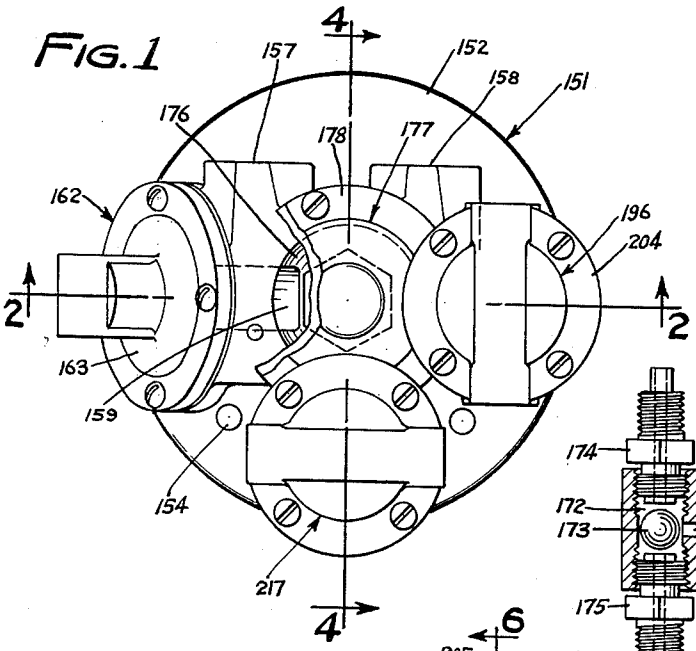
Dec. 4, 1962 S. A. LUNDEEN 3,066,801

CONTROL VALVE MEANS

Filed Feb. 19, 1958 3 Sheets-Sheet 1

FIG. 1



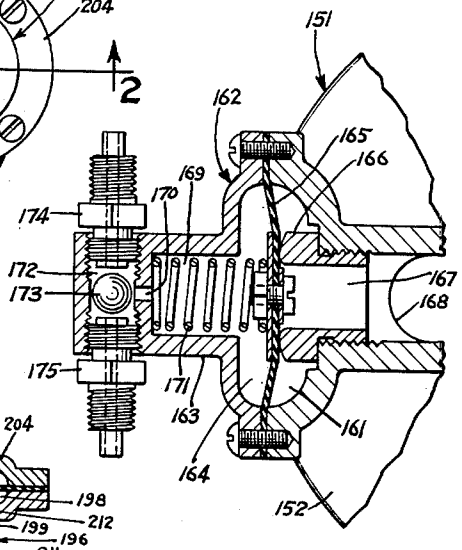


FIG. 3

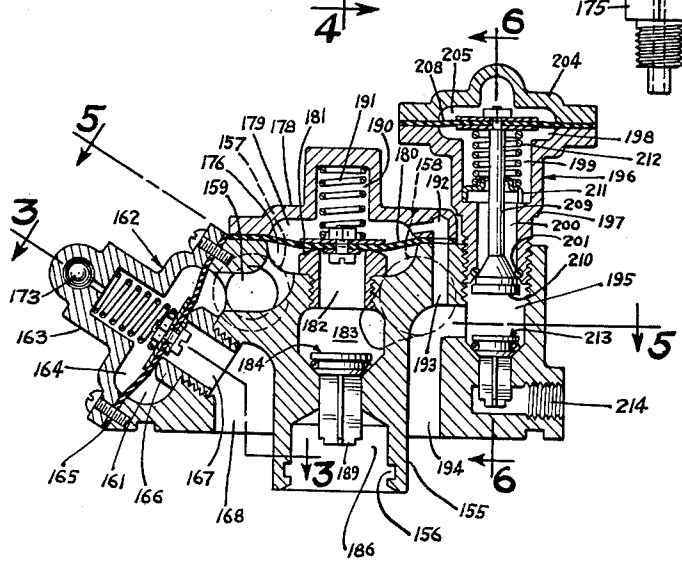


FIG. 2

INVENTOR.
STANLEY A. LUNDEEN
BY Moore, White & Burd
ATTORNEYS

Dec. 4, 1962 S. A. LUNDEEN 3,066,801

CONTROL VALVE MEANS

Filed Feb. 19, 1958 3 Sheets-Sheet 2

FIG. 4

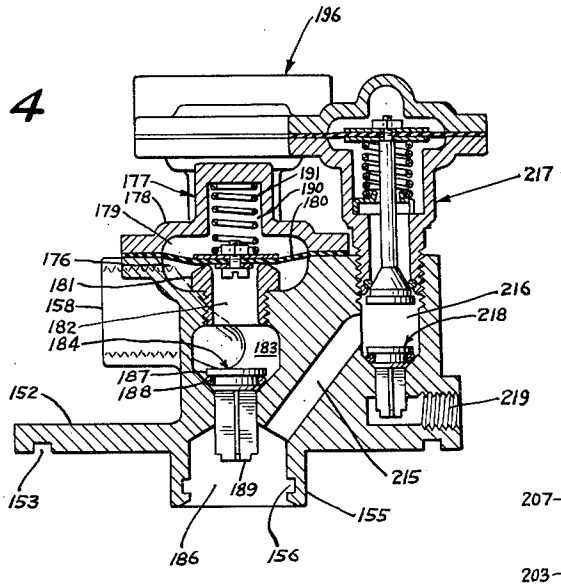
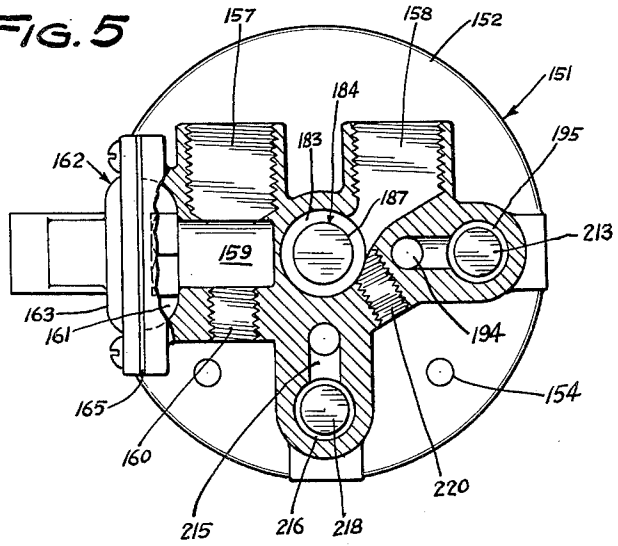


