bell 124 or other signal device. With the switch in this position when the test indicates water of more than the desired hardness, the bell will ring during the time that contact 36 is closed. Likewise, when the test for regenerating solution in the wash water is desired, a switch 125 is thrown from the position shown in Fig. 2 to a lower position to close contacts 126 which places the contacts 109 and 111 in control of the testing time and the contact 121 of the relay 95 in control of the bell so that a signal will be given when water free of hardness producing constituents passes into the observation cell 37 and the next succeeding test is accomplished.

It will be seen that I have provided a generally improved zeolite water softener wherein regeneration of the softener is initiated in response to the change in character of the effluent, and wherein each step of the regeneration in which liquid flows through the softener is initiated in response to changes in the effluent so that the maximum efficiency in the regeneration operation is obtained. I have also provided improved testing means for testing the character of the water and improved means for actuating the valves of a softener or other mechanism as a result of the test. I have also provided a test mechanism wherein the frequency of the test is proportioned to the time of flow of the fluid being tested.

While I have thus described and illustrated specific embodiments of the invention, I am aware that numerous alterations and changes may be made therein without resort to invention, and I do not want to be limited except as required by the scope of the appended claims, in which I claim:

1. The combination in a water softener of a softener tank having a hard water inlet and a source of regenerating solution, valve means for controlling the flow through said tank movable between service, regenerating, and rinse positions, light sensitive means for periodically testing the effluent of the softener for hardness and for regenerating solution connected to receive effluent water from said softener tank, and means responsive to said testing means for moving said valve means from the service position when the test indicates hardness in the water, from the regenerating position when the test indicates regenerating solution in the water, and from the rinse position when the test indicates the absence of regenerating solution in the wash water.

2. The combination in a water softener of a softener tank having a hard water inlet and a source of regenerating solution, valve means for controlling the flow through said tank movable between service, regenerating, and rinse positions, light sensitive means connected to receive effluent from said softener for periodically testing the effluent for hardness and for regenerating solution, means responsive to said testing means for moving said valve means from the service position when the test indicates hardness in the water, from the regenerating position when the test indicates regenerating solution in the water, and from the rinse position when the test indicates the absence of regenerating solution in the wash water, and means to vary the frequency of test in different positions of the valve means.

3. The combination in a water softener of a softener tank having a hard water inlet and a source of regenerating solution, valve means for controlling the flow through said tank movable between service, regenerating, soak and rinse positions, light sensitive means connected to receive effluent from said softener for testing the effluent for hardness and for regenerating solution, means responsive to said testing means for moving said valve means out of the service position when the test indicates hardness in the water, out of the regenerating position when the test indicates regenerating solution in the water, and out of the rinse position when the test indicates the absence of brine in the water, and timing means for initiating the movement of said valve means from the soak position.

4. The combination with liquid treatment apparatus of conduits for conducting liquid to and from said apparatus valve means in said conduits for controlling the flow of said liquid through said apparatus and means for actuating said valves in response to changes in the character of the liquid flowing from said apparatus comprising means for periodically performing a light sensitive test on said liquid flowing from said apparatus including a drive motor, clutch means to drive said valve means, and an electrical circuit means for engaging said clutch means in response to a predetermined result from said light sensitive test means.

5. The combination with liquid treatment apparatus of conduits for conducting liquid to and from said apparatus valve means in said conduits for controlling the flow of said liquid through said apparatus and means for actuating said valve means through a predetermined cycle in response to changes in the character of the liquid flowing from said apparatus comprising light sensitive means connected to receive said liquid flowing from said apparatus for periodically testing the same including a drive motor, a magnetic clutch for establishing driving connection between said motor and said valve means in response to a predetermined result from said testing means, and switch means set by operation of the clutch to establish control circuits for subsequent valve operations.

6. The combination with liquid treatment apparatus of conduits for conducting liquid to and from said apparatus, valve means in said conduits for controlling the flow of said liquid and means for actuating said valve means through a predetermined cycle in response to changes in

the character of the liquid flowing from said apparatus comprising light sensitive means connected to receive said liquid flowing from said apparatus for periodically testing said liquid including a drive motor, a magnetic clutch for establishing driving connection between said motor and said valve means in response to a predetermined result from said testing means, control circuits for said magnetic clutch, switch means set by operation of the clutch to establish said control circuits for successive valve operations, and means for determining the frequency of tests comprising an electric timing motor and a flow switch for controlling the supply of current to the timing motor adapted to be held closed by a predetermined flow of water in the water supply line.

