CONTROL UNIT FOR A WATER SOFTENER

Inventors: Edward C. Grout; Donald F. Klasy, both of Delavan, Wis.

Assignee: Sta-Rite Industries, Inc., Delavan, Wis.

Filed: Sept. 14, 1972

Appl. No.: 288,924

U.S. Cl. 210/127, 210/134, 210/136, 210/140, 210/191

Int. Cl. C02b 1/22

Field of Search 210/134, 136, 190, 191, 210/140, 127

References Cited

UNITED STATES PATENTS
2,800,229 7/1957 Spaulding, Jr. 210/142

ABSTRACT

A valve control unit for a water softener. The control unit is mounted on the ion exchange resin tank and includes a series of cam operated valves which control the flow of water and brine through the tank during various cycles of the regeneration process.

21 Claims, 18 Drawing Figures
CONTROL UNIT FOR A WATER SOFTENER

BACKGROUND OF THE INVENTION

This invention relates to a valve control unit for a water softener and more particularly to a control unit for controlling the flow of water and brine through the tank containing the ion exchange resin during the regeneration procedure.

The conventional water softener includes a softening tank containing a bed of ion exchange resin, and during normal service, hard water containing dissolved metal salts flows through the bed where the soluble metal ions in the water are adsorbed on the resin. Periodically the resin must be recharged by purging the resin with brine. The regeneration process is normally controlled in an automatic manner and is initiated by one of various means, such as a timer, a conductivity sensor, a flow meter, or the like. The common regeneration process includes a backwash cycle in which the flow of water through the resin bed is reversed from its normal flow. Following the backwash, brine is passed through the resin bed, and depending on the particular system, the brine purging can be either upward or downward through the resin bed. The backwash is followed by a slow rinse. The slow rinse is followed by a fast rinse in which water is flushed at increased volume through the resin bed, and this is followed by a refilling cycle in which the brine tank is refilled with water. After refilling, the programing returns the valve to the original condition for normal service operation.

During the entire regeneration procedure a provision is made to bypass hard water around the softener so that hard water is available in the household lines during the regeneration.

SUMMARY OF THE INVENTION

The invention is directed to an improved valve control unit for a water softener. According to the invention, the control unit includes a fitting which is mounted within an opening in the upper end of the tank which contains the ion exchange resin. The fitting includes a hard water inlet, a soft water outlet and a main control valve which directs the flow of incoming water either into the tank, as during normal service operation, or into a regeneration chamber during the regeneration procedure. A tube extends downwardly from the fitting within the resin bed to the lower end of the tank, and the interior of the tube communicates through a check valve with the outlet, so that during normal service, the water entering the tank directly from the fitting will pass downwardly through the resin bed, into the tube, and then upwardly through the check valve to the outlet.

The regeneration procedure is initiated by a backwash cycle. In this cycle, the main control valve directs the hard water to the regenerating chamber which communicates via a passage with the upper end of the tube in the resin tank. Flow through the passage is controlled by a three-way valve, and in the backwash cycle, the valve establishes communication between the regeneration chamber and the passage so that the hard water can flow from the regeneration chamber through the passage, downwardly within the tube and then upwardly through the resin bed in a reverse path to the normal service operation.

The fitting also includes a second passage that is connected between the upper end of the resin tank and a drain line and is controlled by a second three-way valve. During the back-wash cycle, the second three-way valve establishes communication between the second passage and the drain line so that the water passing upwardly through the resin bed can be discharged to the drain. A brine cycle follows the backwash cycle. In the brine cycle water passes from the regeneration chamber through a bypass passage controlled by a bypass valve to an ejector. Water discharged from the ejector, creates a negative pressure or aspirating effect which serves to draw brine from a brine tank. The brine passes downwardly within the resin bed in the softening tank and then upwardly within the central tube to the first passage. At this time the first three-way valve establishes communication between the first passage and the drain line so that the brine will be discharged to the drain line. This cycle continues for a period of time in an excess of that required to deplete the brine supply so that after the brine is exhausted the water continues to pass through the resin bed provides a slow rinse.

The next cycle is the fast rinse and during this cycle the second three-way valve acts to connect the regeneration chamber with the second passage and the first three-way valve connects the first passage to the drain so that water flows from the regeneration chamber through the second passage, downwardly through the resin bed and then upwardly through the central tube and through the first passage to the drain line.

The final cycle is the brine refill cycle, and in this cycle the main control valve is open, both three-way valves are closed, the bypass valve is open, so that hard water from the inlet will pass through the main control valve, through the resin bed in the softening tank, and a portion of the resulting soft water will flow through the by-pass valve to refill the brine tank with soft water. After the brine tank has been refilled, the valving returns to its normal service condition.

The main control valve, both three-way valves and the bypass valve are all operated in the desired sequence by camactuated rocker arms. The cam shaft is driven by a timer motor or other power source. Rotation of the cams causes the valves to be actuated through the rocker arms in the designed sequence to provide the various cycles of the regeneration procedure.