FIG. 5



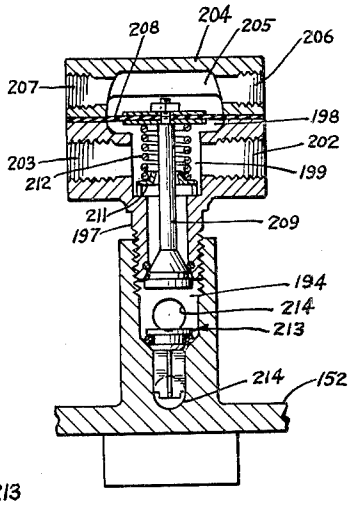


FIG. 6

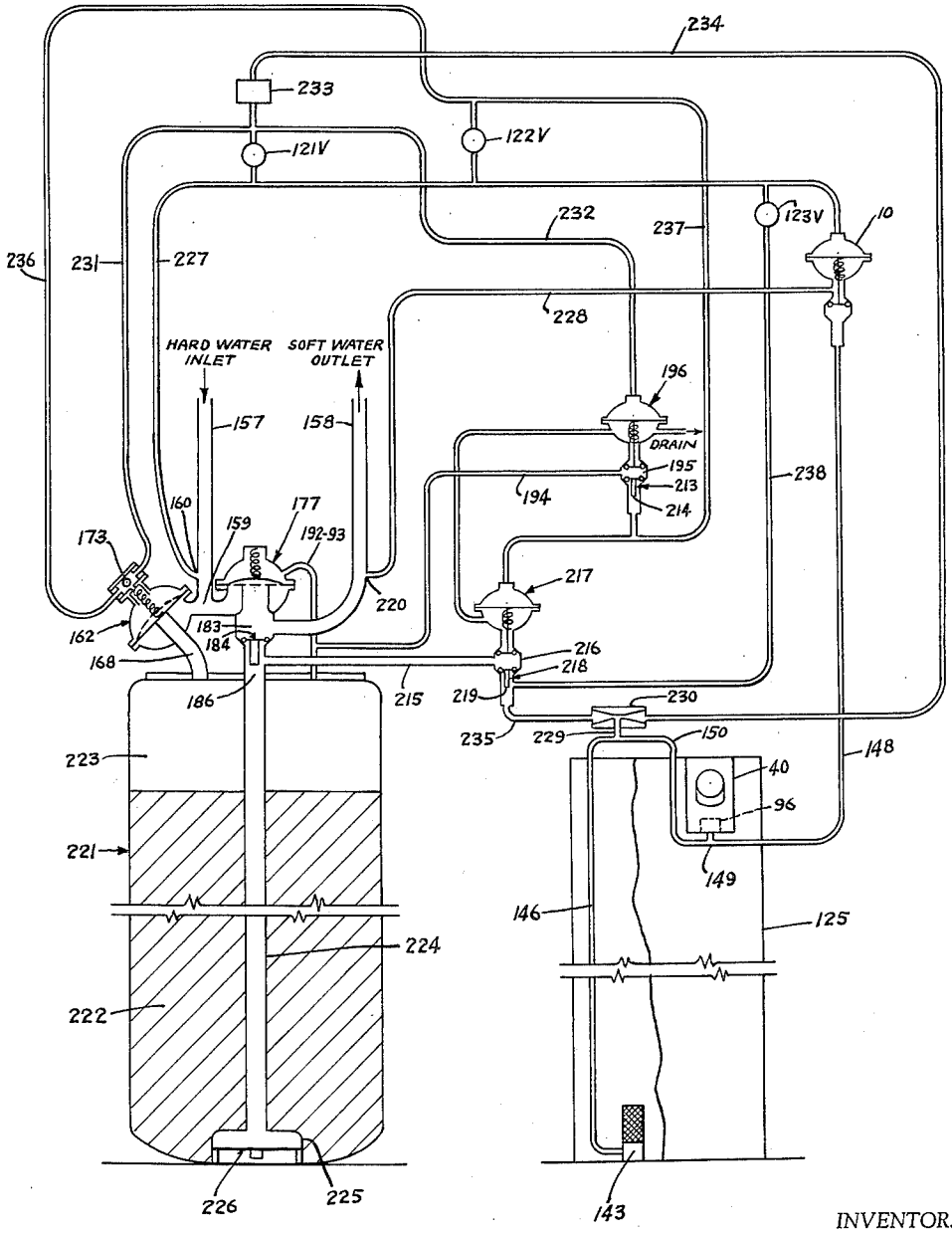
INVENTOR.
STANLEY A. LUNDEEN
BY Moore, White & Burd
ATTORNEYS

Dec. 4, 1962 S. A. LUNDEEN 3,066,801

CONTROL VALVE MEANS

Filed Feb. 19, 1958 3 Sheets-Sheet 3

FIG. 7



INVENTOR.
STANLEY A. LUNDEEN
BY Moore, White & Burd
ATTORNEYS

United States Patent Office

3,066,801
Patented Dec. 4, 1962

3,066,801

CONTROL VALVE MEANS

Stanley A. Lundeen, 2946 Stinson Blvd., Minneapolis 18, Minn.

Filed Feb. 19, 1958, Ser. No. 716,151
12 Claims. (Cl. 210—98)

This application relates to a multi-functional control valve means. More particularly, this invention relates to a versatile multi-functional, multi-port control valve means for automatic water softening systems.

The principal object of this invention is to provide a compact versatile control valve means for automatic water softening systems adapted to permit a variety of sequences of operating cycles in the regeneration of the mineral water softening bed of the water softening system.