7. The combination in a zeolite water softener having a softening tank provided with a raw water inlet, valve means for controlling the flow of liquid to and from said tank, means connected to receive effluent from said tank for testing the effluent to determine the point of exhaustion of the zeolite, a source of electric current for said testing means, means including circuit means for initiating regeneration of the softener in response to said test, and means for determining the frequency of said tests comprising an electric timing motor connected to said source of current and a flow switch in the circuit of said timing motor for controlling the supply of current to the timing motor, said switch being held closed by a predetermined flow of water through the softener whereby to operate the timing motor only upon the flow of water through the softener.

8. The combination in a water softener of a softener tank having a hard water inlet and a source of regenerating solution, valve means for controlling the flow through said tank movable between service, regenerating, and rinse positions, light sensitive means connected to receive effluent from said tank for periodically testing the effluent for hardness and for regenerating solution, means responsive to said testing means for moving said valve means out of the service position when the test indicates hardness in the water, out of the regenerating position when the test indicates regenerating solution in the water, and out of the rinse position when the test indicates the absence of regenerating solution in the water, and means connected to said testing means for decreasing the sensitivity of the testing means when the valve means occupies the regenerating position.

9. The combination with liquid treatment apparatus of valve means for controlling the flow of liquid and means for actuating said valve means through a predetermined cycle in response to changes in the character of the liquid comprising light sensitive means connected to receive treated liquid from said apparatus for periodically testing said liquid, a plurality of circuit closing mechanisms for initiating tests at different intervals, means for driving said valve means in response to a predetermined result from said testing means, and means set upon movement of the valve means to select said circuit closing mechanisms for different frequencies of test in different valve positions.

10. The combination with liquid treatment apparatus of light sensitive testing means comprising means for testing the light absorption characteristic of said liquid flowing from said apparatus, a control circuit for said testing means, a plurality of timing means for periodically energizing said last mentioned means at different intervals to determine the frequency of said tests, and manually operable means for connecting any one of said timing means in circuit with said testing means to energize the same at different testing intervals.

11. The combination with liquid treatment apparatus of light senstive testing means for testing the light absorption characteristics of said liquid flowing from said apparatus, means to be operated in response to a predetermined test result, a control circuit for said testing means, a plurality of timing means for initiating operation of the testing means at different time intervals, and manually operable means for connecting any one of said timing means in circuit with said testing means to select different testing periods for different liquid conditions.

12. The combination in a zeolite water softener of a softener tank having a hard water inlet and a source of regenerating solution, valve means for controlling the flow through said tank, means for operating said valve means to admit regenerating solution thereto and wash the same therefrom, light sensitive testing means connected to receive effluent from said softener for periodically testing the hardness of the effluent water from said tank and for the presence of regenerating solution, said testing means having a plurality of circuits, means in one of said circuits to emit a signal when said effluent reaches a predetermined hardness and upon the absence of regenerating solution, a plurality of timing means in said circuits for initiating operation of the testing means at different time intervals, and manually operable means for connecting different timing means in circuit with said testing means when testing for hardness and for regenerating solution to select different testing periods.

13. The combination in a zeolite water softener of a softener tank having a hard water inlet and a source of regenerating solution, valve means for controlling the flow through the softener, means for operating said valve means light sensitive testing means connected to receive effluent from said tank for testing the effluent of said softener having a plurality of circuits, timing means in one of said circuits for periodically initiating said testing means to test the effluent for hardness, signal means, relay means in one of said circuits electrically connected to said signal means operative in response to a predetermined result of said testing means corresponding to a predetermined hardness to energize said signal means, a second timing means in one of said circuits for initiating the testing means at more frequent intervals, and switch means manually operative to place the secondary timing means in control of the testing period and to energize the signal means upon failure of the relay means to respond to the testing means to indicate the absence of hardness producing constituents in the effluent.

14. The combination in a water softener of a softener tank having a hard water inlet and a source of regenerating solution, valve means for controlling the flow through said tank movable between service, regenerating and rinse positions, light sensitive means connected to receive effluent from said tank for periodically testing the effluent of the softener for hardness and for regenerating solution, means for periodically supplying current to said testing means and means re-

sponsive to said testing means for moving said valve means from the service position when the test indicates hardness in the water, from the regenerating position when the test indicates regenerating solution in the water, and from the rinse position when the test indicates the absence of regenerating solution in the water, said last mentioned means including a relay, a plurality of circuits controlled by said relay, and switches in said circuits selectively operated in different positions of said valve means.

15. The combination in a water softener of a softener tank having a hard water inlet and a source of regenerating solutions, valve means for controlling the flow through said tank movable between service, regenerating and rinse positions, light sensitive means connected to receive effluent from said softener for periodically testing the effluent for hardness and for regenerating solution, means for periodically supplying current to said testing means, means responsive to said testing means for moving said valve means from the service position when the test indicates hardness in the water, from the regenerating position when the test indicates regenerating solution in the water, and from the rinse position when the test indicates the absence of regenerating solution in the water, said last mentioned means including a relay, a plurality of circuits controlled by said relay, and switches in said circuit selectively operated in different positions of said valve means, and means in circuit with said testing means to vary the frequency of test in different positions of the valve means.