The three-way valves provide increased versatility for the regeneration in that it is possible to obtain any desired sequence of backwashing, rinsing and brining as desired.

Furthermore, the three-way valves include pressure balanced plungers which are constructed so that an increase of pressure has virtually no effect on the force needed to depress the valve. This enables larger diameter porting to be employed without increasing the forces on the cam assembly, thereby permitting an increase in flow rates in the backwash and rinsing cycles over conventional valve control units.

The main control valve and the check valve which controls the flow of water from the central tube are vertically stacked. This enables the diameter of the fitting to be reduced over a side-by-side arrangement while maintaining the same flow rates or conversely, enables larger flow rates to be obtained with the same diameter fitting.

As a further advantage, the soft water which is supplied to the brine tank during the brine tank refill cycle...
is supplied through the ejector and this eliminates the need for additional supply lines which are normally required for supplying refill water to the brine tank.

With a minor modification the valve control unit can be employed with both upflow and downflow brining. In upflow brining, as the brine is heavier than water, the brine will tend to lift the resin, so the common practice has been to provide a screen at the outlet to prevent the discharge of resin from the tank. In the conventional valve control unit, discharge from the tank during up-brining is through the main inlet line and the screen is thus positioned across the main water inlet line. If the screen becomes clogged this can affect the water supply to the tank during normal service. In contrast to this, the discharge during the up-brining with the control unit of the invention is through an outlet separate from the main water inlet line, so that any screening which is required across this outlet will not affect the flow of water into the tank during normal service operation.

The invention also includes an improved mounting construction for the rocker arms and cams. The rocker arms are all mounted on a common shaft and separated by plastic U-shaped spacers which are snapped into place on the shaft. By removing the spacers, the rocker arms can be shifted axially along the shaft to thereby move the rocker arms out of alignment with the valves so that the valves can be readily removed from the unit. With this construction, the valves can be removed without removal of the cams or rocker arm assemblies.

Other objects and advantages will appear during the course of the following description.

The drawings illustrate the best mode present contemplated of carrying out the invention.

In the drawings:

FIG. 1 is a side elevation of the control unit of the invention as mounted on a water softening tank;

FIG. 2 is a top view of the control unit;

FIG. 3 is an enlarged side elevation of the control unit with parts broken away in section;

FIG. 4 is a transverse section taken along line 4—4 of FIG. 1;

FIG. 5 is a vertical section taken along line 5—5 of FIG. 2;

FIG. 6 is a vertical section of the valve control unit and softening tank showing the main control valve in the open position as in the normal service and brine refill cycles;

FIG. 7 is a section taken along line 7—7 of FIG. 6, and showing the valve positions in the service cycle;

FIG. 8 is a view similar to FIG. 6 showing the main control valve in the closed position as in the backwash, brine and fast rinse cycles;

FIG. 9 is a perspective view of the main control valve;

FIG. 10 is a horizontal section taken along line 10—10 of FIG. 1;

FIG. 11 is a view similar to FIG. 7 showing the valves in the backwash cycle;

FIG. 12 is a view similar to FIG. 7 showing the valving in the brine and slow rinse cycle;

FIG. 13 is a view similar to FIG. 7 showing the valving in the fast rinse cycle;

FIG. 14 is a view similar to FIG. 7 showing the valving in the brine tank refill cycle;

FIG. 15 is an enlarged vertical section of the three position valves;

FIG. 16 is a side elevation of the structure shown in FIG. 1;

FIG. 17 is a perspective view of a rocker arm spacer; and

FIG. 18 is a perspective view of a ring used in the valve structure.

The drawings illustrate a water softening tank 1 preferably formed of a corrosion resistant material, such as fiber reinforced resin, which contains a bed 2 of an ion exchange resin, and a valve control unit 3 is mounted on the upper end of the tank.

The valve control unit 3 includes a fitting 4 which is threaded into a ring 5 mounted in an opening in the upper end of the tank 1. A head 6 encloses the upper end of the fitting 4 and is attached to the fitting by a series of screws 7.

As illustrated in FIG. 6, the fitting 4 includes a hard water inlet 8 and a soft water outlet 9 which are disposed in axial alignment. Formed integrally with the inlet 8 and outlet 9 is a vertical conduit 10 which projects downwardly into the tank 1. The lower end of the conduit 10 carries a sleeve 11 which bears against an internal shoulder formed in the lower end of the conduit 10 and a dip tube 12 is pressed fitted within the sleeve and extends downwardly to a location slightly above the bottom of the tank 1. The lower end of the tube 12 is provided with a series of slots 13 which establish communication between the interior of the tank 1 and the interior of the tube 12.

