United States Patent [19]

Grout et al.

[11] **3,872,004**

[45] **Mar. 18, 1975**

[54] **CONTROL UNIT FOR A WATER SOFTENER**

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[73] Assignee: **Sta-Rite Industries, Inc.,** Delavan, Wis.

[22] Filed: **Sept. 14, 1972**

[21] Appl. No.: **288,924**

[52] **U.S. Cl.** **210/127,** 210/134, 210/136, 210/140, 210/191

[51] **Int. Cl.** **C02b 1/22**

[58] **Field of Search** 210/134, 136, 190, 191, 210/140, 127

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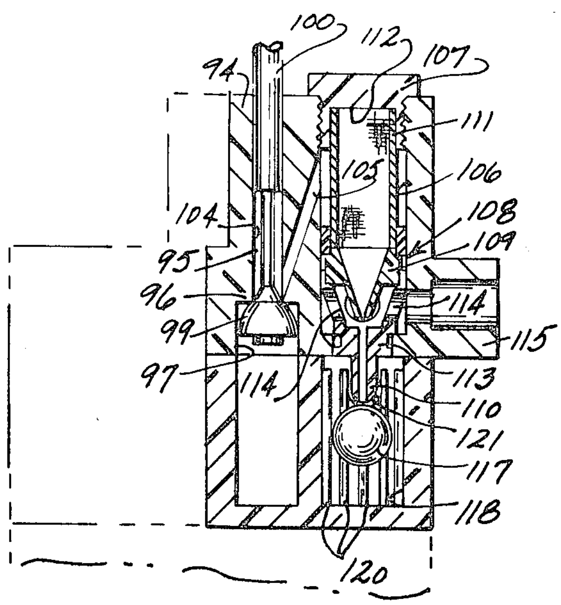
Primary Examiner—Frank A. Spear, Jr.
Attorney, Agent, or Firm—Andrus, Sceales, Starke & Sawall