16. The combination in a water softener of a softener tank having a hard water inlet and a source of regenerating solution, valve means for controlling the flow through said tank movable between service, regenerating and rinse positions, electrical means for actuating said valve means between said positions, light sensitive means connected to receive effluent from said softener for periodically testing the effluent for hardness and for regenerating solution, means for supplying current to said testing means, and means including a relay in circuit with and responsive to said testing means, a plurality of circuits to said electrical means, and switch mechanism for selectively connecting said circuits to the relay in different positions of the valve means, said circuits and switch mechanism being arranged to successively energize said electrical means to move said valve means from the service position when the test indicates hardness in the effluent, from the regenerating position when there is regenerating solution in the effluent, and from the rinse position when the test indicates the absence of regenerating solution in the effluent.

17. The combination in a water softener of a softener tank having a hard water inlet and a source of regenerating solution, valve means for controlling the flow through said tank movable between service, regenerating and rinse positions, light sensitive means connected to receive effluent from said softener for periodically testing the effluent for hardness and for regenerating solution, control circuits for supplying current to said testing means, controlled circuits, means responsive to said testing means for moving said valve means from the service position when the test indicates hardness in the water, from the regenerating position when the test indicates regenerating solution in the water, and from the rinse position when the test indicates the absence of regenerating solution in the water, said last mentioned means including a relay in said controlled circuits actuated in response to said tests, and a plurality of timing means selectively operable on said testing means to initiate tests thereby at different intervals, and switch means for connecting predetermined timing means into said control circuits in different positions of the valve means to perform tests at different intervals in different positions of the valve.

18. The combination in a water softener of a softener tank having a hard water inlet and a source of regenerating solution, valve means for controlling the flow through said tank movable in succession through service, regenerating and rinse positions, light sensitive means connected to receive effluent from said softener for periodically testing the effluent for hardness and for regenerating solution, control circuits for supplying current to said testing means, controlled circuits, and switch mechanism in said controlled circuits movable by the valve means to set up said controlled circuits for effectuating the next succeeding valve operation, said testing means including relay means in said controlled circuits for completing said controlled circuits in response to a predetermined outcome of said tests.

19. The combination in a zeolite water softener of a softening tank having a hard water inlet and a source of regenerating solution, valve means for controlling the flow of liquid through service, regenerating and rinse steps, means connected to receive effluent from said softener tank for testing the effluent from said tank for hardness and for regenerating solution, and means for determining the frequency of test on said effluent comprising a circuit, an electric motor in said circuit and a flow switch in said circuit for controlling the supply of current to the motor adapted to be held closed by a predetermined flow of water in the water supply line.

20. The combination in a liquid treating device of a liquid treatment tank having an inlet for liquid to be treated, means for controlling the flow of liquid through said tank, means connected to receive liquid from said tank for testing the effluent from said tank for a predetermined characteristic, and means for determining the frequency of test comprising a circuit, an electric timing motor in said circuit for energizing said testing means, and a flow switch in said circuit for controlling the supply of current to the motor adapted to be held closed by a predetermined flow of liquid through said tank.

21. The combination with a water softener having a softener tank having a hard water inlet, a source of regenerating solution, valve means for controlling the flow through said tank movable between service, regenerating and rinse positions, and means for moving said valve means between said positions of light sensitive means connected to receive effluent from said softener tank for periodically testing the effluent of the softener for hardness and for brine, and means including a circuit for varying the sensitivity of the testing means in different positions of said valve means.

22. The combination with liquid treatment apparatus of valve means for controlling the flow of said liquid, and means for actuating said valve means through a predetermined cycle in response to changes in the character of the liquid comprising light sensitive means connected to receive treated liquid from said apparatus for periodi-

cally testing said liquid including a motor for driving the tester, circuits for supplying current to said tester and said motor clutch means for driving said valve means from said motor, a plurality of circuits controlled from said testing means, means in one of said controlled circuits for engaging said clutch in response to a predetermined test result, and switch means set at the time of operation of the clutch to successively establish said control circuits for successive valve operations.

23. The combination in a water softener of a softener tank having a hard water inlet and a source of regenerating solution, valve means for controlling the flow through said tank movable between service, regenerating and rinse positions, means for driving said valve means progressively through said positions, light sensitive means connected to receive effluent from said softener tank for testing the effluent of said softener through a hardness testing cycle, a regenerating solution testing cycle and a rinse testing cycle, circuits for each valve position, switch means in said circuits controlled by the valve means to set said tester for said successive cycles and to set said circuits for each valve position, and means for closing said circuits in reponse to predetermined results in each of said test cycles to index the valve means through a regeneration cycle.

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