The central portion of the conduit 10, above the collar 11, defines a valve seat 14 and a check valve 15 is adapted to engage the seat 14. The check valve 15 includes a valve member 16 which normally bears against the valve seat 14 and is mounted within a groove in support 17. The valve member 16 is biased into engagement with the valve seat 14 by a spring 18 which surrounds a pair of upstanding guides 19 on the support 17. The lower end of the spring 18 bears against valve member 16, while the upper end of the spring is seated within a peripheral groove in an adapter 20. The upper end of the support 17 is guided for sliding movement within the central recess 21 by guides 19 of adapter 20 so that the valve member 16 can move to the open position under normal water pressure. The lower peripheral edge of the member 20 is sealed against the interior of the conduit 10 by an O-ring 22, while the upper peripheral edge of the adapter 20 is sealed to the conduit 10 by O-ring 24. The central wall 25 of adapter 20 is provided with an upstanding tongue 26 having a hole within which a wire or tool can be inserted to remove the adapter 20 from the conduit 10.

The central portion of the adapter 20 above wall 25 is provided with a pair of holes 27 which communicate with a port 28 in the wall of conduit 10. The port 28 in turn is connected by a passage 29 to the interior of the tank 1. In addition to the port 28, the conduit 10 is provided with a second opening or port 30 (See FIG. 6) which is connected by a vertical passage 31 to the outlet 9.

The upper end of the adapter 20 defines a valve seat 32 which is adapted to be engaged by a main control valve 33. As shown in FIG. 6, the main control valve 33 includes a rubber valve member 34 which is adapted to engage the seat 32 and valve member 34 is carried by a valve body 35. The valve member 34 is mounted within a peripheral groove in the body 35 so that the valve member and body are an integral unit.
As best shown in FIG. 9, the body 35 includes a pair of interconnected arms 36 which comprise a yoke and are located diametrically opposite each other and the spaces between the arms constitute passages for the flow of water. The body 35 is adapted to slide within a ring 37 which is located within the upper end of the conduit 10 and is sealed to the interior wall of the conduit by a suitable O-ring. The ring 37 is prevented from moving upwardly within the conduit 10 by a series of posts 39 which extend upwardly from ring 37 and are received within sockets or recesses 40 in head 6. See FIG. 15. The lower end of the ring 37 defines a second valve seat 38 spaced above the valve seat 32, and valve member 34 is adapted to engage seat 38 when the valve member is in its upper position to shut off the flow through ring 37.

The main control valve 33 also includes a valve stem 41 which is connected to the body 35. The lower end of the valve stem 41 extends through an opening in the yoke 36 of body 35 and a retaining ring 42 is engaged within a groove in the valve stem 41 beneath its connection with the yoke. Retaining ring 42 enables the body 35 and valve member 34 to move in accordance with upward movement of the valve stem 41, but permits the valve stem to move downwardly relative to the yoke and valve member. Spring 43 is located around the projecting end of the valve stem 41 and bears between the retaining ring 42 and the base of the yoke. The spring 43 insures that the valve member 34 will seat firmly against the valve seat 41, as well as permitting overtravel for the valve stem so that the valve operating mechanism, hereinafter described, can be operated with certain tolerances.

The stem 41 extends upwardly within a tubular extension 44 on the head 6 and the upper end of the stem is rounded as indicated by 45. To urge the main control valve upwardly to the open position a spring 46 is located around the upper projecting end of the valve stem 41 and bears between the upper end of the extension 44 and a spring retainer 47 which is secured adjacent the upper end of the valve stem 41.

To seal the valve stem with respect to the extension 44 and O-ring seal 48 is mounted within a peripheral groove in the valve stem.

During normal service operation, the main control valve 33 is open and hard water will enter the inlet 8 of fitting 4, pass through the opening 49 in conduit 10, through the open valve 33 and then through the ports 27 and 28 and passage 29 to the tank. The water will flow downwardly through the bed of resin 2 where the soluble metal ions in the water are adsorbed on the ion exchange resin. The water will then enter the lower end of the tube 12 through the slots 13, pass upwardly through the open check valve 15, through the port 30 and passage 31 to the outlet 9. This flow path of water during the normal service operation is illustrated in FIGS. 6 and 7.

The undersurface of head 6 defines a recess or regeneration chamber 50 that is in communication with inlet 8 when the valve 33 is closed, as shown in FIG. 8. During regeneration, when the main control valve 33 is closed, the water will flow through the opening 49 and through the sleeve 37 to the chamber 50, as illustrated in FIG. 8.

The chamber 50 communicates with the upper end of the passage 31 so that a portion of the water in the chamber 50 will be directed through the passage 31 to the outlet 9 so that hard water will be available throughout the household lines during the regeneration process.

As best shown in FIG. 15, the fitting 4 is provided with a vertical, generally circular passage 51 and the lower end of passage 51 is connected to the interior of conduit 10 beneath the level of check valve 15, while the upper end of the passage 51 communicates with a bore 52 formed in the head 6. A series of corrosion resistant rings 53, 54 and 55 are stacked vertically within the bore 52, and ring 55 is formed integrally with an end cap 56 that is threaded within the upper end of bore 52. The lowermost ring 53 of the stack bears against an O-ring 57 that is supported on an internal shoulder located at the lower end of the bore 52. Similar O-rings 57 are employed to space the rings 53 and 54, and 54 and 55. As illustrated in FIG. 15, the lower ring 53 is provided with a series of ports 59 which are in communication with a hole 60 in head 6 that communicates with the chamber 50, while the ring 54 is provided with a series of ports 61 that provide communication with a hole 62 in the head 6, and the hole 62 communicates with a drain line 63, as best shown in FIG. 10.