A further object of this invention is to provide a compact versatile fluid pressure actuated diaphragm valve means for controlling the operation of an automatic water softening system.

Other objects of the invention will become apparent as the description proceeds.

To the accomplishment of the foregoing and related ends, this invention then comprises the features hereinafter fully described and particularly pointed out in the claims, the following description setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

The invention is illustrated by the drawings in which the same numerals refer to corresponding parts and in which:

FIGURE 1 is a top plan view of one embodiment of the control valve means of this invention, shown partly broken away to reveal the interior of the valve body;

FIGURE 2 is a vertical section through the valve means taken on the line 2—2 of FIGURE 1 and in the direction of the arrows;

FIGURE 3 is an enlarged section taken on the line 3—3 of FIGURE 2 and in the direction of the arrows;

FIGURE 4 is a vertical section taken on the line 4—4 of FIGURE 1 and in the direction of the arrows;

FIGURE 5 is a partial horizontal section taken on the line 5—5 of FIGURE 2 and in the direction of the arrows;

FIGURE 6 is a partial vertical section taken on the line 6—6 of FIGURE 2 and in the direction of the arrows; and

FIGURE 7 is a schematic representation of the elements of the control valve means according to this invention shown in conjunction with other elements of an automatic water softening system operatively connected to control a three phase regeneration cycle.

The control valve means indicated generally at 151, includes a base flange 152 adapted to be secured to the open end of the mineral tank of a water softening system. The bottom surface of the flange 152 is provided with a gasket or an annular groove 153 to receive a resilient O-ring to form a seal to prevent leakage between the top of the water softening tank and the bottom of the valve body. The flange 152 is also provided with openings 154 adapted to receive bolts or equivalent fastening means for securing the control valve means to the mineral tank. The bottom of the base flange of the control valve means is provided with a central annular projecting collar 155 adapted to receive the upper end of a pipe or tube connecting the control valve means with the bottom of the mineral tank and function as a soft water inlet, as explained in greater detail hereinafter. The inner surface of collar 155 is provided with an annular groove 156 adapted to receive a resilient O-ring to frictionally engage the end of the tube inserted in the collar and to prevent leakage around that tube.

The control valve means is provided with a hard water inlet port 157 adapted to be connected by means of conventional plumbing connections and fittings to any domestic or commercial water distribution system supplying hard water. The control valve means is also provided with a soft water outlet port 158 adapted to be connected by means of conventional plumbing fittings to any commercial or domestic water distribution system for supplying soft water to the taps and faucets of that system. Hard water inlet 157 communicates directly with a chamber 159 integrally formed in the body of the valve means. A further external port 160 communicates directly with chamber 159 in the control valve body and is adapted to be fitted with a connection extending to a flow line to a series of solenoid controlled valves and to maintain water main pressure on the diaphragm of a metering valve, as explained in greater detail hereinafter.

Chamber 159 also communicates directly with the lower pressure chamber 161 of a first pressure controlled diaphragm valve, indicated generally at 162. The lower pressure chamber 161 of the first diaphragm valve 162 is formed integrally with the control valve body. A cap 163 provided with a shallow bowl-shaped depression 164 which acts as an upper pressure chamber in the completed valve is adapted to be secured over the lower pressure chamber 161 by means of screws or bolts, or equivalent fastening means. A resilient diaphragm 165 is fitted between opposed faces of the cap 163 and the portion of the control valve body surrounding the lower pressure chamber 161.

The lower pressure chamber 161 is provided with a central annular valve seat fitting 166 whose central channel 167 communicates directly with a hard water outlet port 168 leading to the top of the mineral water softening tank. It will be seen that when the water pressure in the lower pressure chamber 161 exceeds the total pressure in the upper pressure chamber 164 that the diaphragm valve 162 is open and permits flow of hard water from the hard water inlet 157, through the chamber 159, through the lower pressure chamber 161 and thence through channel 167 to the outlet port 168 to the water softening bed. Means are provided in the cap 163 for interrupting this normal flow during regeneration of the mineral water softening bed by applying increased pressure on the upper side of the resilient diaphragm 165 in the upper pressure chamber 164.

The valve cap 163 includes a tubular pressure chamber extension 169 of somewhat lesser diameter than the upper pressure chamber 164. The end of the pressure chamber extension 169 opposite to the diaphragm 165 is provided with an outlet port 170 of substantially reduced diameter. A coil spring 171 seats in the pressure chamber extension 169 to normally urge the resilient diaphragm 165 against the valve seat 166 to close the diaphragm valve 162. Water pressure is applied to the upper pressure chamber 164 through port 170 through a two-way check valve including a transverse channel 172 in the outer end of the cap 163 fitted with a ball valving element 173 or other similar functioning valving element, such as a sliding cylindrical plug.

The ball valving element 173 is of a size to fit with a loose rolling fit in the channel 172 and is held in place by a pair of fittings 174 and 175, each adapted to be connected to a separate pressure source. When water pressure is applied through the fitting 174, the ball 173 is forced against the opening in the inner end of fitting 175 preventing flow out through that fitting while at the same time permitting application of the water pressure through the port 170 to the chambers 169 and 164 and against the resilient diaphragm 165. In the same manner, when pres-

sure is applied through the fitting 175, the ball is forced against the opening in the inner end of fitting 174 to prevent outward flow of fluid through that fitting while at the same time permitting the application of pressure against the diaphragm 165.

The entry chamber 159 from the hard water inlet 157 also communicates directly with the lower pressure chamber 176 of a second pressure controlled diaphragm valve indicated generally at 177. The lower pressure chamber 176 is in the form of a shallow depression formed integrally with the control valve body. A cap 178 is adapted to be fitted over the lower pressure chamber 176 and secured by means of screws or bolts or equivalent fastening elements. The cap 178 is provided with a shallow bowl-shaped depression 179 which serves as an upper pressure chamber in the assembled valve. A resilient diaphragm 180 is fitted between the opposed faces of the control valve body surrounding the lower pressure chamber 176 and cap 178 so that when the cap is secured in place on the control valve body, a fluid tight seal is formed.