[57] **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



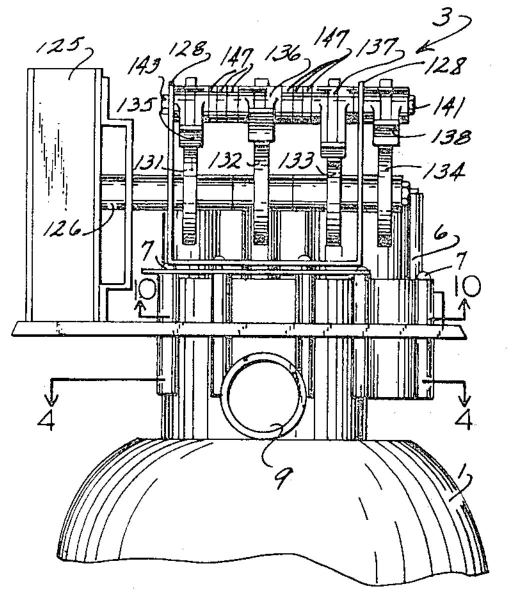


Fig.1

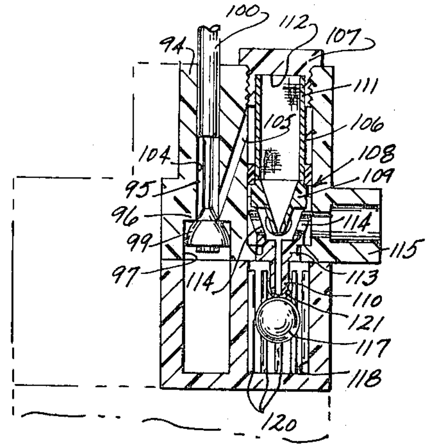


Fig.5

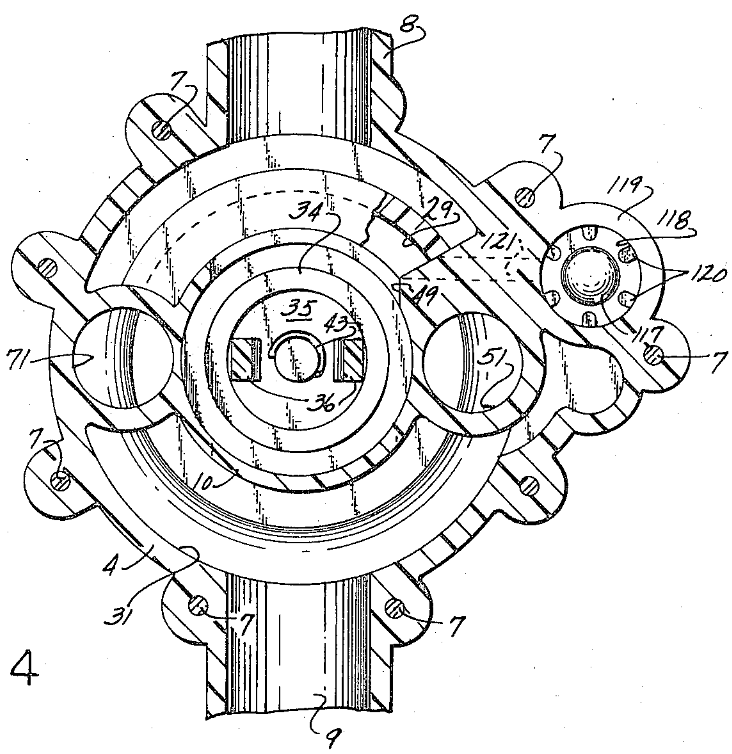