A three-way valve 64 is mounted for sliding movement in bore 52 and is adapted to control the flow of water in the passage 51. The three-way valve 64 includes a cylindrical lower end 65 adapted to slide within the rings 53, 54 and 55, and the upper end of the valve 64 has a reduced diameter and is provided with outlet ports 66 adapted to communicate with the drain ports 61 in ring 54 when the valve 64 is in a lower position, as illustrated in FIG. 12. When the valve 64 is in a central or neutral position, the drain ports 61 will be closed off, as well as the ports 59, so that there will be no flow of water through the valve 64. When the valve 64 is moved to the upper position, the drain ports 61 will be closed off by the lower cylindrical portion 65 of the valve 64, but the lower end of the valve will be located above the ports 59, thereby opening the ports. The three-position valve 64 serves, in the neutral position, to prevent flow within the passage 51, while in the lower position, establishes communication between passage 51 and the drain line 63, and in the upper position establishes communication between the chamber 50 and the passage 51.

The three-position valve 64 is actuated through a valve stem 67 which extends upwardly in sealed relation through an opening in the cap 56 and the upper end of the stem is rounded, as indicated by 68. The valve 64 is urged upwardly to its uppermost position by a coil spring 69 which surrounds the upper projecting end of the stem 67 and bears between the upper surface of the cap 56 and a spring retainer 70 which is secured to the stem 67 adjacent the end 68, as shown in FIG. 11.

In addition to the vertical passage 51, the fitting 4 is provided with a second vertical passage 71 located diametrically opposite passage 51. As shown in FIG. 7, the lower end of the passage 71 is connected to a bore 72 formed in a tubular extension 73 in the head 6.

As in the case of the bore 52, a series of rings 74, 75 and 76 are stacked within the bore 72, as shown in FIG. 15, and the upper ring 76 is formed integrally with a cap 77 that is threaded within the upper end of bore 72. Lowermost ring 74 is supported on an internal shoulder 78 and is separate from the shoulder by an O-ring 79. Similar O-rings 79 space the rings 74-76. The lower-
most ring 74 is provided with a series of ports 80 which communicate through a hole 81 formed in the head 6 with the chamber 50. The middle ring 75 is provided with a series of drain ports 82, similar to drain ports 61, which communicate through a hole 83 in the head 6 with drain line 63.

A three-position valve 86, similar to three-position valve 64, is mounted for sliding movement within the bore 72. The valve 86 is provided with a cylindrical lower end 87 and an upper end 88 of reduced diameter. A series of openings 89 are provided in the upper end 88 and are adapted to communicate with the drain ports 82 when the valve 86 is in its lowermost position. As in the case of valve 64, when the three-position valve 86 is in its neutral position the ports 80 and drain ports 82 will be closed off so that there will be no flow in the passage 71. When the valve 86 is in its uppermost position, the lower end of the cylindrical portion 87 will be located above the ports 80 to thereby establish communication between the chamber 50 and the passage 71.

The three-position valve 86 is carried by a stem 90 which extends upwardly in sealed relation through the cap 77 and the upper end of the stem terminates in a rounded end 91. To urge the three-way valve 86 to the upper position, a coil spring 92 is disposed around the upper projecting portion of the stem and bears between the upper surface of the cap 77 and a retaining ring 93 secured to the upper end of the stem, as shown in FIG. 11.

The head 6 is also provided with a third upwardly extending extension 94 having a vertical opening 95 and the lower portion of opening 95 defines a valve seat 96 and is connected by a by-pass passage 98 with the chamber 50. As shown in FIG. 10, the by-pass passage is formed in the head 6 and extends around the three-way valve 64.

A valve 99 is adapted to engage the valve seat 96, and the valve 99 is carried by a vertical stem 100 which projects upwardly beyond the upper end of the extension 94 and terminates in a rounded end 101. The valve 99 is biased to the closed position by a coil spring 102 which is located around the upper projecting end of the stem 100 and bears between the upper end of the extension 94 and the spring retainer 103 attached to the upper end of the stem.

The portion of the opening 95 in the extension 94, above the valve seat 96, defines a chamber 104 and chamber 104 communicates via a diagonal passage 105 with a chamber 106 formed in head 6. The upper end of the chamber 106 is closed off by a threaded cap 107.

As illustrated in FIG. 5, the chamber 106 houses a nozzle assembly 108 which consists of a nozzle 109 and a venturi 110, which is located beneath the nozzle. The lower end of a screen 111 bears against the upper end of the nozzle, while the upper end of the screen is received within a recess 112 in the cap 107.