An annular valve seat 181 is fitted into a central opening in the bottom wall of the lower pressure chamber 176 of the second diaphragm valve 177. Central channel 182 through the valve seat element 181 communicates directly with an interior chamber 183 in the control valve body. A one-way check valve element 184 seats in an opening in the bottom wall of chamber 183 which communicates with the chamber 186 contained within the annular sleeve 155 in the bottom of the control valve body. The check valve element 184 prevents flow from chamber 183 to chamber 186 when the pressure in chamber 183 is greater than that in chamber 186, but permits flow in the opposite direction when the pressure in chamber 186 is greater than that in chamber 183.

Although a simple ball check valve element will function in this instance, a preferred form of check valve construction is illustrated and comprises a flat disc 187 having a peripheral annular groove fitted with a resilient O-ring 188 and provided with a depending pilot stem 189. The pilot stem 189 is formed from two identical slotted sheet metal pieces fitted together at right angles to one another in their respective slots and soldered or similarly secured to the bottom surface of the disc 187.

Soft water outlet 158 communicates directly with chamber 183 in the interior of the control valve body. So long as the pressure in upper pressure chamber 179 is greater than that in the lower pressure chamber 176, as is true during the normal water softening cycle of a water softening system, the resilient diaphragm 180 is held in place against the valve seat 181 and the second diaphragm valve 177 is closed. Thus, during the normal water softening cycle, soft water from the mineral water softening bed enters chamber 186 from the tube held in the collar 155 and lifts the check valve element 184 so that soft water may flow into the chamber 183 and out through the soft water outlet 158.

On the other hand, when the pressure is greater in lower pressure chamber 176 than in the upper pressure chamber 179, as is true during the regeneration cycle of the water softening system, then the resilient diaphragm is forced away from the valve seat 181 and the second diaphragm valve 177 is opened. Thus, during regeneration, hard water from the hard water inlet 157 is bypassed through chamber 159, into lower pressure chamber 176, through channel 182 to chamber 183 and soft water outlet 158. It will be seen that if any of the soft water taps connected to the water softening system are opened during the period that regeneration is taking place, fresh (but hard) water will be drawn from those taps. However, since regeneration is scheduled to take place during periods of least water consumption, in the normal course there should be no occasion to draw water during the period that regeneration is taking place. The hard water by-pass insures that the water distribution system of which the softener is a part, remains operative at all times. Cap 178 of diaphragm valve 177 is provided with a tubular extension 190 of upper pressure chamber 179 in which a coil spring 191 is seated. Coil spring 191 normally urges the resilient diaphragm 180 against the valve seat 181 to maintain the diaphragm valve 177 in closed position. Fluid pressure is introduced into the upper pressure chamber 179 by means of a duct 192 in the rim of cap 178, through an opening adjacent to the edge of diaphragm 180, which, in turn, communicates with a duct 193 through the control valve body and with a channel 194, which functions as a second port connecting the control valve means and the top of the water softening tank upon which it is used. In this manner, the full pressure of the top of the water softening tank (which is substantially the pressure of the hard water main) is maintained against the top of the resilient diaphragm 180 during the water softening cycle.

The opposite end of channel 194 communicates directly with an interior chamber 195 in the control valve body. The upper portion of channel 195 is tapped to receive the threaded body of a first diaphragm drain valve, indicated generally at 196. The diaphragm drain valve 196 includes a threaded casing 197 provided with a shallow bowl-shaped interior depression 198 which serves as a lower pressure chamber for the completed valve. The valve casing 197 is provided with a central annular channel 199 which serves as an extension of the pressure chamber 198 and a somewhat narrower outlet channel or port 200 communicating with the chamber 195 in the control valve body.

The lower end of the outlet port 200 is provided with an annular groove into which there is fitted a resilient O-ring 201. A pair of ports 202 and 203 in the wall of the drain valve casing communicate with the pressure chamber 198 and pressure chamber extension 199. The diaphragm drain valve 196 includes a cap 204 provided with an interior shallow bowl-shaped depression 205 which functions as an upper pressure chamber in the completed valve. A pair of ports 206 and 207 communicate with the pressure chamber 205. A resilient diaphragm 208 is fitted between the opposed faces of the casing 197 and the cap 204. Depending from the center of diaphragm 208 is a valving member including an elongated stem 209 at the end of which is a frusto-conical valving element adapted to seat within the resilient O-ring 201.

An open 3-footed spider or bridging member 211 rests in the bottom of the pressure chamber extension 199 and provides a seat for a coil spring 212 which normally urges the resilient diaphragm 208 upwardly so as to maintain the conical valving element 210 seated against the O-ring 201 so that the drain valve 196 is normally maintained closed. The function of the spider 211 is to permit free flow of water through the valve when the valve is open. Without the use of the spider, it occasionally happens that the coils of the coil spring 212 may be so tightly compressed as to inhibit the flow of water through the coil spring. The spider 211 is provided with a central annular upwardly extending flange which functions to center the coil spring 212 around the valve stem 209.

It will be seen that because of the pressure of coil spring 212 the diaphragm drain valve 196 will normally be closed. However, upon introduction of pressure to the upper pressure chamber 205, sufficient to overcome the pressure exerted by the coil spring, the spring will be compressed and the plunger moved so that the valve will be opened and flow from chamber 195 into channel 200 and pressure chamber 198 and 199 and out through port 202 or 203 will be permitted.

A one-way check valve 213 is disposed in an opening in the bottom wall of chamber 195 connecting with an inlet port 214 to the control valve body. The construction of check valve 213 is substantially the same as that previously described for check valve 184. Check valve 213 is effective to prevent flow of water from chamber 195 to port 214 but upon application of greater pressure upon

port 214 than upon chamber 195 the check valve 213 will lift and permit flow of water from the inlet 214.