Fig. 4

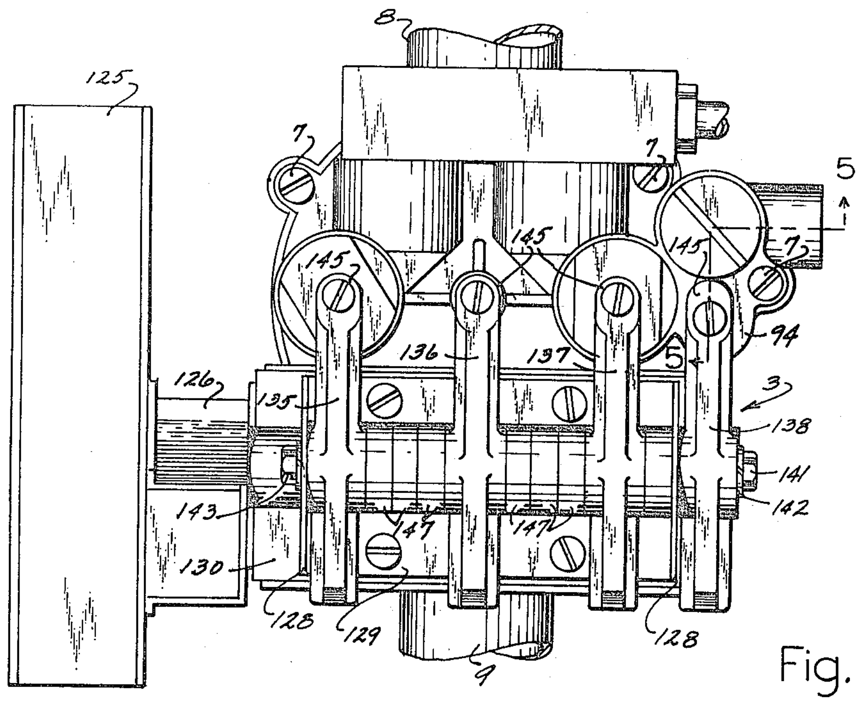

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Fig. 2

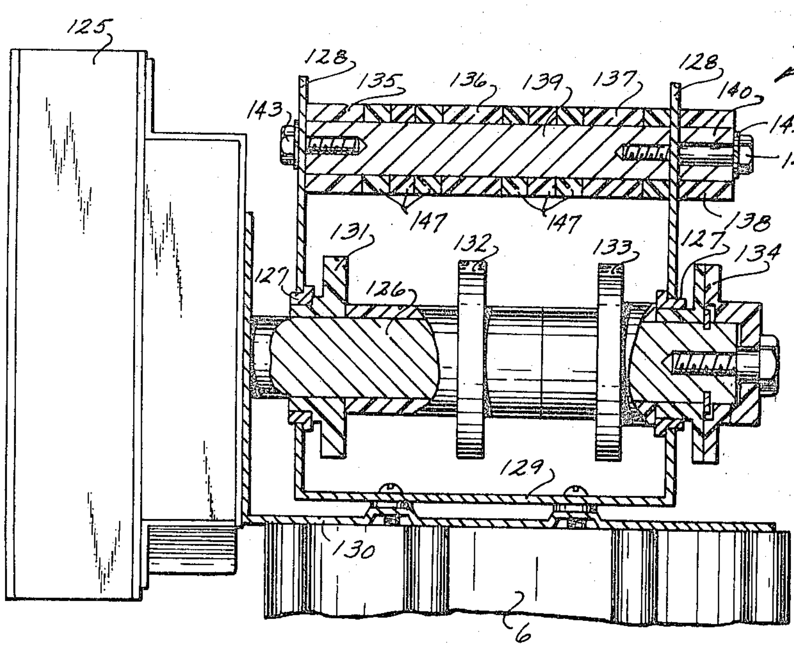
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Fig. 3