When the valve 99 is in the open position, water will flow from the chamber 50 through the by-pass passage 98 to the chamber 97 and then through the open valve 99 and diagonal passage 105 to the chamber 106 where it will be filtered by screen 111 before entering the nozzle 109.

The upper end of the venturi 110 is provided with an annular flange 113 having a series of holes 114, and as the water is ejected from the nozzle 109 an aspirating effect is produced by the decreased pressure which acts to draw brine, during the brine cycle, from a brine tank through a nipple 115 to the chamber 106 as will be hereinafter described.

The lower end of the venturi 110 serves as a seat for a ball check valve 117 which is free to float within the lower end of a chamber 118 formed in well 119 of fitting 4 and located in alignment with chamber 106 in head 6. The internal walls of the well 119 are provided with a series of ribs 120 and when the ball valve 117 is in the open position, the water being discharged downwardly from the venturi 110 can then pass upwardly within the grooves between ribs 120 into the inclined passage 121 formed in the fitting 4 and then downwardly to passage 29 to the interior of the tank 1.

Valves 33, 64, 86 and 99 are operated in the desired sequence by cam-actuated rocker arms. As best illustrated in FIGS. 2 and 3, the operating mechanism includes a timer 125 having an output shaft 126. The timer 125 is a conventional type utilizing a timer motor which drives the output shaft 126 for a predetermined time period at preset intervals, such as for example, several times per week when it is desired to regenerate the resin bed. In place of the timer 125, other conventional actuating mechanisms, such as those responsive to the volume of water flow through the unit, or those responsive to the conductivity of the water, can be utilized to operate the shaft 126.

The shaft 126, is journal bearing by a pair of bearings 127 mounted in the vertical flanges 128 of a generally U-shaped bracket 129 which is connected by a frame 130 to the head 6. Timer 125 is carried by shaft 126.

The shaft 126 carries a series of cams 131, 132, 133 and 134, which are adapted to operate the valves 86, 82, 64 and 99, respectively. Associated with each of the cams 131-134 is a roller arm 135-138 and the rocker arms 135-138 are mounted on a horizontal shaft 139 that extends between the side flanges 128 of bracket 129, while roller arm 138 is mounted on shaft extension 140 which is located outside of flange 128 and is connected to one end of shaft 139 by stud 141 and washer 142. The opposite end of shaft 139 is attached to flange 128 by a stud 143 which extends through an opening in flange 128 and is threaded into the end of shaft 139.

One end of each rocker arm defines a follower 144 which is adapted to ride on the peripheral surface of the respective cam, while the opposite end of each rocker arm is provided with a head 145 which bears against the rounded upper end of the respective valve stem 90, 41, 67 and 100. The outer peripheral surface 146 of each cam is provided with the desired notch or recessed contour in order to operate the respective valves through the rocker arms in the desired sequence.

As a feature of the invention, the rocker arms 135-138 are mounted on the shaft 139 by a series of flexible U-shaped spacers 147, as shown in FIG. 17, which are snap-fitted over the shaft between the rocker arms. The spacers 147 are formed of a flexible material, such as plastic, that can be snapped into place on the shaft. This construction facilitates the removal of the valves from the unit for maintenance or replacement. By removing one or more spacers 147 from the shaft, the rocker arms can be shifted axially along the shaft to a position out of alignment with the respective valve stem. The valve stem and the valve can then be removed from the head 6 without interference from the rocker arm.
The control unit of the invention is adapted to provide the conventional five-cycle regeneration program and consists of (i) normal service, (ii) backwash, (iii) brine and slow rinse, (iv) fast rinse, and (v) brine tank refill. The operation of the various cycles is as follows:

SERVICE CYCLE

The service cycle is in operation during periods when the resin bed is not being regenerated. During this cycle, as shown in FIGS. 6 and 7, the main control valve 33 is open, while the three-way valves 64 and 86 are both in the neutral position so that there will be no flow through these valves. In addition, the valve 99 is in the closed position. With this valve arrangement, water entering the inlet 8 passes through the opening 49, through open main control valve 33, through adapter 32, port 28 and passage 29 to the interior of the tank 1. The water flows downwardly through the resin bed 2 where the soluble metal ions are absorbed on the ion exchange resin and then passes through the slots 13 into the lower end of the tube 12. The pressure of the water will open the check valve 15 so that the water can flow from tube 12 through the port 30 and passage 31 to the outlet 9.

Thus, in the service cycle, the main control valve 33 is open and the hard water flows downwardly through the resin bed and tank 1 upwardly through the tube 12 to the outlet.