A channel 215 communicates between chamber 186 in the bottom of the control valve body and another interior chamber 216. The top of chamber 216 is tapped to receive a threaded second diaphragm drain valve, indicated generally at 217. The construction of the second drain valve 217 is in all respects similar to that described in detail for drain valve 196 and these details will not be repeated. A check valve 218 is provided in the opening in the bottom wall of chamber 216 connecting with a further inlet port 219. The construction of check valve 218 is substantially the same as that already described for check valve 184. Check valve 218 functions to prevent the flow of water from chamber 216 to port 219 while permitting flow in the opposite direction from port 219 to chamber 216.

A port 220 communicates with chamber 183 adjacent the soft water outlet. Through port 220 the control valve is connected to the inlet of a metering valve according to my co-pending application, Serial No. 676,777, filed August 7, 1957, to meter soft water into a brine generating device for the generation of a brine solution proportional to the volume of soft water drawn through the soft water outlet 158 of the control valve means.

The utility and functioning of the control valve means of this invention with reference to one automatic water softening system is illustrated schematically in FIGURE 7. The water softening system illustrated in FIGURE 7 is so organized as to provide a three-phase regeneration cycle. In the first phase, the regeneration cycle is initiated and brine for revitalization of the mineral water softening bed is drawn from a brine generating vessel, introduced to the bottom of the mineral bed and forced upwardly through the bed. In the second phase, the direction of flow is reversed and the brine which has collected in the freeboard of the water softening tank is forced downwardly through the mineral bed and followed by a wash with fresh water in the same direction. During the third phase of regeneration, the mineral bed is washed with fresh water in an upflow operation and the regeneration cycle is terminated.

It is to be understood that this is but one arrangement in which the control valve means of this invention may be utilized. Depending upon the organization of the elements comprising the water softening systems, the phases of the regeneration cycle and their sequence of operation may be changed at will to accommodate the system to particular conditions. It is also to be understood that in arranging the several elements of the control valve means and of the automatic water softening system in the single plane of a sheet of drawing the positional relationships of certain of the elements were necessarily distorted. The functional relationships among the several elements, however, remain the same.

Referring now to FIGURE 7 of the drawings, the control valve of this invention is shown schematically, mounted on the top of an elongated and upright tank 221 adapted to contain a supply or bed 222 of a water softening ion exchange material, such as zeolite, to a level at about one-half to three-fourths of the tank's volumetric capacity to leave a freebroad area 223 at the top of the tank. Tank 221 is desirably formed of noncorrosive reinforced synthetic resinous material and is preferably provided with a rounded bottom.

The tank 221 is provided with a central tubular conduit 224 whose upper end is fitted into the projecting collar 155 on the bottom of the control valve means and is held in place by a resilient O-ring in the annular groove 156. Tube 224 is likewise preferably formed from a noncorrosive synthetic resinous material. The lower end of tube 224 terminates in a bell 225 supported by feet just off the surface of the bottom of the tank 221. A fine screen 226 stretched across the bottom of the inverted bell 225 prevents the ion exchange material in the tank from being drawn into the central vertical tube.

The control valve means is connected into a water distribution system with the hard water inlet connected to a source of hard water and with the soft water outlet 158 connected on the discharge side of the distribution system. During the softening cycle, the pressures upon diaphragms in diaphragm valves 162 and 177 are such that the diaphragms assume the positions shown in broken lines in FIGURE 7. Diaphragm valve 162 is opened and diaphragm valve 177 is closed. During the softening cycle hard water enters through inlet 157 to chamber 159. Flow through diaphragm valve 177 is prevented because the greater pressure on the top of the diaphragm in that valve maintains the valve closed.

Port 160 is permanently opened so that the pressure of the hard water supply is maintained in line 227 to maintain pressure upon the top of the resilient diaphragm in the metering valve 10. Any flow of water from line 227 is prevented by solenoid actuated valves 121V, 122V, and 123V, which remain closed during the water softening cycle. Because the pressure exerted by the hard water supply main on the lower side of the diaphragm in diaphragm valve 162 is greater than the pressure on the upper side of the diaphragm that valve remains open. Hard water may thus flow through valve 162 to chamber 168 and into the top of the water softening tank 221. The hard water is forced down through a bed of mineral 222 in the tank 221 and in the course of its passage becomes softened by ion exchange, as is well understood in the art. The resulting soft water enters the inverted bell at the bottom of the tank and is forced upwardly through tube 224 to the chamber 186 at the bottom of the control valve.

Outward flow from chamber 186 through channel 215 is prevented by virtue of check valve 218 and the fact that diaphragm valve 217 is maintained closed by spring pressure and by the water pressure of the tank against the plunger to hold it closed. The soft water being under pressure, may, however, lift check valve 184 and enter chamber 183. No soft water may flow through diaphragm valve 177 because that valve is closed. It is closed by virtue of the superior pressure applied from the top of the water softening tank through channel 194 and ducts 192 and 193, to the cap of the diaphragm valve 177, supplemented by spring pressure. No hard water may escape through channel 194 because of check valve 213 and the fact that diaphragm valve 196 is maintained closed by spring pressure and by the water pressure of the tank against the plunger.

Upon the opening of any tap or faucet connected in the soft water distribution system, soft water may flow out through the soft water outlet 158. At the same time, soft water is permitted to flow through port 220 through a line 228 to a metering valve 10 in a predetermined fixed proportion to the amount of soft water drawn through the soft water outlet, in the manner described in detail in my aforesaid co-pending application, Serial No. 676,777. The soft water metered out by the metering valve 10 flows under pressure through a line 148 through a T-fitting 149 which is connected to the vacuum dashpot 96 of a clock control unit of the type described in my co-pending application, Serial No. 693,481, filed October 30, 1957, and thence through a line 150 to a T-fitting 229 (which, in turn, is connected to the throat of a venturi tube 230), and thence through tubing 145 to a salt strainer device 143 at the bottom of a brine generating tank 125 where it contacts stored salt to generate a brine solution for use in regeneration of the mineral water softening bed.