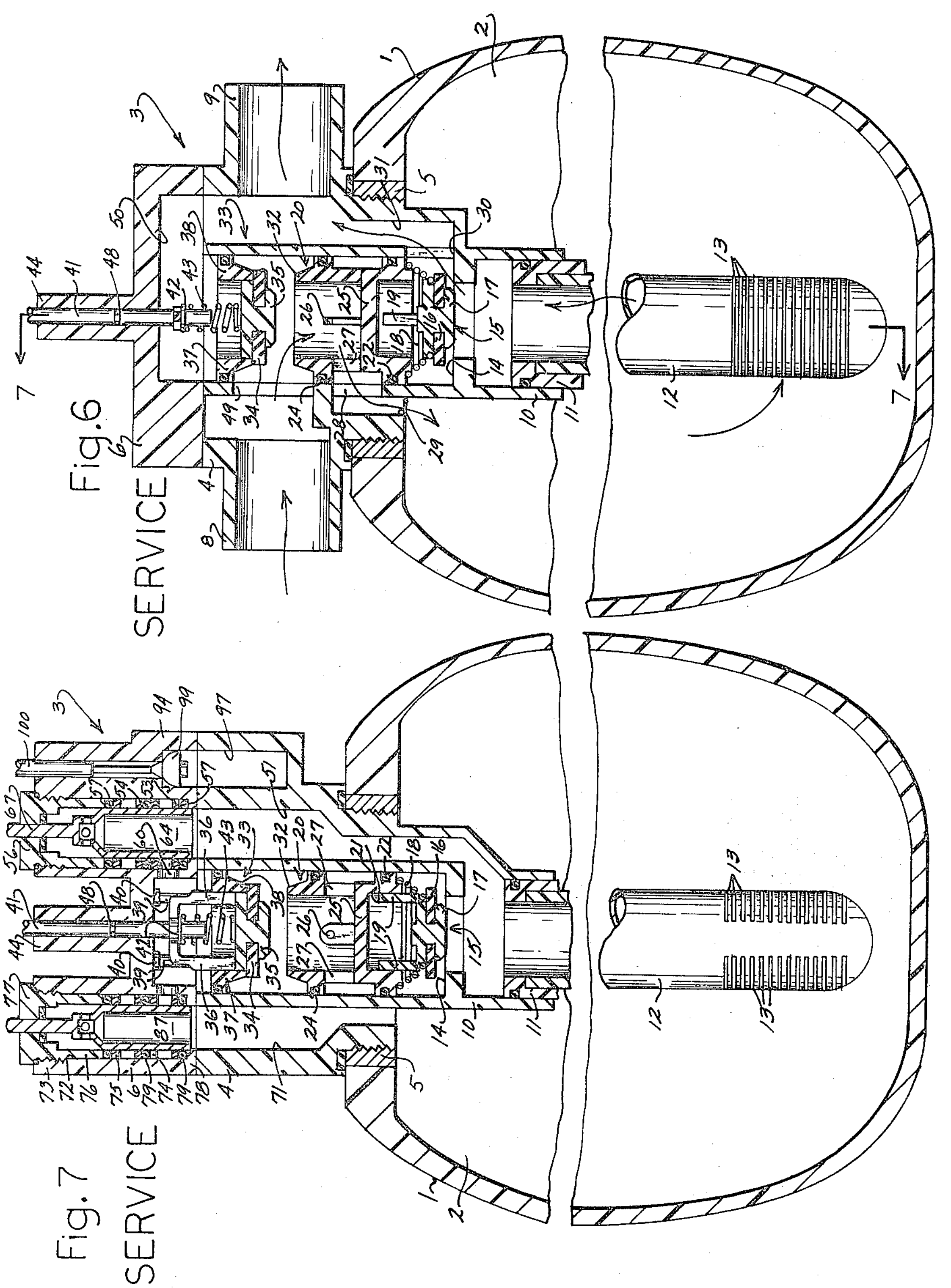


Fig. 6 SERVICE

Fig. 7 SERVICE

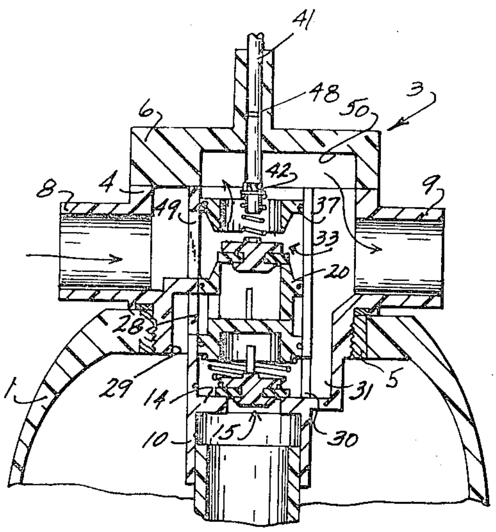


Fig.8

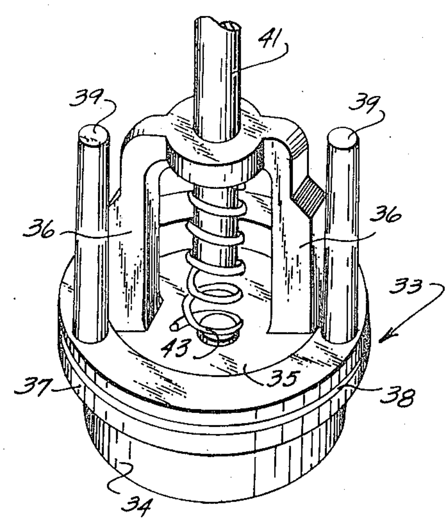


Fig.9

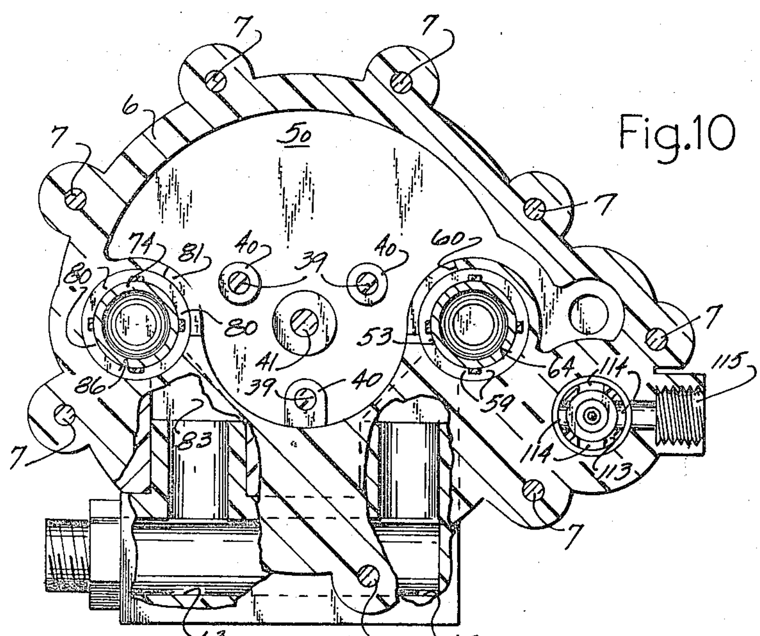


Fig.10

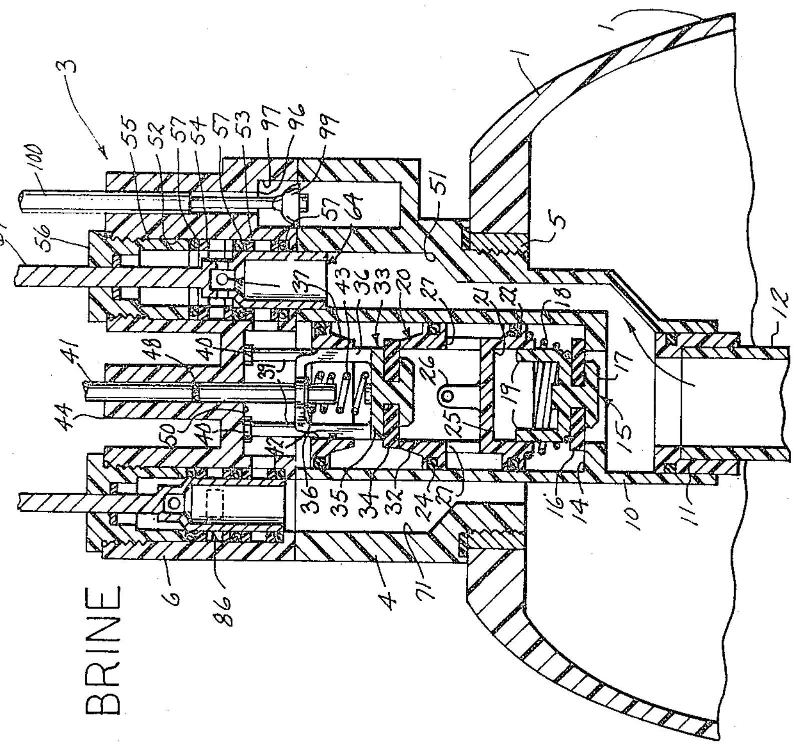


Fig.12

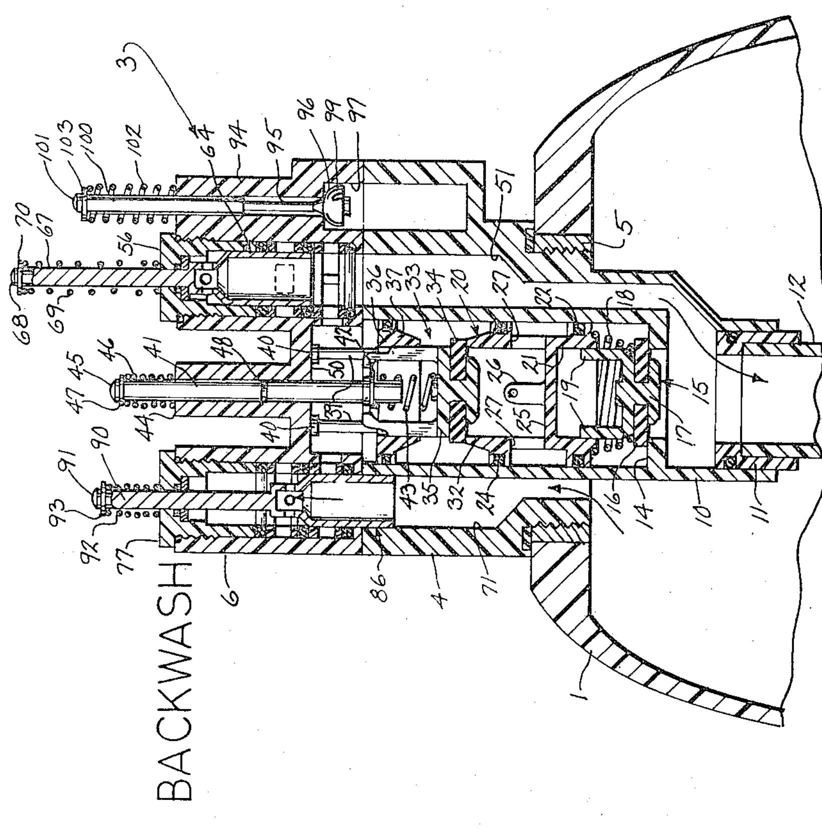


Fig.11

BRINE REFILL

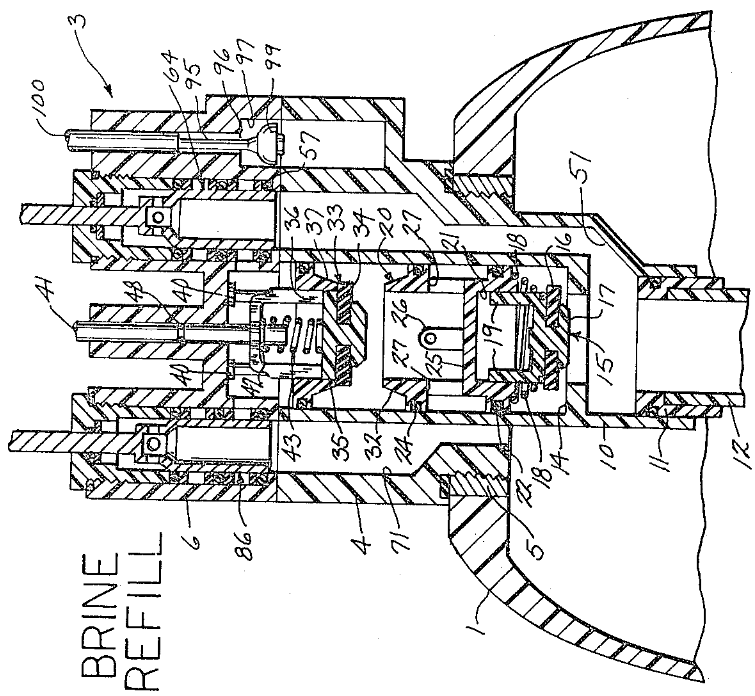


Fig.14

FAST RINSE

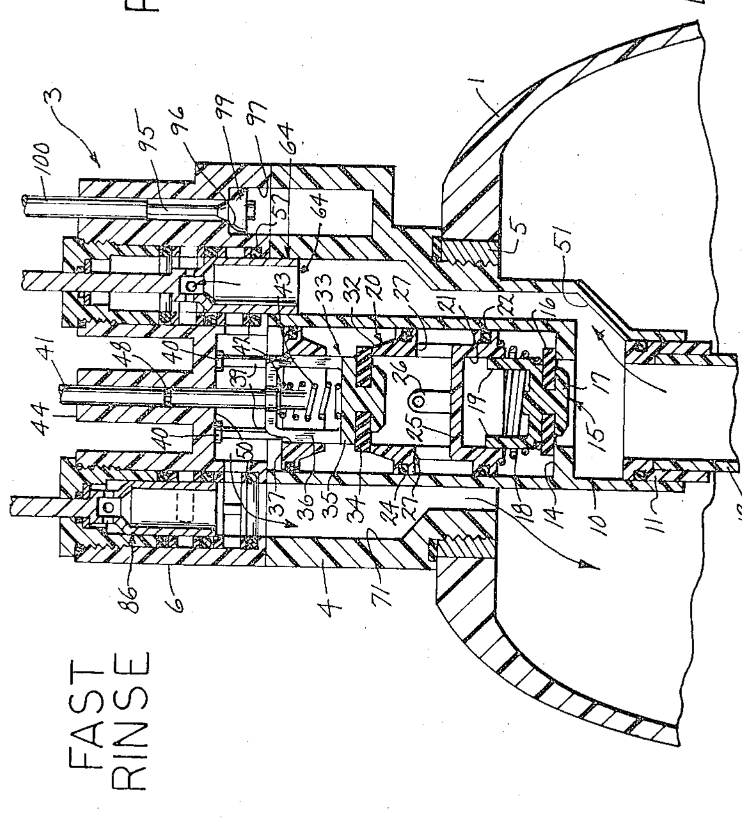


Fig.13

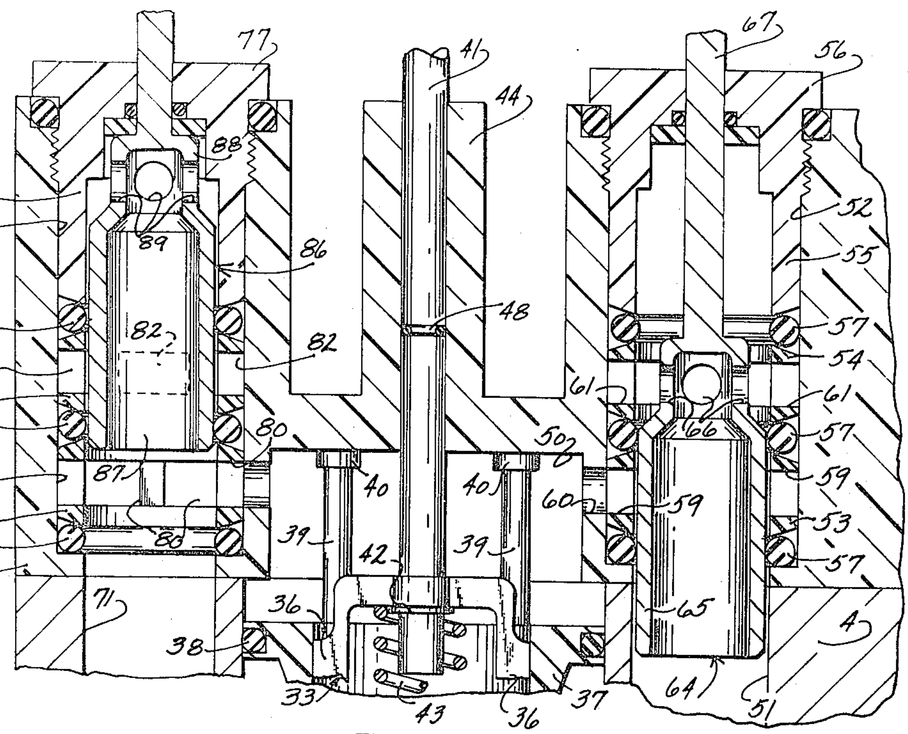


Fig.15

Fig.17

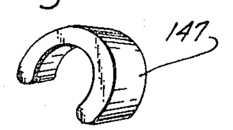
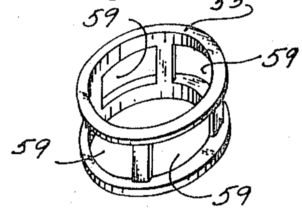


Fig.18



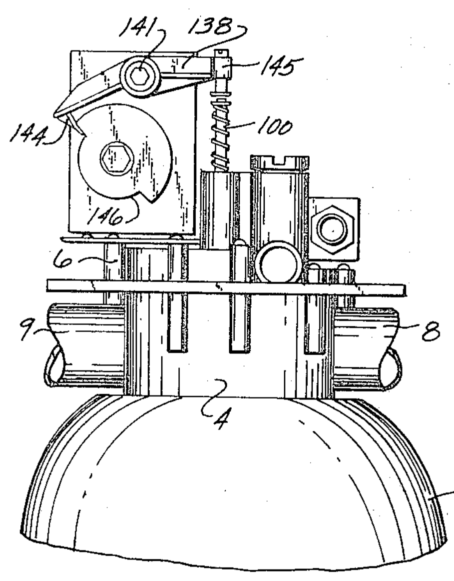


Fig.16

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 rengerated 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 valves 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 witin 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 back-wash 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 that the brine will be discharged to the drain line. This cycle continues for a period of time in excess of that required to deplete the brine supply so that after the brine is exhausted the water continuing 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 effect 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 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 adpater **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** benath 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 paggage **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 lowermost 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 journalled 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**, 33, 64 and **99**, respectively. Associated with each of the cams **131–134** is a rocker 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 rocker 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 notched 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 thre 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 annular 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 back wash 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 programing, a measured quantity or volume of brine is draw 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 downbrining 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 upbrining 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 upper 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 **33** 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 seated 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.

I 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 slidable 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 slidable 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 the 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 slidable within said bore from a first position in which 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 a third position wherein said conduit means is connected to said water inlet opening said water inlet opening is located adjacent said end of the bore and said drain opening is 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 the first position, and said aperture is disposed in communication with said drain opening when the valve member is in the 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 the 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 slidable 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 valve 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 and extending between said operating members, the side edges of adjacent spacers being in contact to space the 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.

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