BACKWASH CYCLE

The backwash cycle is initiated by the timer 125, or other actuating mechanism, which starts the regeneration cycle. The timer 125 drives the cam shaft 126 and cams 131–135. Rotation of the cams operates through rocker arms 135–138 to move the valves 86, 33, 64 and 99 to the positions shown in FIGS. 8 and 11 for the backwash cycle. In this cycle, the three-position valve 64 is in the down position, the main control valve 33 is in the closed position, while the three-position valve 86 is in the up position, and the valve 99 is in the up or closed position. As the main control valve 33 is closed, the water entering through the inlet 8 will pass upwardly within the central conduit 10 through sleeve 37 to the angular chamber 50. As the three-way valve 86 is in the up position at this time, openings 59 and 60 will be exposed so that the water can flow from the chamber 50 into the vertical passage 51 and downwardly into the tube 12, where it is discharged from the slots 13 into the lower end of the resin bed. The water then passes upwardly through the resin bed to provide a backwashing action and is discharged from the upper end of tank to the vertical passage 71. As the three-position valve 86 is in the lower position at this time, the openings 89 will be in registry with the drain opening 63 so that the water can flow from the vertical passage 71 to the drain line 63.

In order to provide hard water to the household lines during regeneration, chamber 50 is in communication with the outlet 9 via passage 31, as shown in FIG. 8, so that hard water from the chamber 50 can flow through the outlet 9.

Thus, during the backwash cycle, the main control valve 33 is closed and hard water will flow to the regeneration chamber 50 where a portion will then flow downwardly through the central tube 12 to the bottom end of the tank and upwardly through the resin bed to backwash the resin, while a second portion of the hard water will pass directly from the chamber 50 to the outlet 9 to provide hard water to the household lines during regeneration.

BRINE AND SLOW RINSE CYCLE

Continued rotation of the cam shaft 126 and cams 131–134 will move the valves to the position shown in FIGS. 8 and 12 to provide the brine and slow rinse cycle. During this cycle, the valve 86 is in the neutral position in which flow through passage 71 is cut off, the main control valve 33 is in the closed position, the three-position valve 61 is in its lower or drain position, and the valve 99 is open. With the main control valve 33 closed, the hard water entering the inlet 8 will be directed to the chamber 50 in the manner described with respect to the backwash cycle. However, the valve 99 is in the open position and water will flow from the chamber 50 through the by-pass passage 98 to the chamber 97 where it will flow through the open valve 99 to the chamber 104, through the diagonal passage 105 to the chamber 106. The water will then pass through the screen 111 downwardly through the nozzle 109 and venturi 110 creating a pressure differential which will draw brine from the brine tank which is connected to the nipple 115. The pressure of the water and brine being discharged through the venturi 110 will open the check valve 117, and the brine and hard water will pass into the well 118 and then upwardly through the grooves 120 to the inclined passage 121 and passage 29 to the tank 1. The brine will then flow downwardly through the resin bed 2 to the lower end of the tank 1 where it passes through the slots 13 and into tube 12.

The brine is discharged from the upper end of tube 12 into vertical passage 51. As the three-position valve 64 is in its lower position, the ports 66 are in registry with the drain opening 61 so that the brine can be discharged through the valve 64 to the drain line 63.

As in the case of the back-wash cycle, a portion of the water during the brine and slow rinse cycle passes from the chamber 50 directly to the outlet 9, as shown in FIG. 8, to provide hard water for the household lines during the regeneration procedure.

In the conventional programming, a measured quantity or volume of brine is drawn into nozzle assembly 108 through the brine inlet 115 and this measure quantity is determined by a brine valve, not shown. Generally, the valve 99 is maintained in the open position for a time period longer than the time required to draw the measured quantity of brine into the system, so that after the measured quantity of brine has been supplied, the remaining portion of the cycle will constitute a slow rinse in which only hard water is discharged through the nozzle 109 and passes through the passages 121 and 29 to the tank 1. The rinse water will then flow downwardly through the resin bed and then upwardly through the central tube 12 for discharge through the three-position valve 64.

While the above description has shown a down-brining procedure in which the brine is flushed downwardly through the resin bed, it is contemplated that by a simple modification the unit can be utilized for an up-brining cycle. In an up-brining cycle, passage 121 is connected to the passage 71, rather than to the passage 29 so that the brine would enter the tank through the tube 12. For up-brining, the positions of the three-position valves 64 and 86 would be reversed so that the
valve 64 would be closed and the valve 86 would be open to the drain so that the brine passing upwardly within the resin bed could be discharged to the drain line 63 through valve 86.

FAST RINSE CYCLE

Continued rotation of the cam shaft 126 will move the valves to the position for the fast rinse cycle. As shown in FIGS. 8 and 13, three-position valve 86 is in the up position, the main control valve 33 is closed, the three-position valve 64 is in the down or drain position and the valve 99 is in the closed position.

As the main control valve 33 is closed, the water will be directed to the chamber 50 in the manner previously described and a portion of the water in the chamber 50 will flow directly to the outlet 9, as shown in FIG. 8, to provide hard water for the lines during the cycle. As the three-position valve 86 is in the up position, the aligned openings 80 and 81 will be exposed so that water can flow from the chamber 50 into the passage 71 and then downwardly through the resin bed in the tank 1. The water will then flow through the slots 13 into the lower end of the tube 12, upwardly within the tube and into the vertical passage 51. As the three-position valve 64 is in the down or drain position, the outlet port 66 will be in registry with the drain port 61 so that the rinse water in passage 51 will flow to the drain line 63.