The construction of the salt strainer device 143 is described in detail in my co-pending application, Serial No. 496,802, filed March 25, 1955, now Patent No. 2,902,155 issued Sept. 1, 1959 and a preferred form of brine generating vessel is described in my co-pending application, Serial No. 709,055, filed January 15, 1958, now Patent

No. 2,985,514 issued May 23, 1961. Thus, in the operation of the water softening system to soften water, soft water is withdrawn from the distribution system for use as needed and this is furnished by passage of hard water through the system and out in the manner described. Simultaneously with the normal consumption of soft water a predetermined fixed small proportion of the soft water is by-passed to the brine generating vessel for preparation of a brine solution for use in revitalizing the mineral bed when necessary.

Regeneration may be carried out when determined to be necessary according to the volume of soft water consumed as reflected by the level of brine present in the brine generating vessel, as described in detail in my aforesaid copending application, Serial No. 693,481. Alternatively, in some installations, as, for example, where soft water consumption is fairly uniform, regeneration may be carried out at predetermined fixed intervals, such as every day, or every other day, or every third day or the like. In any event, regeneration preferably is carried out during periods of minimum soft water consumption, such as in the extreme early morning hours, as, for example, 3:00 a.m.

The regeneration cycle is initiated by action of the control clock 40 operating a switch to energize a solenoid controlling valve 121V. When this happens, the pressure of the hard water supply main is exerted through the hard water inlet 157 upon chamber 159 and through port 160 and line 227 upon the valve 121V. Since this valve is now open, the water at main pressure is permitted to flow through the valve for distribution as follows.

When valve 121V is opened, the pressure of the hard water supply line is exerted through line 231 upon one side of the two-way ball check valve element 173 and upon the upper side of the resilient diaphragm of the diaphragm valve 162. This pressure, plus auxiliary spring pressure, forces the diaphragm against the valve seat in the solid line position shown in FIGURE 7 to close valve 162. Pressure upon the ball 173 prevents outward flow from the opposite side of the channel of the two-way check valve.

When valve 121V is opened, the pressure of the hard water supply line is also exerted through line 232 upon the upper pressure chamber and diaphragm of diaphragm drain valve 196. One of the entry ports 206 or 207 to the pressure chamber is plugged. The main pressure in the upper pressure chamber of diaphragm drain valve 196 is sufficient to overcome the pressure or the coil spring in that diaphragm valve and open that valve to chamber 195 so that water may then flow from chamber 195 and out through one of the ports 202 or 203 below the diaphragm to a drain or sewer. A constant flow control device 233 is inserted between the valve 121V and line 234 to venturi tube 230 (or, more precisely, between lines 231 and 232 and line 234, as shown in FIGURE 7) in order to reduce the volume of the stream of water permitted to flow to the venturi tube.

Thus, with the first phase of the regeneration cycle initiated and solenoid controlled valve 121V open, the pressure of the hard water supply main is applied against the diaphragm of diaphragm valve 162 to maintain that valve closed, with the assistance of spring pressure. Hard water from chamber 159 is prevented from flowing to the top of the water softening tank relieving the top of the water softening tank from the supply main pressure and also thereby relieving the top of the diaphragm of diaphragm valve 177 from that pressure. Accordingly, if any of the soft water taps are opened during the period of regeneration, hard water may now flow from the chamber 159 through the open diaphragm valve 177 to the chamber 183. Check valve 184 prevents flow of this hard water into chamber 186 and tube 224. The hard water may, however, flow out through the soft water outlet 158 and in this manner, hard water is by-passed during the regeneration cycle. If any water is drawn from the soft water taps during regeneration, a predetermined small proportion of this water will flow through port 220 to be metered by metering valve 10 into the brine generating vessel. This flow, however, will be negligible since normally no water will be drawn from the water distribution system during the regeneration cycle.

After initiation of the regeneration cycle the water flow released by opening of valve 121V maintains pressure upon the diaphragms of diaphragm valve 162 and diaphragm drain valve 196 in the manner described. The reduced flow through the flow control device 233 and line 234 to the venturi tube 230 passes through a line 235 and through port 219 to the control valve means lifting check valve 218 and passing through channel 215 to chamber 186. Diaphragm drain valve 217 remains closed, during this first phase of the regeneration cycle. As the water from line 234 flows through the restricted throat of the venturi tube 230 it creates a reduced pressure within the throat which draws the brine from the bottom of the tank 125 through the salt strainer unit 143 and up through the tubing 146 and through the venturi tube for passage through line 235 and past check valve 218 into chamber 216 and channel 215 to chamber 186 at the bottom of the control valve means and at the top of tube 224 in the water softening tank.

Chamber 183 in the control valve means is at the pressure of the hard water supply main. This insures that check valve 184 remains in place. The brine solution is thus forced down through tubing 224 to the bottom of the bed 222 of mineral water softening material and is distributed on the bottom of the tank and forced upwardly through the mineral bed in ion exchanging relationship. The brine solution rises through the mineral bed to the freeboard 223 of the tank pushing the fresh water in the freeboard of the tank ahead of it and out through channel 194 to chamber 195. Since the pressure upon the diaphragm in diaphragm drain valve 196 now holds that valve open, the water forced from the water softening tank passes through the drain valve 196 to a drain or sewer. Flow from chamber 195 is otherwise prevented by check valve 213.

After all of the brine in the brine generating tank has been withdrawn through the tube 146, the float valving element seats in the resilient valve seat of the salt strainer unit 143 and creates a suction within tubing 146 which, in turn, transmits itself through line 150 and fitting 149 to the vacuum dashpot 96 on the control clock. The vacuum exerted upon the dashpot 96 of the control clock introduces a time delay of sufficient length to permit substantially all of the brine solution to pass through the mineral bed to the freeboard of the tank 221.

At the expiration of this delay period the clock control actuates microswitches which deenergize the solenoid controlling valve 121V and energize the solenoid controlling valve 122V. When this occurs, pressure is relieved upon diaphragm drain valve 196 causing that valve to close. At the same time, pressure is relieved upon one side of the two-way ball check valving element 173 and would relieve pressure upon the diaphragm in diaphragm valve 162 except that with solenoid controlled valve 122V now opened, the pressure of the hard water supply line is asserted through valve 122V and line 236 upon the opposite side of the ball 173 to maintain the pressure upon diaphragm valve 162. The pressure of the hard water supply main is also asserted through valve 122V and line 237 on the top of the diaphragm of diaphragm drain valve 217. At the same time, water from line 237 passes under pressure through port 214 (lifting check valve 213) and passes through channel 194 into the top of the water softening tank 221.