During the fast rinse cycle the volume of water flowing through the resin bed will be substantially greater than the volume of water flowing through the bed during the slow rinse cycle.

BRINE TANK REFILL CYCLE

Continued rotation of the cams 131–134 will move the valves to the position for the brine tank refill cycle, as shown in FIGS. 6 and 14. During this cycle, the three-position valves 64 and 86 are both in the neutral or closed position so that there will be no flow through the valves. The main control valve 33 is open and the valve 99 is also in the open position.

Hard water from the inlet will be directed through the open valve 99 and passage 29 to the upper end of tank 1 where it will flow downwardly through the resin bed and the soluble metal ions will be adsorbed on the regenerated resin. The softened water will flow upwardly within tube 12 through check valve 15 to outlet 9. In addition, the softened water will also pass from passage 31 to chamber 50. The water in the chamber 50 will flow through the by-pass passage 98 and through the open valve 99 to the chamber 104 and then to chamber 106 via passage 105. As the drain lines 63 and 84 are closed at this time, positive pressure acting through passage 121 will cause check valve 117 to remain sealed and the water will pass from the nozzle 109 through nipple 115 to the brine tank to refill the brine tank with soft water.

Continued rotation of the cam shaft 125 and cams 131–134 will move the valves back to their original position for the service cycle and the timer motor will stop. There will be no further valve movement until the next initiation of the regeneration cycle.

With the fitting of the invention, the main control valve 33 and the check valve 15 are vertically stacked, as opposed to conventional construction in which the valves are normally in a side-by-side relation. By stacking the valves vertically, the diameter of the fitting can be reduced for a given diameter of inlet or outlet, or conversely, the diameter of both the control valves can be increased for a given external fitting diameter, thereby serving to increase the flow rate of water during the regeneration operation.

The three-position valves 64 and 86 provide increased flexibility for the water softener. Any combination of back-washing, brining and rinsing can be employed as desired by merely changing the cam arrangement. By means of a simple modification, the system can be changed from a down-brining to an up-brining cycle.

The three-position valves include pressure balanced plungers which are designed so that an increase of pressure has little effect on the force required to push the valves downwardly, thereby enabling the plungers to be provided with large outlet ports without an increased force on the cam assembly. The larger porting increases the flow rate during the regeneration cycles over that of conventional control units.

During the brine tank refill cycle, soft water is supplied to the brine tank through the ejector or nozzle assembly 108 and the check valve 117 is utilized to prevent hard water from the tank 1 from passing to the brine tank during this cycle. This feature simplifies the construction and eliminates the need for an auxiliary line connected to the brine tank for supplying soft water to the brine tank for refilling.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

1 claim:

1. In a control unit for a water softener, a tank, a casing mounted on the tank and having a water inlet and a water outlet, a tubular member disposed within the casing and extending downwardly within the tank with the lower portion of the tubular member communicating with the interior of the tank, first port means providing communication between the inlet and the tubular member, a first valve seat located in said tubular member, a main control valve disposed to engage said first valve seat and movable between an open and a closed position, second port means providing communication between the tubular member at a location below said valve seat and the upper end of the tank, third port means located in the tubular member below said second port means and connected with said outlet, check valve means located in the tubular member beneath said third port means, said check valve means disposed to permit flow of water from said tubular member through said third port means to the outlet and disposed to prevent flow of water in the opposite direction, and sealing means for sealing off the tubular member at a location between said second port means and said third port means to prevent direct communication therebetween, when said main control valve is in the open position water entering said inlet passes through said first port means into said tubular member and through said second port means to the interior of the tank, and then upwardly through said tubular member and through said check valve means and said third port means to the outlet.

2. The control unit of claim 1, wherein said check valve means is disposed in vertical alignment with said main control valve.
3. The control unit of claim 1, wherein said casing defines a chamber communicating with the upper end of the tubular member, a second valve seat disposed in said tubular member in spaced relation above said first valve seat, said main control valve adapted to seat on said first valve seat in a lower position and to seat on said second valve seat when in an upper position, and fourth port means connecting the chamber to the outlet, whereby water passes from said inlet through said second valve seat to said chamber when said main control valve is in the lower position and then through said fourth port means to the outlet.

4. The control unit of claim 3, and including a first passage providing communication between the chamber and the tank, a drain line connected to said first passage, fifth port means connecting the chamber to said first passage, a three-position valve member disposed within said passage, said valve member having a first position in which said first passage is connected through said fifth port means to said chamber and having a second position wherein said first passage is connected to said drain line and having a third position wherein said first passage is out of communication with said drain line and said chamber.

5. The control unit of claim 4, wherein said first passage is a bore in the casing and the valve member is a hollow cylindrical element slidingly within the bore.