This inflow of fresh water to the top of the water softening tank forces the brine left in the freeboard of the tank back down through the mineral bed in the opposite direction and up through the central tube 224 so that the brine solution passes through the mineral bed twice, once in each direction. This dual upflow and downflow contact of the brine with the mineral water softening

material thus provides double the contact time between the brine and mineral facilitating and insuring complete revitalization of the mineral.

The brine solution forced upward through the central tube 224 into chamber 186 passes through channel 215 to chamber 216. Outflow from chamber 216 through port 219 is prevented by check valve 218. However, since diaphragm drain valve 217 is now pressurized, that drain valve is open and the brine solution passes through that valve and through the lower bowl of drain valve 196 to the drain or sewer. The flow of fresh water through solenoid actuated valve 122V is continued for a time period predetermined by the setting of the control clock sufficient to insure removal of all of the brine from the mineral bed and to thoroughly rinse the mineral with fresh water.

At the end of this second phase of the regeneration cycle, the clock control actuates microswitches to deenergize the solenoid controlling valve 122V and to energize the solenoids controlling valves 121V and 123V. When this occurs, diaphragm drain valve 217 is again closed, diaphragm drain valve 196 is again opened and diaphragm valve 162 remains pressurized, but from line 231, instead of line 236, because of the shift in position of the two-way ball check 173. Fresh water is injected from valve 121V into port 219 and through tube 224 to the bottom of the mineral bed, in the manner heretofore described for the introduction of the brine, but because of the relatively low volume of this flow, it is supplemented by a further flow through valve 123V and line 238 to port 219. This larger volume supplemental flow flushes and rinses the mineral bed in its upflow passage to remove any traces of brine or other contaminants which may remain after the previous downflow rinsing.

This third phase of the regeneration cycle is allowed to continue for a time sufficient to insure complete washing of the mineral bed. At the end of this period, the control device deenergizes all of the solenoids so that valves 121V and 123V are then closed and the system is returned to its normal water softening function. This means that diaphragm valve 162 is depressurized, diaphragm valve 177 is pressurized, and diaphragm valves 196 and 217 are both depressurized, but maintained closed by spring action. With the system returned to its normal condition, the next water softening cycle is initiated.

By simple modification of its structure, the control valve means of this invention may be utilized in other water softening systems. One example of such a system which is somewhat simpler than that described in detail with reference to FIGURE 7 is one having a two phase regeneration cycle in which the second passage of the brine-solution in contact with the mineral bed is dispensed with. This introduces a number of simplifications into the system. As an example, the second diaphragm drain valve 217 may be eliminated and the threaded opening in the top of chamber 216 may simply be fitted with a solid plug. At the same time, check valve 213 is no longer necessary and port 214 may be plugged. The diaphragm valve 162 may simply be pressurized by the line 231 alone so that the two-way check valve in the diaphragm valve 162 may be eliminated. Solenoid controlled valve 122V is no longer necessary.

Since the second flow of the brine solution in contact with the mineral bed has been eliminated, there is no need for the time delay in initiating the second stage of the regeneration cycle and the vacuum dashpot 96 on the control clock along with the switches controlled by the dashpot are no longer necessary. It will be apparent that other arrangements may be made whereby the number and sequence of phases in the regeneration cycle may be varied at will, along with the direction of flows during each of the phases. The control valve is versatile and adaptable to meet the operating demands of virtually any water softening system.

In some water softening systems, such as semi-commercial or commercial installations, handling large volumes of water, it is desirable to utilize more than one tank of water softening mineral. In these installations, the several water softening tanks are connected so that the mineral beds are regenerated in sequence, such as, for example, in a two-tank system, the first tank may be regenerated on alternating nights with the second tank. Since in such an installation the tank which is not being regenerated is available to supply fresh soft water during the regeneration cycle of the other tank, there is no need for a fresh water by-pass in the system. Accordingly, the control valve means, when used in a system employing more than one water softening tank, may be modified and simplified by the deletion of diaphragm 180, spring 191, ducts 192—193, and the substitution of a hollow plug for the annular valve seat element 181. Such a simpler modified control valve means may then be utilized to regulate the desired number of phases of the regeneration cycle and the sequence of their operation as described above.

It will be noted that the upper pressure chambers of each of the diaphragm drain valves 196 and 217 are provided with two entry ports. Likewise, the lower bowls of these diaphragm valves are provided with two ports. In many applications, such as, for example, the system illustrated in FIGURE 7, only one of these ports may be used, in which event the other port is simply plugged. As shown in FIGURE 7, the drain discharge from diaphragm valve 217 passes through the lower bowl of diaphragm valve 196 on its way to the drain. This is a matter of convenience and drain valve 217 could, if desired, be connected directly to a drain.

It is apparent that many modifications and variations of this invention as hereinbefore set forth may be made without departing from the spirit and scope thereof. The specific embodiments described are given by way of example only and the invention is limited only by the terms of the appended claims.

I claim:

1. A multi-port control valve mans comprising a valve body, a first inlet port to said valve body and a first outlet port from said valve body, said first ports being in communication through a first connecting chamber, a second inlet port to said valve body and a second outlet port from said valve body, said second ports being in communication through a second connecting chamber, a pressure controlled diaphragm valve positioned in said first chamber between said first inlet port and first outlet port, a one-way check valve positioned in said second chamber between said second inlet port and second outlet port to permit flow only in the direction toward said outlet port, a third inlet port and channel in communication with said second inlet port, a one-way check valve positioned in said third port and channel to permit inflow only through said third port and channel, a drain port from said control valve means, a third outlet port and channel in communication with said drain port, a second pressure controlled diaphragm drain valve positioned between said third outlet port and channel and said drain port, means for pressurizing said diaphragm valves, and a further outlet port from said valve body, said further outlet port being positioned between said second outlet port and the one-way check valve between said second inlet port and said second outlet port.