6. The control unit of claim 5, wherein said valve member has a closed upper end and an open bottom end, the side wall of the valve member is provided with a hole which is disposed to register with the drain line when said valve member is in the second position, said valve member having a length such that the bottom end of the valve member is located upwardly beyond said fifth port means when the valve member is in said first position to establish communication between said fifth port means and said first passage.

7. The control unit of claim 6, and including a series of rings stacked within said bore, said series of rings including a first ring having an opening communicating with said fifth port means and a second ring having an opening communicating with said drain line, said valve member being slideable within said stacked rings.

8. The control unit of claim 7, wherein an annular seal is disposed between the adjacent edges of said rings.

9. The control unit of claim 8, wherein said casing is provided with a ledge to support the first ring of said series, said series of rings including a last ring threaded within the bore, whereby threading down of said last ring compresses the annular seals.

10. The control unit of claim 4, and including a second passage providing communication between the chamber and said tank, said drain line being connected to said second passage, sixth port means connecting the chamber to said second passage, a second three-position valve member disposed within said second passage, said second valve member having a first position in which said second passage is connected through said sixth port means to said chamber and having a second position wherein said second passage is connected to said drain line and having a third position wherein said second passage is out of communication with said drain line and said chamber.

11. The control unit of claim 10, and including operating means for operating said first and second valve members in the desired sequence.

12. The control unit of claim 10, wherein the axes of said first and second passages are disposed parallel to the axis of said tubular member.

13. In a control unit for a water softening apparatus, including a tank to contain an ion exchange resin, a casing defining a cylindrical bore, conduit means providing communication between an end of the bore and the tank, a valve member slidably disposed within said bore, said bore having a drain opening providing communication between a drain line and the side of the bore, and said bore having a water inlet opening providing communication between a water inlet source and the side of said bore, said valve member being slideable within said bore from a first position wherein said conduit means is out of communication with said drain opening and said water inlet opening, to a second position wherein said conduit means is connected to said drain opening and said water inlet opening, said water inlet opening being located adjacent said end of the bore and said drain opening being located axially inward of said water inlet opening, said valve member is a hollow cylindrical element having a closed end and an open end, said open end facing said end of the bore and communicating with said conduit means, said cylindrical element being provided with an aperture which is disposed out of registry with said drain opening and said water inlet opening when the valve member is in said first position, and said aperture is disposed in communication with said drain opening when said valve member is in said second position, and the open end of the cylindrical element is disposed inwardly of the end of the bore to expose said water inlet opening when the valve member is in said third position.

14. The control unit of claim 13, and including a series of rings stacked within said bore, a first ring of said series having an opening in registry with said water inlet opening and a second ring in said series having an opening in registry with said drain opening, said valve member being slideable within said series of rings.

15. The control unit of claim 14, wherein said casing is provided with a shoulder to support the first ring, and said series of rings includes a last ring which is threaded within the opposite end of the bore, said unit also including an annular resilient seal disposed between the ends of adjacent rings, whereby threading down of said last ring in said bore compresses said seals.

16. In a control unit for a water softening apparatus, a tank to contain an ion exchange resin, a casing mounted in the tank, a series of valve members movable within said casing to control the flow of water to and from said tank during the service and regeneration cycles, a valve stem connected to each of said valve members and extending outwardly of said casing, a pivotable operating member engaged with each of said valve stems, shaft means for mounting the operating members for pivoting movement, actuating means for pivoting said operating members about said shaft means in sequence, to thereby move said operating members in the desired operating sequence, said operating members being spaced longitudinally on said shaft means, and a series of flexible generally U-shaped spacers press fitted on the outer surface of said shaft means extending between said operating members, the side edges of adjacent spacers being in contact to space said operating members on the shaft means, said spacers being removable from said shaft means to thereby per-
mit said operating members to be moved longitudinally along said shaft means and out of engagement with the respective valve stems.

17. The control unit of claim 16, wherein said actuating means comprises a series of rotatable cams, each of said operating members includes a follower adapted to ride on a surface of the respective cam to thereby pivot the operating member in the desired sequence.

18. The control unit of claim 17, wherein said operating member is a rocker arm having one end engaged with the upper end of the respective valve stem and the opposite end defines said follower.

19. The control unit of claim 16, wherein said spacers are formed of a flexible plastic material.

20. In a control unit for a water softening apparatus, a tank to contain an ion exchange resin, first conduit means connected to the tank, ejector means located within said first conduit means and including a nozzle, second conduit means interconnecting the first conduit means at a location downstream of said nozzle with a brine tank, check valve means disposed within said first conduit means at the discharge end of said ejector means, means for flowing soft water through said ejector means, and means responsive to the flow of soft water through said ejector means for maintaining the check valve means in the closed position, whereby soft water flowing through said ejector means will be directed through said second conduit means to refill the brine tank.

21. The control unit of claim 20, wherein said ejector means is vertically disposed and said check valve means includes a valve seat located adjacent the lower discharge end of the ejector means, said check valve means also including a float ball valve engageable with said valve seat.

* * * * *