2. A control valve means according to claim 1 further characterized in that said means for pressurizing said diaphragm valves includes an auxiliary outlet port from said valve body, said auxiliary outlet port being positioned between said first inlet port and said pressure controlled diaphragm valve between said first inlet port and first outlet port, and an inlet port to the diaphragm pressure chamber forming part of each of said diaphragm valves.

3. A control valve means according to claim 1 further characterized in that said first inlet port and second outlet port are in communication through an interconnecting

chamber and a further pressure controlled diaphragm valve is positioned in said chamber between said first inlet port and second outlet port.

4. A control valve means according to claim 2 further characterized in that said inlet port to the diaphragm pressure chamber of said first pressure controlled diaphragm valve includes a two-way check valve, the opposite sides of said check valve being in communication with said auxiliary outlet port.

5. A control valve means according to claim 1 further characterized in that said check valves each comprise a circular disc, a resilient O-ring disposed in an annular groove around the periphery of said disc, and a pilot stem comprised of a pair of flat slotted members fitted together in said slots and secured to depend from said disc.

6. An automatic water softening system comprising means for connection to a source of hard water and means for connection to a soft water distribution system, a water softening tank in communication with said hard water and soft water connecting means through a control valve means to receive and soften said hard water and discharge soft water for distribution, a brine tank in communication with said water softening tank through said control valve means for generating and storing brine for regeneration of water softening mineral adapted to be contained in said water softening tank, said control valve means being connected to said water softener tank, said control valve means comprising a valve body having a hard water inlet port and a soft water outlet port, a hard water outlet port in communication with said hard water inlet port and said water softener tank, a soft water inlet port in communication with said water softener tank and said soft water outlet port, a pressure controlled diaphragm valve between the hard water inlet port and hard water outlet port, a one-way check valve between the soft water inlet port and soft water outlet port to permit flow of soft water only in the direction from the inlet port to the outlet port, a brine and fresh water inlet port and channel in communication with said soft water inlet port and said brine tank, a one-way check valve in said brine and fresh water inlet port and channel to permit inflow only through said port and channel, a drain port from said control valve means, a brine and fresh rinse water discharge port and channel from said water softener tank to said drain port, a pressure controlled diaphragm drain valve in said brine and rinse water discharge port and channel to control discharge to said drain port, means for pressurizing said diaphragm valves, and an auxiliary soft water outlet port from said control valve means, said auxiliary outlet port being positioned between said first mentioned soft water outlet port and the one-way check valve which is between the soft water inlet port and said first mentioned soft water outlet port, said auxiliary soft water outlet port being in communication with said brine tank.

7. An automatic water softening system according to claim 6 further characterized in that said control valve means is provided with a further pressure controlled diaphragm valve between the hard water inlet port and soft water outlet port to permit bypass of hard water during regeneration of the system.

8. An automatic water softening system according to claim 6 further characterized in that said means for pressurizing the diaphragm valves of said control valve means includes an auxiliary hard water outlet port from said control valve means, said auxiliary hard water outlet being positioned between said first mentioned hard water inlet port and the pressure controlled diaphragm valve which is between the hard water inlet port and said first mentioned hard water outlet port, and an auxiliary hard water inlet port to the diaphragm pressure chamber forming part of each of said diaphragm valves.

9. An automatic water softening system according to claim 6 further characterized by the provision of a further fresh water inlet port in said control valve means in communication with said brine and rinse water discharge port and channel from said water softener tank and a one-way check valve in said further inlet port to permit inflow only to said discharge port and channel, and the provision of a further pressure controlled diaphragm drain valve in said control valve means in said brine and fresh water inlet port and channel, said drain port communicating with one chamber of said second pressure controlled diaphragm drain valve.

10. An automatic water softening system according to claim 8 further characterized in that the auxiliary hard water inlet port to the diaphragm pressure chamber of the first mentioned pressure controlled diaphragm valve between the hard water inlet port and hard water outlet port of the control valve means includes a two-way check valve, the opposite sides of said two-way check valve being in communication with said auxiliary hard water outlet port.

11. An automatic water softening system according to claim 6 further characterized in that said one-way check valves of said control valve means each comprise a circular disc, a resilient O-ring disposed in an annular groove around the periphery of said disc, and a pilot stem comprised of a pair of flat slotted members fitted together in said slots and secured to depend from said disc.

12. A multi-port control valve means comprising a valve body, a first inlet port to said valve body and a first outlet port from said valve body, said first ports being in communication through a first connecting chamber, a second inlet port to said valve body and a second outlet port from said valve body, said second ports being in communication through a second connecting chamber, a pressure controlled diaphragm valve positioned in said first chamber between said first inlet port and first outlet port, a one-way check valve positioned in said second chamber between said second inlet port and second outlet port to permit flow only in the direction toward said outlet port, a third inlet port and channel in communication with said second inlet port, a one-way check valve positioned in said third port and channel to permit inflow only through said third port and channel, a drain port from said control valve means, a third outlet port and channel in communication with said drain port, a second pressure controlled diaphragm drain valve positioned between said third outlet port and channel and said drain port, a fourth inlet port in communication with said third outlet port and channel, a one-way check valve in said fourth inlet port to permit inflow only to said third port and channel, a further pressure controlled diaphragm drain valve in said third inlet port and channel, said drain port communicating with one chamber of said further diaphragm drain valve, and means for pressurizing said diaphragm valves.

References Cited in the file of this patent

UNITED STATES PATENTS

1,839,428	Waugh	Jan. 5, 1932
2,265,225	Clark	Dec. 9, 1941
2,352,629	Griswold	July 4, 1944
2,596,915	Pick	May 13, 1952
2,677,390	Davis et al.	May 4, 1954

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,066,801 December 4, 1962

Stanley A. Lundeen

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 7, line 47, for "or" read -- of --; column 10, line 39, for "mans" read -- means --.

Signed and sealed this 4th day of June 1963.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents