July 12, 1932. A. G. HORVATH 1,866,890

WATER SOFTENING APPARATUS

Filed Feb. 23, 1926 4 Sheets-Sheet 1

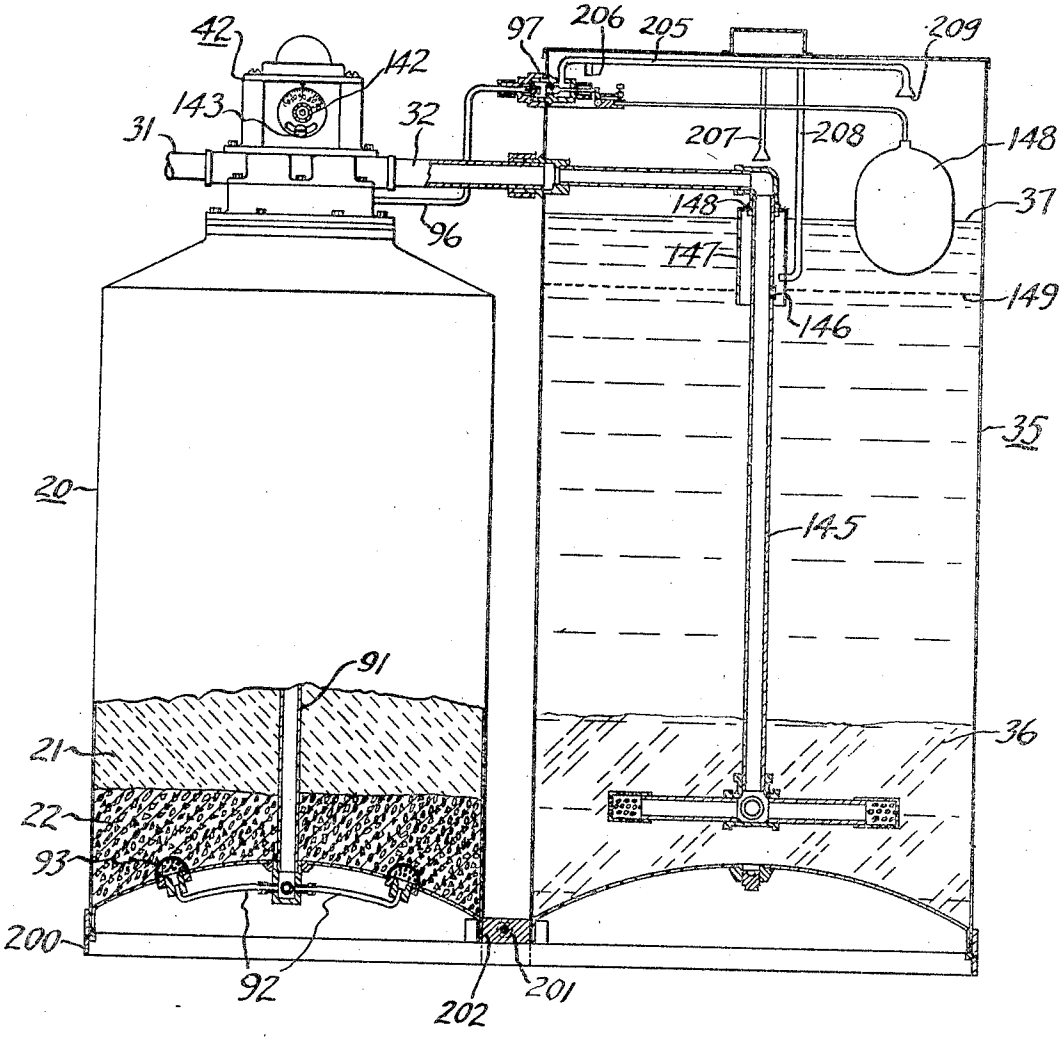


Fig. 1.

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WATER SOFTENING APPARATUS

Filed Feb. 23, 1926 4 Sheets-Sheet 2

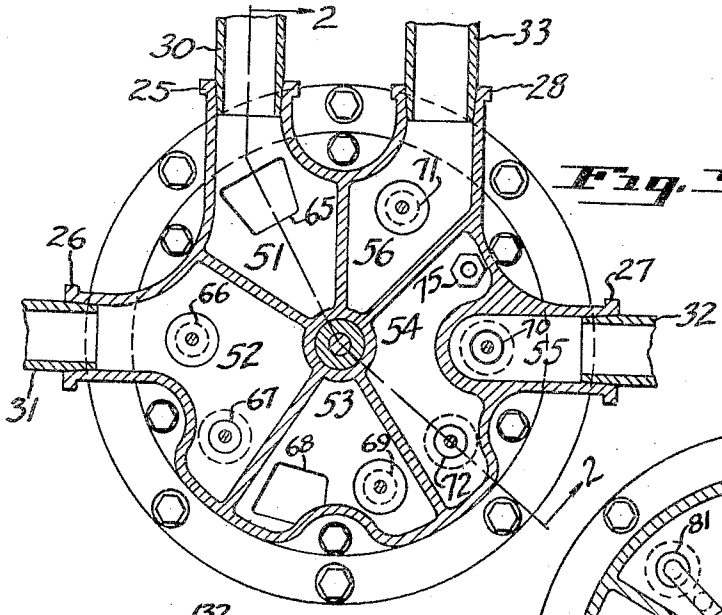


Fig. 1.

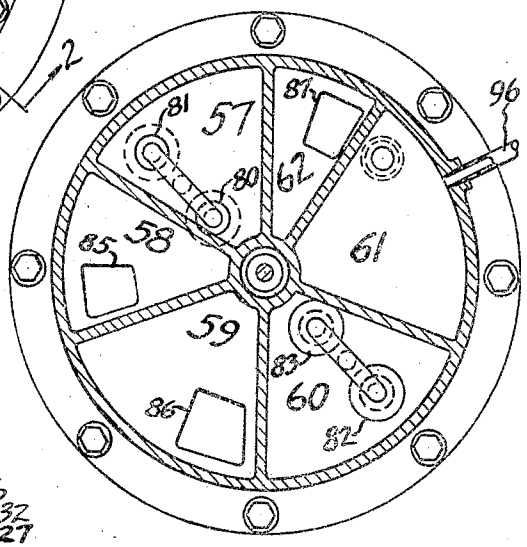


Fig. 4.

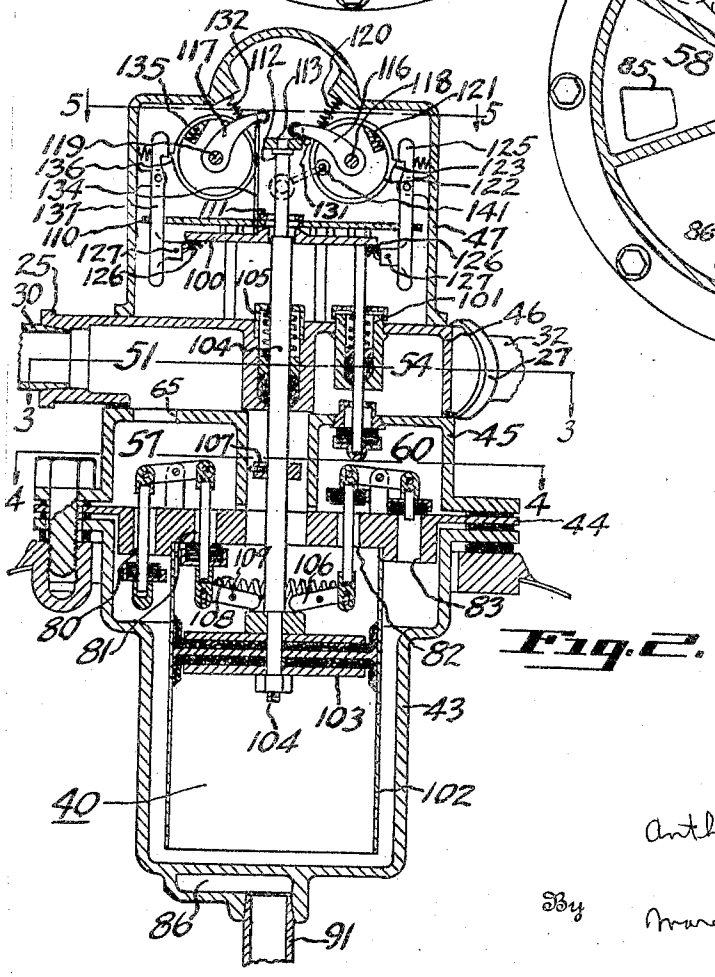


Fig. 2.

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WATER SOFTENING APPARATUS

Filed Feb. 23, 1926 4 Sheets-Sheet 3

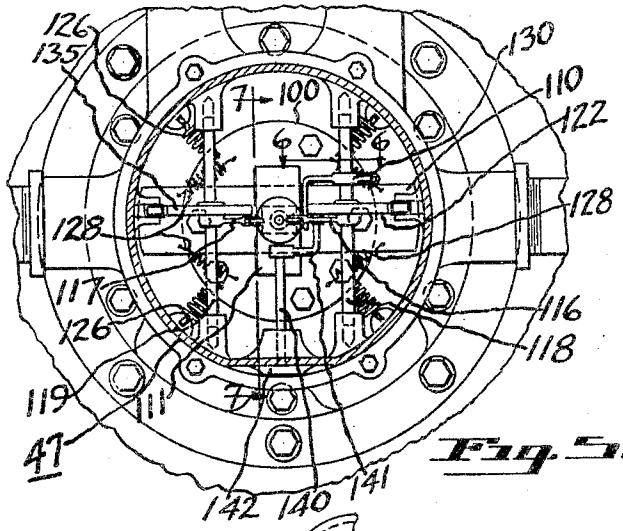


Fig. 5.

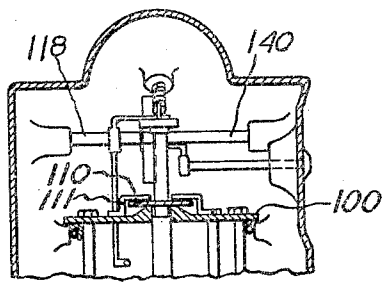


Fig. 7.

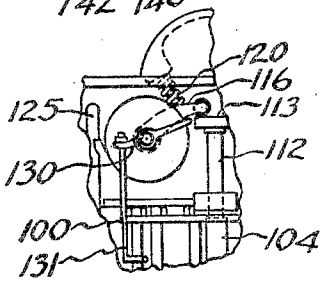


Fig. 6.

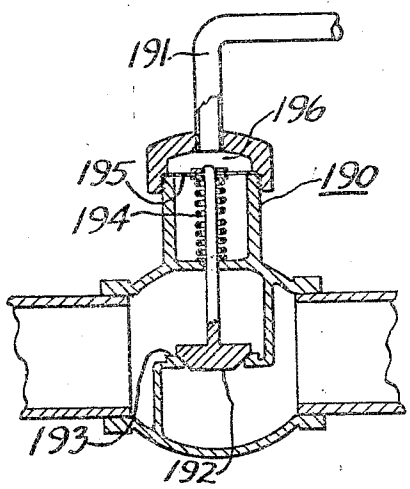


Fig. 9.

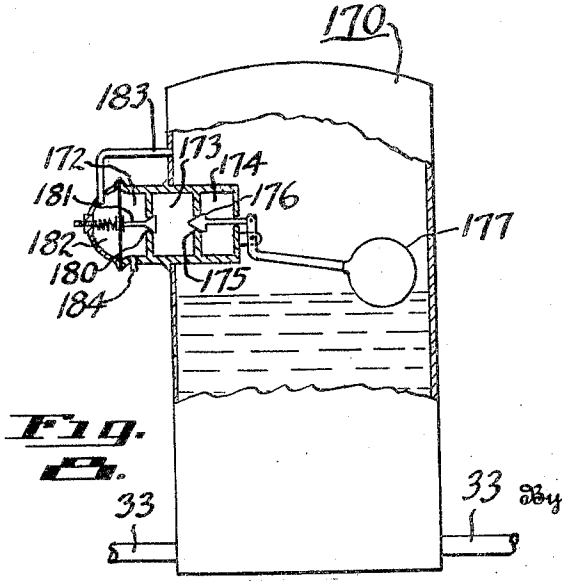


Fig. 8.

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WATER SOFTENING APPARATUS

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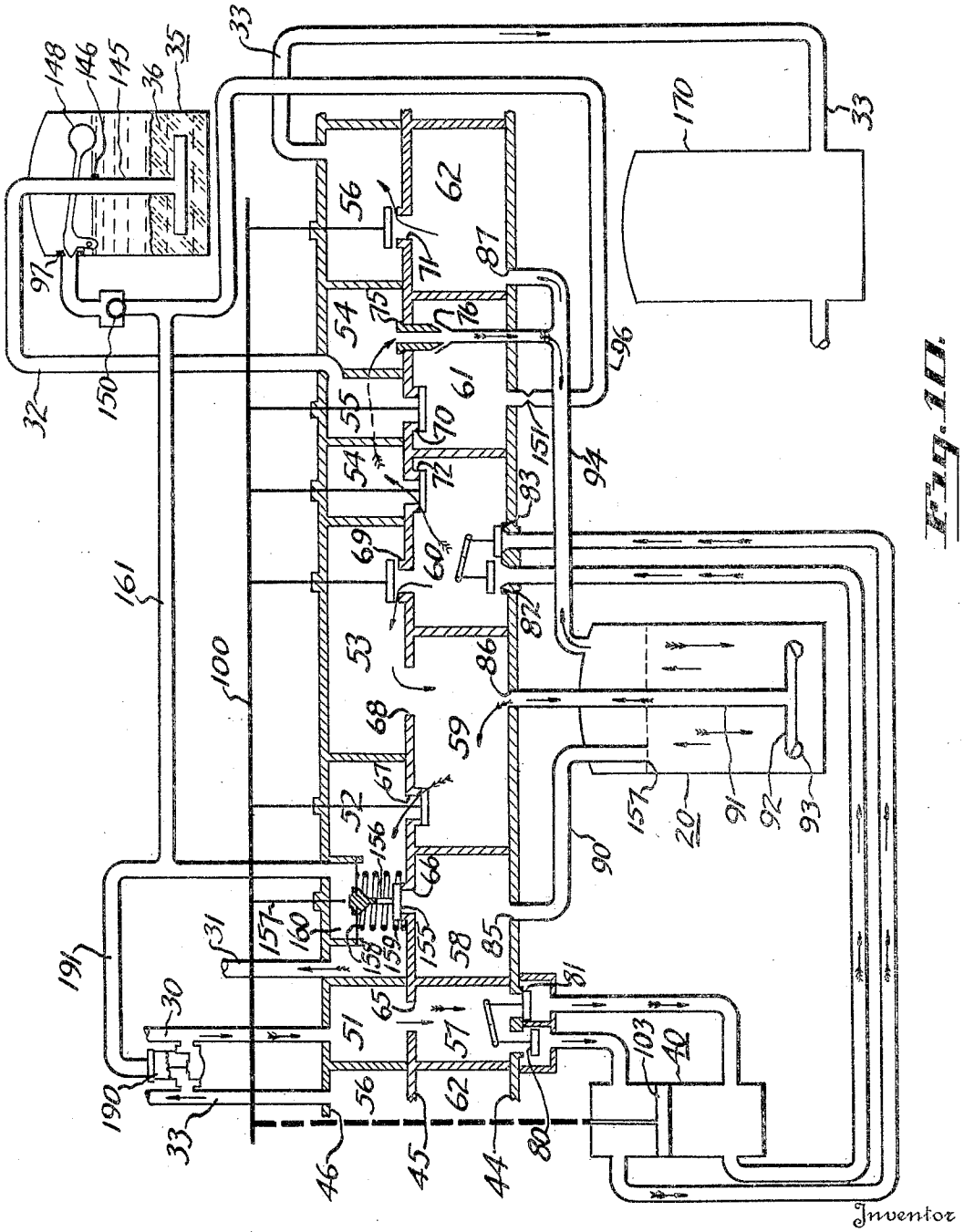


Fig. 10.

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UNITED STATES PATENT OFFICE

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WATER-SOFTENING APPARATUS

Application filed February 23, 1926. Serial No. 89,989.

This invention relates to water-softening apparatus and more particularly to apparatus of the type adapted for domestic use.

One of the principal objects of the invention is to provide a water-softening apparatus capable of automatically regenerating or reconditioning itself.

Another object is to provide an automatic water softener having means for positively actuating the valves for controlling the various stages of operation.

Still another object is to provide such a device in which the softening tank may be purged of all brine, hard water or other liquid passed through the softening tank incident to the regenerating operation, and the softening tank conditioned to supply soft water to the service lines immediately upon demand therein after the regenerating operation.

Another object is to provide an automatic water softener which may be adjusted for the hardness of the water by the movement of a single adjustment element.

Still another object of the invention is to provide a simple means normally exposed and readily operable for adjusting the automatic water softener for the hardness of water passing therethrough.

Other objects and advantages of the invention will be apparent from the following description when taken in connection with the accompanying drawings, in which like characters of reference designate like parts in the several figures:

Fig. 1 is a vertical elevation of the softening tank and the brine tank of the present invention, parts being shown in section to illustrate features of the construction;

Fig. 2 is a vertical section of the control unit mounted on the upper end of the softening tank, such section being taken on the irregular line 2—2 of Fig. 3;

Fig. 3 is a horizontal section taken on the line 3—3 of Fig. 2.

Fig. 4 is a horizontal section taken on the line 4—4 of Fig. 2;

Fig. 5 is a horizontal section taken on the line 5—5 of Fig. 2;

Fig. 6 is a vertical section taken on the line 6—6 of Fig. 5;

Fig. 7 is a vertical section taken on the line 7—7 of Fig. 5;

Fig. 8 is a vertical section of a liquid pressure tank forming part of the present invention;

Fig. 9 is a vertical section of a hard-water by-pass valve; and

Fig. 10 is a view illustrating diagrammatically the relation of the chambers, ports, passages and valves to the other parts of the present invention, the arrangement of chambers illustrated being in the nature of a development on a section line just inside the generally circular wall of Figs. 3 and 4, the development beginning at a point between the supply and service lines and continuing in a counter-clockwise direction as viewed in Fig. 3, terminating at a point between the supply and service lines.

Referring to the drawings, the water-softening apparatus comprises generally a water-softening tank 20 containing a bed of water-softening material or mineral such as green sand 21, which is adapted to take up certain elements, such as calcium and magnesium, from the hard water passing therethrough, thereby rendering such water "soft" and suitable for domestic use. The mineral 21 may and preferably is laid upon a bed of gravel 22. The water-softening tank has at its upper end connections 25, 26, 27, and 28 adapted to be connected respectively with hard-water supply line 30, drain line 31, salt-water or regenerating line 32, and service line 33. During the softening stage hard water entering from the supply line 30 passes through the softening tank and is delivered as soft water to the supply line 33.

After a period of use the green sand or softening mineral 21 will lose its effectiveness as a water softener due to the fact that it has taken up extensive amounts of elements, such as the calcium and magnesium referred to, and provision is therefore made for restoring the softening material to its original condition and effectiveness by passing therethrough a solution of sodium chloride, or brine. This stage of operation is known as regenerating the softening mineral. Whereas the hard water to be softened is generally

passed upwardly through the bed of softening material during the softening stage, the salt water is preferably passed downwardly through the bed of softening material during the regenerating stage. For the purpose of establishing a suitable source of brine or salt water, there is provided a brine tank 35 which may contain a bed 36 of sodium chloride or salt and a quantity of brine 37 which is preferably concentrated. This salt water or brine is drawn from the brine tank 35 through the brine pipe 32 and passed through the bed of softening mineral 21, and then wasted through the drain line 31.

After the regeneration of the softening mineral in the softening tank 20 I purge the tank and recondition the same for delivering soft water to the service line upon demand therein.

For controlling the various stages of operation of the softening apparatus, there is provided suitable control mechanism, one of the principal parts of which consists of a water motor or metering means designated generally at 40 adapted to control the duration of the softening stage according to the degree of hardness of the water passing through the apparatus, to automatically cause regeneration of the softening material, and to reestablish connections for the softening stage. The water motor 40 is preferably so connected in the system that all the hard water coming from the supply line passes through the motor during both the softening and the regenerating stages, and the control of the softening and regenerating stages is preferably made primarily dependent upon the amount of water passing through said motor so that this motor is really a water metering means, suitable provision being made for variation in the duration of the softening period according to the condition of the hard water which is to be treated by the softening apparatus.

The control mechanism comprises a control unit mounted upon the softening tank 20 and designated generally by reference character 42. This control unit includes most of the mechanism for controlling the operation of the water-softening apparatus and comprises a pump housing 43, valve plate 44, chamber and valve housings 45 and 46, and housing 47, all of which are preferably stacked upon one another, the cooperating surfaces being preferably parallel and their surfaces adapted to have water-tight connections one with the other, gaskets being provided between the cooperating surfaces if desired.

Referring particularly to Figs. 2, 3, 4, and 10, the upper chamber housing 46 which is preferably a casting, has formed therein chambers 51, 52, 53, 54, 55, and 56, and the lower chamber housing 45, which is also preferably a casting, has formed therein chambers 57, 58, 59, 60, 61, and 62. The hard-water supply line 30 is connected with chamber 51, the drain line 31 is connected with chamber 52, the brine or salt-water line 32 is connected with chamber 55, and the service line 33 is connected with chamber 56. The upper wall of the lower housing 45 is provided with ports by which connection is established between chambers in the upper and the lower housings, there being a port 65 for establishing communication between chambers 51 and 57, valved ports 66 and 67 for establishing communication between the upper chamber 52 and the lower chambers 58 and 59 respectively, port 68 between upper chamber 53 and lower chamber 59, valved port 69 between upper chamber 53 and lower chamber 60, valved port 72 between chambers 54 and 60, valved port 70 between chambers 55 and 61, and valved port 71 between upper chamber 56 and lower chamber 62. Provision is also made in the upper wall of chamber 61 for the reception of an injector nozzle 75 having suction openings 76 whereby fluids may be withdrawn from the chamber 61 upon down movement of a suitable power fluid through the injector nozzle, the purpose of this being described hereinafter.

The valve plate 44 is provided with valved inlet ports 80 and 81 for controlling the admission of water from chamber 57 to the water motor 40, and valved outlet ports 82 and 83 for controlling the discharge of water from the water motor 40 to chamber 60. The plate 44 also contains ports 85, 86, and 87 opening into the chambers 58, 59, and 62 respectively. Port 85 is connected through pipe 90 to a point in the softening tank 20 below the top thereof. Port 86 is connected with down pipe 91 of the distributor extending downwardly through the softening tank 20 and connected at its lower end with branch distributing pipes 92 having screened distributor caps 93 opening into the softening tank at a plurality of points. Port 87 is connected through pipe 94 to the upper part of the softening tank 20. A pressure pipe 96 is connected between the chamber 61 and water inlet valve 97 of the brine tank 35. In Fig. 10 pipe 96 is shown as connected with the bottom of chamber 61 but in practice it preferably takes off through the side wall as shown in Fig. 1. The pipes or passages 90 and 94 which are connected with the interior of the softening tank 20 may be lead to the tank 20 in any convenient manner but preferably the arrangement is such that they pass directly downwardly from chambers 58 and 62 which are in practice directly over the tank 20.

The valves above referred to for controlling the ports which connect chambers at the upper and lower housings 46 and 45 are controlled by a plate 100, which as shown in Figs. 2 and 5 is circular in outline, but which is shown diagrammatically in Fig. 10 as a line. The valves are each operative-

ly connected with the plate 100 and adapted to be moved into open or closed position according as the plate 100 is moved to its upper or lower position. The connection between one of the valves 72 and plate 100 is illustrated in Fig. 2 wherein it will be seen that the valve rod passes through the upper wall of the housing 46, a suitable stuffing box being provided at 101 to prevent the escape of fluid along the valve stem, either from the housing 46 into the housing 47, or vice versa. The connection between each of the valves and the plate 100 is similar to that illustrated for the valve 72.

The plate 100 has but two positions, its upper or softening position as shown in Figs. 2 and 10, and a down or regenerating position during which brine is passed through the water-softening tank to regenerate the softening mineral. As already stated the duration of the softening stage and the regenerating stage is controlled by the water motor 40 through which all hard water passes on its way to the water-softening tank.

The manner by which the water motor 40 controls and actuates the plate 100 will now be described. Referring to Fig. 2, it will be seen that the plate 44 is provided with a depending cylinder or sleeve 102 containing a reciprocating piston 103 mounted upon piston rod 104, the latter being guided by the piston and stuffing box 105. The valved ports 80, 81, 82, and 83 control the operation of the water motor. In the position of the valves illustrated hard water entering through the supply line 30 passes through chambers 51 and 57, and port 80 into the lower part of the water motor thereby moving the piston upwardly as indicated by the arrow. At the same time water in the upper part of the water motor is escaping through outlet port 82 into the chamber 60, whence the water passes to the water-softening tank or other part of the apparatus as will be more fully described hereinafter. At the top of its upward stroke the piston 103 comes into engagement with the valve levers 106 pivoted at 109 and actuates the same to reverse the position of the valves 80, 81, 82, and 83. Water coming from the supply line now passes through the port 81 into the upper part of the motor to move the piston downwardly, the water below the piston being forced out of the motor into the chamber 60 through the port 83. As the piston approaches the lower end of its stroke collar 107 carried by the piston rod 104 comes into engagement with the levers 106 to again reverse the position of the water motor valves. As shown in Fig. 2 the mechanism for actuating the inlet and outlet valves of the water motor is of a type which is adapted to actuate the valves quickly. The valve levers 106 and the valves are held in either of their operating positions by a spring 108 which is connected between the outer ends of the valve levers. Due to the lost motion connection between the levers 106 and the valves, there is no movement of the valves until the levers 106 have been moved past their dead center, after which the spring 108 snaps the valve levers 106 to their other position and quickly reverses the position of the inlet and outlet valves 80, 81, 82, and 83. The present invention thus provides a water motor which is accurate and reliable at all times, and free from the annoyance and uncertainty of operation which would result in motors liable to stoppage on dead center.

From the foregoing description it will be apparent that all the hard water passing from the supply line to the water-softening apparatus goes through the water motor 40 and causes actuation thereof, and advantage is taken of this to control the duration of the regenerating stage and the softening stage in accordance with the amount of hard water received from the supply line during each of these stages of operation. The control unit comprises mechanism within the housing 47 for controlling the duration of the water-softening and the regenerating periods of operation, such mechanism being actuated by the reciprocating movement of the water motor 40. Referring to Figs. 2, 5, 6, and 7 a plate 100 is shown in its upper or water-softening position. A unitary or a divided sliding bar 110 is mounted on the plate 100 in such a fashion that the bar may slide longitudinally of its own length, that is, horizontally, a suitable bracket 111 being provided to retain the bar 110 in position upon the plate 100. The piston rod 104 passes through apertures formed in the plate 100, bar 110 and bracket 111, and is provided in its upper end with a notch 112 having shoulders adapted to engage the bar 110 when the latter is moved horizontally into the path of these shoulders. The upper end of the piston rod 104 carries a head or plate 113 which is adapted, at certain times, to engage and lift the clutch arms 116 and 117 mounted respectively upon transverse shafts 118 and 119 disposed on opposite sides of the piston rod 104 and having their bearings in the side walls of the housing 47. As shown in Fig. 2, the head 113 is in engagement with the clutch arm 116, which may be termed the softening lever, and rocks the same back and forth about its axis. Spring 120 tends to move the lever 116 downwardly while the piston rod rocks the lever upwardly against the resistance of this spring. Carried upon the shaft 118 is a roller clutch 121 which is adapted to actuate clutch collar or housing 122 in a clockwise direction as viewed in Fig. 2. Rotation of the clutch collar 122 in a clockwise direction in virtue of reciprocatory movement of the water motor, progres-

sively advances a cam 123 fastened to the clutch collar 122. After a predetermined period of operation the cam 123 comes into engagement with a lever 125 the lower end of which passes through an opening in the bar 110, and rocks said lever to cause the bar to be moved horizontally to the left sufficiently to bring the bar into the notch 112 formed in the piston rod. On the next down stroke of the piston, the shoulder formed by the upper end of this notch 112 engages the bar 110 and carries the same downwardly, together with the plate 100 which is connected therewith.

The plate 100 is normally held in either its up or its down position by springs 126 guided upon arms which are pivoted upon the housing 47 at 127. As soon as the plate 100 is carried downwardly below a horizontal line passing through the pivots 127, the springs 126 snap the plate into its down or regenerating position and the bar 110 is carried along with the plate. Means is provided for causing the bar 110 to become disengaged from the notch 112 after the plate 100 has been moved to its down or regenerating position. Such means may consist of a lever 130 loosely mounted upon shaft 118, such lever having at one end a latterly extending finger adapted to engage and lift the softening lever 116. An arm or hook 131 depends from the other end of the lever 130 with its hooked portion lying in the path of movement of the plate 100 and so disposed that downward movement of the plate 100 results in rocking the lever 130 and advancing the clutch housing 122 and cam 123 sufficiently to permit the lever 125 to return to its original position, thus permitting the bar 110 to become disengaged from the notch 112. Spring 128 connected between the bar 110 and plate 100 tends to normally hold the bar 110 in its central position out of engagement with the notch 112. It is to be noted also that the raising of the softening lever 116, moves the same out of engagement with the head 113 and the softening lever is thus held inoperative during the regenerating stage.

The second clutch arm 117 which may be termed the regenerating lever is normally held inoperative during softening by means of a rod 134 which is engaged by the plate 100 when the latter is in its upper or softening position. When now the plate 100 is moved down to the regenerating position, as just described, the regenerating lever 117 is permitted to drop into engagement with the head 113 on the piston rod, and to be rocked thereby. Rocking of the regenerating lever 117 against the resistance of the spring 132 serves to progressively advance a clutch collar 135 in a counter-clockwise direction as viewed in Fig. 2, the shaft 119 carrying a roller clutch mechanism corresponding to that carried by the shaft 118. The clutch collar or housing 135 carries a cam 136 which, after a predetermined period of operation, engages the upper end of lever 137, the lower end of which lever cooperates with an opening in the bar 100, the arrangement being such that actuation of the upper end of lever 137 by the cam 136 causes the bar 110 to move horizontally to the right into the notch 112, so that on the next succeeding upward stroke of the piston, the rod 110 and plate 100 are carried upwardly. As in the downward movement of the bar 110 and plate 100, so also here, when the plate 100 is elevated above the line connecting the points 127, it snaps upwardly into the softening position. Such upward movement of the plate 100 raises the rod 134 and advances the clutch housing 135 and cam 136 carried thereon sufficiently to permit the lever to drop off the cam 136, thus restoring lever 137 to its original position and permitting spring 128 to withdraw bar 110 out of the notch 112. The upward movement of plate 100 thus results in disconnection of the bar 110 and notch 112. The action just described serves to move and hold the regenerating lever 117 out of engagement with the head 113 and, at the same time, to release the softening lever 116 so that the latter is now in position to be operated by the movement of the piston.

The amount of water passing through the water motor during the regenerating stage is ordinarily a great deal less than the amount of water passing during the softening stage. Moreover the amount of water passing during the regenerating stage is in preferably of more or less constant amount whereas the amount passing during the softening stage is varied according to the hardness of the water. Consequently if the movement of the regenerating lever 117 and the clutch collar 135 is such as to give a complete revolution of the clutch collar during the regenerating stage (as is preferably the case), then means must be provided to reduce the action of the softening lever 116 and its clutch collar 121 so that a complete revolution of this clutch collar will correspond to the passage of a much larger volume of water through the water motor 40. This is preferably accomplished by stopping the downward movement or follow of the softening lever 116 so as to reduce the movement thereof resulting from the up strokes of the piston 104. Referring particularly to Figs. 2 and 5, there is shown a shaft 140 rotatably mounted in a suitable bearing or box formed in the housing 47. Rigidly secured to the inner end of this shaft is an arm 141 having a lateral extension adapted to be moved into the path of the softening lever 116 and to stop the downward movement of the softening lever at various positions depending upon the position of the shaft 140. For example, if the arm 141 is horizontal the softening lever 116

will be permitted to follow the head 113 of the piston rod during the entire downward stroke of the piston, but if the arm 141 is adjusted upwardly, the lever 116 will be stopped or arrested at any desired point during its downward or follow movement, depending on the position of the arm 141. An indicating dial or lever 142 may be secured to the outer end of the shaft 140 in a position for convenient adjustment by the user of the water-softening apparatus, and preferably there are provided suitable indications or graduations whereby the control dial 142 may be readily and quickly set according to the degree of hardness of the water passing through the softening apparatus. If, for example, we have a softening tank containing about 2 cubic ft. of mineral, or of green sand, and we assume further that the green sand has an exchange capacity of 3,000 "grains" per cubic foot, then it is apparent that the total exchange capacity of the softening tank is 6,000 grains. If the hard water to be softened is of 20 "grains" of hardness then 300 gallons of water may be softened by the apparatus before the mineral is exhausted, but if, on the other hand, the water is of only 5-grain hardness then the apparatus is capable of softening 1,200 gallons of water before the mineral is exhausted. Obviously graduations or indicia may be placed upon or associated with the control dial so that the latter may be at once set in the proper position after one has determined the degree of hardness of the water to be softened. This feature of the invention whereby the apparatus may be quickly and easily regulated by the user is one of considerable importance when it is appreciated that the degree of hardness of water to be softened varies widely according to the locality in which the water softener is to be used, and that it is not practical to so adjust water softeners at the factory to operate satisfactorily under varying conditions of use. Means is preferably provided, as at 143, for locking the dial 142 in position after adjustment.

The construction of the various features of the present invention not yet described, may best be brought out in connection with the description of the following operation of the water-softening apparatus taken as a whole.

For the operation of the water-softening apparatus reference is made particularly to the diagrammatic showing in Fig. 10. As already stated all hard water enters the apparatus through the supply line 30 and passes through the chambers 51 and 57, and thence through the water motor 40 to the chamber 60. From this point on the passage of the water through the various chambers varies depending upon the particular stage of operation of the apparatus. Assuming that the apparatus is in its softening stage, then the plate 100 will be in its up position as shown in Figs. 2 and 10, and the ports 67, 72, and 70 will be closed, whereas the ports 69 and 71 will be open. There being a demand for soft water upon the service line 33, hard water passes from the supply line 30 to the chamber 60 as already described, thence by port 69, chamber 53, port 68, and chamber 59 to the down pipe 91 of the distributor which discharges the hard water into the softening tank 20 at the bottom thereof. Such hard water passing upwardly through the softening mineral becomes softened and passes from the top of the softening tank 20 through pipe 94, port 87, chamber 62, port 71, and chamber 56 to the service line 33. The path of the hard water during the softening stage is indicated by plain arrows in Fig. 10.

After a predetermined amount of water has passed through the water motor, such amount being regulated by the position of regulating dial 142, the water motor moves the plate 100 into its down or regenerating position. At such time the ports 66, 69, and 71 are held closed while the ports 67, 72, and 70 are open. The hard water flows from the supply line 30 through the motor 40 into the chamber 60, as heretofore, then through port 72, chamber 54, injector nozzle 75, and pipe 94 to the top of the softening tank 20. The flow of water through the injector nozzle withdraws fluid from the chamber 61 through the opening 76, and the chamber 61 being connected through the pipe 32 with the brine tank 35, brine is withdrawn from the brine tank through pipe 145, such brine then passing through pipe 32, chamber 55 into chamber 61. Such brine is withdrawn from the chamber 61 by the action of the injector and mixed with the hard water passing through the injector into the softening tank. This salt water mixture passes downwardly through the bed of softening material and regenerates the same. The outlet for the salt water is upwardly through the distributor pipe 91, chamber 59, port 67, and chamber 52 to the drain line 31. As already stated, the regenerating operation continues for a period of time determined by the amount of hard water which passes through the water motor 40 during this period, but it will be understood that the regenerating period is of sufficient duration to withdraw from the brine tank 35 a sufficient amount of salt water to completely regenerate the mineral in the softening tank 20. Provision is made, at the same time for purging or backwashing the softening tank 20. Such purging consists first in discontinuing the supply of salt water to the softening tank and then passing clear water through the softening tank to remove all trace of the salt water so that salt water will not be supplied to the supply line upon a subsequent demand therein. For the purpose of determining the

amount of brine to be withdrawn from the tank 35, the pipe 145 is provided with a vent 146 over which there is a shell or hood 147 mounted upon the pipe 145 at a point above the vent 146 and having one or more air holes 148 therein. Normally the salt water in the tank 35 is at the level indicated by reference character 37 in Fig. 1, such level being determined by the float 148 which controls the inlet of water through the valve 97. When the level of the brine falls, during the regenerating period, to the top of the vent 146, as indicated by line 149 in Fig. 1, then the suction is broken by the vent 146 to prevent further withdrawal of salt water from the brine tank. The valves being still in their regenerating position, nozzle 75 continues to act upon the chamber 61 and causes the withdrawal or sucking of air from the brine tank 35, which air mingles with the clear hard water passing into the softening tank. Such air is not carried out of the tank 20 by the water but is trapped in the upper part of the tank and utilized in a manner which will hereafter be pointed out. It is to be noted in connection with the regenerating operation that a check valve 150 is placed in the pressure pipe 96 so as to prevent air from entering pipe 96 from the brine tank and then passing into chamber 61 to thereby break the suction therein.

Upon the return of the plate 100 to its up or softening position the ports and valves are restored to the position shown in Fig. 10. There being no demand upon the service line, hard water flows into the chamber 60 and thence through port 69, chamber 53, port 68, chamber 59, distributor pipe 91, upwardly through softening tank 20, through pipe 94 and upwardly through the pipe 76 of the injector into the chamber 61. From this chamber the water passes through pressure line 96 into the brine tank 35 to replenish the same, such fresh hard water supplied to the brine tank 35 taking up salt from the body of undissolved salt contained in the brine tank. The pressure line 96 contains a restriction 151 which limits the amount of water that may pass into the pressure line 96. So long as water is flowing into the brine tank through the valve 97 the pressure in the pressure line 96 can not build up to a pressure equal to that in the supply line, and this is taken advantage of to further control the valve which governs the port 66. As shown in Fig. 10 the port 66 is closed by a valve 155 the stem of which is in two sections designated 156 and 157 respectively. The valve 155 and lower stem 156 are supported by the flexible wall of an expansible chamber which, in the present case, may consist of a rubber diaphragm 158. A spring is provided at 159 tending to normally hold the valve 155 in its up or open position. During the regenerating period the upper valve stem 157 holds the valve 155 closed, but when the plate 100 is raised for the softening stage the upper stem 157 is withdrawn from the lower stem, thus leaving the valve 155 under the control of the spring 159 and of the pressure within the expansible chamber. The expansible chamber 160 is connected by means of pressure line 161 with the pressure line 96. Consequently upon the elevation of the plate 100 to restore the valves to their softening position, and during the period that the brine tank is being refilled with water, the expansible chamber 160 is under a reduced internal pressure, insufficient to resist the opening of the valve 155 by the water in chamber 58, and consequently valve 155 may be opened, the water in chamber 58 being under the pressure of the supply line. It will thus be seen that immediately upon the elevation of the plate 100 at the termination of the regenerating stage, the various valves controlled by the plate 100 will be set for the passage of water through through the tank 20 in a direction for softening, that is, the water will flow upwardly through the softening mineral. There being no demand upon the service line the pressure of the water in the tank 20 will be sufficient to unseat the valve 155 causing a flow of water through pipe 90, chamber 58, passage 66, and chamber 52, to the drain line 31, and this flow of water will carry with it all excess air below the level of the orifice for pipe 90, indicated at 157, leaving in the tank such air as may be trapped above the line 157. The upward flow of water through the softening mineral to the drain constitutes a purging operation which removes from the softening tank 20 any hard water or other liquid that may remain in the tank upon the termination of the regenerating period, and leaves the softening tank filled with soft water so that immediately upon a demand in the service line 33, soft water will be obtained from the softening tank instead of hard water as is the case in prior forms of water-softening apparatus. The flow of water through pipe 90 to drain may continue during the period of low pressure in the pressure lines 96 and 161, but after the liquid level in the brine tank 35 has been restored to its original level and the valve 97 has been closed by the float 148, pressure builds up in the pressure lines 96 and 161 to such a value as to hold the valve 155 closed, thus preventing further flow of water to the drain line. It will be understood that the duration of the low pressure in the pressure lines 96 and 161 is dependent largely upon the extent of the restriction 151 in the pressure line 96 and that the low pressure period may be controlled as desired by varying this restriction.

In order that the user may not be deprived of an adequate supply of soft water during the regenerating period, during which period the port 71 is closed, an air

pressure tank 170 is connected in the service line 33, as indicated generally in Fig. 10 and more in detail in Fig. 8. This pressure tank which may be of any suitable capacity, for example 50 gallons, contains a quantity of soft water under pressure this quantity of water being normally adequate to supply the temporary needs of the user during the regenerating stage of operation of the water-softening apparatus. Satisfactory results have been secured with an air pressure tank about two-thirds full of water under an air pressure of say fifty pounds. When the valves of the water-softening apparatus are restored to their water-softening position the first effect of a demand upon the service line 33 is to carry the air which is entrapped in the upper part of the softening tank through the line 33 into the pressure tank 170. The construction and arrangement of the softening tank 20 and associated parts is preferably such that the amount of air supplied to the air pressure tank after each regenerating operation is equal to or slightly more than the requirements of the air pressure tank. However should too much air be supplied to the air pressure tank 170 the volume of water therein may be reduced to such a point that the air pressure tank is inadequate to supply the demand on the service line during regeneration. To maintain the proper proportion of water and air in the tank there is provided an air pressure release for releasing surplus air from the tank, such pressure release mechanism being responsive both to the pressure of the air in the tank and also to the level of the water therein.

Referring particularly to Fig. 8, the air release mechanism comprises a series of chambers 172, 173, and 174 having ports through which air may pass from the interior of the tank to the atmosphere. Port 175 connecting chambers 173 and 174 is controlled by a valve 176 which is actuated by a float 177, the arrangement being such that if the water level is too low by reason of an excess of air, the port 175 will be held open. A second port 180 connecting chambers 172 and 173 is controlled by a valve 181 which responds to pressure in an expansible chamber 182 such expansible chamber being connected with the interior of the tank through pressure pipe 183. If for example it is desired to maintain the water in the tank at a pressure of fifty pounds or more, then the valve 181 is adjusted so that any pressure of fifty pounds or more within the air pressure tank 170 will hold the valve 181 open. If at the same time the water is at the proper level as shown in Fig. 8 no air will escape to the atmosphere because the port 175 is held closed by the valve 176. But, should the water level fall below the level shown in Fig. 8, (the pressure still being adequate to hold the valve 181 open) the valve 176 will be opened by the float 177 to permit the escape of air to the atmosphere through ports 175, 180, and 184. Soft water entering the tank 170 from the softening tank 20 replaces the air thus discharged to atmosphere and eventually closes the valve 176 when the proper water level is attained in the air pressure tank.

It will be seen from the foregoing that the present invention provides a water-softening apparatus comprising an air pressure tank for supplying the normal soft-water requirements of the user during the regenerating period and means for automatically maintaining the air pressure tank in operating condition both as regards the amounts and pressures of the water and of the air therein.

Under some conditions it may be desired to dispense with the air-pressure tank 170, and when the air-pressure tank is thus omitted, immediately provide a by-pass for by-passing hard water from the supply line 30 to the service line 33 during the regenerating period. Such a by-pass valve is indicated generally at 190 in Figs. 9 and 10. It has been pointed out in connection with the description of the operation of the apparatus as a whole that during the regeneration period there is a partial vacuum in the chamber 61. The pressure pipe 96 being connected with the chamber 61, there is of course also a reduced pressure in the pressure lines 96, 161, and 191 which are all in communication with one another. The by-pass comprises valve 192, valve seat 193, and spring means 194 tending to hold the valve to its seat. The valve stem is also connected with the flexible wall 195 of an expansible chamber 196 which is connected through pressure pipes 191, 161, and 96 with the chamber 61. During the regenerating period the pressure in the expansible chamber 196 is insufficient to hold the valve 192 closed against the pressure of the spring 194 and the pressure of the water in the supply line. Consequently water may pass from the supply line to the service line.

The present invention comprises a number of advantageous features of construction not heretofore described in connection with the operation of the apparatus, and these will now be pointed out.

The distributing system for the softening tank 20 comprises a down pipe 91, branch distributing pipes 92, and distributor caps and protective screens 93. Referring to Figs. 1 and 2, a feature of the construction is that the distributing system may be removed for replacement or repair independently of the other parts of the apparatus, the removal being effected by unfastening the parts 92 and 93 which are accessible from the outside of the softening tank and by withdrawing these parts, together with the down pipe 91

from the softening tank. As shown in Fig. 2 the down pipe 91 has a taper fit with the casting 43 to permit easy removal.

Another feature of construction is the connection of the softening tank 20 and the brine tank 35 to form a unitary apparatus. As best shown in Fig. 1 the tanks 20 and 35 are bound together at their bottom by means of a continuous strap 200, the middle portions of the strap being brought together and fastened by means of a suitable bolt or other connection 201. The strap 200 may be drawn together to various degrees by the fastening device 201 but the preferred construction is one in which the straps meet between the tanks 20 and 35 to completely surround each of these tanks, a spacing block being provided at 202 for spacing and reinforcing the tanks.

Still another feature of the present apparatus resides in the washing with fresh water of certain parts in the brine tank which are exposed to the action of the brine, to prevent such parts from becoming corroded or incrusted to such an extent as to interfere with their proper operation. For example the valve mechanism of the valve 97, which embodies several movable parts, is liable to become corroded by the action of the brine thus causing the valve to stick and become inoperative. Likewise the float 148 may become incrusted so that its weight will be changed, and so also the ports 146 and 148 may become clogged owing to incrustation formed thereon. The present invention contemplates means for spraying these parts with fresh water to remove any brine and to prevent corrosion or incrustation. This means is shown in Fig. 1 as a pipe 205 having branches or openings 206, 207, 208, and 209 by which water entering the brine tank through pipe 96 is caused to flow over the valve and other operating parts to cleanse the same. The means for washing the parts may take various forms and is not limited to the form illustrated.

A further feature of the invention is the arrangement of the ports and passages, the control valves therefor, the water motor, and the control mechanism associated with the water motor and with the valves, as a compact unitary structure so constructed that it may be mounted as a unit in the opening of the water-softening tank, although it will be understood that this unit may advantageously be mounted in other positions with reference to the water-softening apparatus than the position on the tank as illustrated in the drawings. The unitary control unit may be readily removed or disconnected from the water-softening apparatus for replacement or repair, thus making it possible to render rapid and satisfactory service with mechanics of but ordinary skill and experience and making it unnecessary to send a highly skilled mechanic to the apparatus for the purpose of making adjustments or repairs. After the control unit has been removed from the water-softening tank it may be returned to the factory and repaired at relatively small expense. It may be pointed out in this connection, that the control mechanism contained within the housing 47 is contained in oil thus insuring proper lubrication and operation of the parts for long periods of time and without the necessary and frequent inspection of lubrication.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. Water-softening apparatus comprising a softening tank containing water-softening mineral; and means for regenerating said mineral, said means comprising a tank of salt water, means for passing salt water from said tank to the softening tank, and means responsive to the level of salt water in the salt water tank for admitting air to said passing means to arrest the withdrawal of salt water from said tank, and provision for flushing said last mentioned means with fresh water.

2. Water-softening apparatus comprising a softening tank containing water-softening mineral; and means for regenerating said mineral, said means comprising a tank of salt water, means for passing salt water from said tank to the softening tank, and means responsive to the amount of salt water withdrawn from the salt water tank for arresting the withdrawal of salt water therefrom, a pipe for supplying refill water to said tank, said pipe terminating closely adjacent said last means to direct the refill water thereto in order to flush the parts above the surface of the salt water.

3. Water softening apparatus comprising a softening tank containing water-softening mineral; and means for regenerating said mineral, said means comprising a tank of salt water, means for lifting salt water by suction from the salt water tank and delivering it to said softening tank, means for refilling said salt water tank and having a connection to the suction side of the lifting means, and valve means in said refilling means providing for flow of refilling water therethrough to the salt water tank and operable to prevent the creation of suction by said lifting means on the refilling means and thus prevent flow in said refilling means from said salt water tank.

4. Water-softening apparatus comprising a softening tank containing water-softening mineral; and means for regenerating said

mineral, said means comprising a source of salt water, and means for lifting, by suction, water from said source and delivering it to the softening tank, said last-mentioned means comprising a pipe in said source of said salt water through which water from said source is lifted, said pipe having an opening for breaking the suction to arrest the withdrawal of the water from the salt water source, and a casing around said pipe opening, and extending below said opening and connected to said pipe above said opening.

5. Water-softening apparatus comprising a softening tank having connections adapted to be connected with supply, service, regenerating and drain lines, a source of regenerating liquid, means for passing regenerating liquid from said source through said tank in one direction, and means for thereafter passing hard water in the opposite direction through said tank to drain, and a spring controlled valve in said last means adapted to close at a predetermined pressure for controlling the duration of the passage of hard water to drain.

6. Water-softening apparatus comprising a softening tank having connections adapted to be connected with supply, service, regenerating and drain lines, means for passing regenerating liquid through said tank and for thereafter passing hard water in a certain direction through the tank to purge the same of regenerating liquid, means for purging the tank of hard water in an opposite direction prior to a demand on the service line, and means for automatically controlling the passage of regenerating liquid in accordance with a predetermined level of the regenerating liquid supply.

7. Water-softening apparatus comprising a softening tank having connections adapted to be connected with supply, service, regenerating and drain lines, a source of regenerating liquid, means for passing regenerating liquid from said source through said tank, and means for purging said tank by a flow in the same direction as the flow of the water being softened and replacing same with soft water whereby to condition the tank to supply soft water to the service line immediately upon a demand therein, the aforesaid two means comprising a valve positively controlled at all times and an automatic valve positively controlled but part of the time.

8. Water-softening apparatus comprising a water-softening tank, means for passing regenerating liquid through said tank, and means for purging regenerating liquid from said tank and for trapping therein a quantity of air.

9. Water-softening apparatus comprising a water-softening tank, a service line connected thereto, a water storage tank connected in said line, means for passing regenerating liquid through said tank, and means for purging regenerating liquid from said tank and for trapping therein a quantity of air in such position as to be carried to the storage tank upon demand in the service main.

10. Water-softening apparatus comprising a water-softening tank, a service line connected thereto, a water storage tank connected in said line, means for passing regenerating liquid through said tank, and means for purging regenerating liquid from said tank and for trapping therein a quantity of air in such position as to be carried to the storage tank upon demand in the service main, and means for wasting from said storage tank excess air accumulated therein.

11. Water-softening apparatus comprising a water-softening tank, a service line connected thereto, a water storage tank connected in said line, means for passing regenerating liquid through said tank, and means for purging regenerating liquid from said tank and for trapping therein a quantity of air in such position as to be carried to the storage tank upon demand in the service main, and means for automatically controlling the water level in said storage tank.

12. In a water-softening apparatus, a water storage tank adapted to have a quantity of trapped air therein, means for supplying air and water to said tank, and means for maintaining said trapped air at a predetermined pressure and automatically wasting excess air from said tank to maintain a proper water level therein.

13. In a water-softening apparatus, a water storage tank adapted to have a quantity of trapped air therein, means for supplying air and water to said tank, and means responsive to both air pressure and water level in said tank for wasting excess air therefrom.

14. Water-softening apparatus comprising a water softening tank, means including ports, passages and valves operable to a water-softening position to cause the passage of water through the tank during the water-softening stage, and operable to a regenerating position to cause regenerating fluid to pass through said tank during the regenerating stage, a storage tank for regenerating fluid adapted to be operatively connected with the softening tank during the regenerating stage, means including a conduit for supplying fluid to the storage tank during the softening stage to replenish the storage tank, and means responsive to the fluid pressure in said conduit for controlling one of said valves.

15. Water-softening apparatus comprising a water-softening tank adapted to be connected in hard water and in service lines, valves for controlling the operation of said apparatus and the supply of water to the service line, a storage tank adapted to contain

regenerating fluid, and to be connected with the softening tank to supply regenerating fluid thereto, means including a conduit for replenishing the storage tank with fluid, and means responsive to the fluid pressure in said conduit for controlling one of said valves.

16. In a water-softening apparatus, a tank having water-softening material therein; and means for directing water through said water-softening material to provide soft water and for regenerating said material said means comprising chambers having ports and valves for said ports, said chambers being formed in a plurality of stacked castings providing a reciprocating piston housing, said castings being rigidly secured together along division lines at right angles to the piston axis.

17. In a water-softening apparatus, a tank having water-softening material therein; and means for directing water through said water-softening material to provide soft water and for regenerating said material said means comprising two superimposed castings having flat cooperating surfaces and each having formed therein chambers and ports for the passage of water.

18. In a water-softening apparatus adapted to be connected with supply, service, drain and regenerating lines, a tank having water-softening material therein; and means for directing water through said water-softening material to provide soft water and for regenerating said material said means comprising tow superimposed castings having flat cooperating surfaces and each having formed therein chambers and ports for the passage of water, and one of said castings having means for connecting certain chambers with the lines.

19. In a water-softening apparatus adapted to be connected with supply, service, drain and regenerating lines, a tank having water-softening material therein; and means for directing water through said water-softening material to provide soft water and for regenerating said material said means comprising two superimposed castings having flat cooperating surfaces and each having formed therein chambers and ports for the passage of water, connecting means for connecting said chambers with said lines, all said connecting means being carried by one of said castings.

20. In a water-softening apparatus, a water-softening tank, means providing ports and passages for the flow of water through said apparatus, a water motor operatively connected in one of said passages and adapted to be operated by the flow of water therethrough, said water motor comprising a reciprocable piston member, and means for controlling the flow of water through the water motor, said last-mentioned means being adapted to receive its initiatory movement from the movement of the piston but to complete its movement independently of the piston.

21. Water-softening apparatus comprising a water-softening tank, means providing ports and passages for the flow of water through the apparatus, water metering means operatively connected in one of said passages and responding to the flow of water therethrough for controlling the operation of the water-softening apparatus to provide a water-softening period of operation and a regenerating period of operation, a plurality of mechanisms operable alternately by said water metering means for controlling the duration of said water-softening period and of said regenerating period, and means operable by the user of the water-softening apparatus for adjusting the operation of one of said mechanisms whereby to vary the duration of the period controlled thereby.

22. Water-softening apparatus comprising a water-softening tank, means providing parts and passages for the flow of water through the apparatus, means operatively connected in one of said passages and responding to the flow of water therethrough for controlling the operation of the water-softening apparatus to provide a water-softening period of operation and a regenerating period of operation, a plurality of mechanisms operable independently of one another, one for controlling the duration of the water-softening period and another for controlling the duration of said regenerating period.

23. A water-softening apparatus comprising a softening tank adapted to contain water-softening material, and means for distributing water within the tank, comprising a main water pipe extending through said tank and a distributing head connected thereto, said head being removable from the exterior of the tank.

24. A water-softening apparatus comprising a softening tank adapted to contain water-softening material, and means for distributing water within the tank, comprising a main water pipe within the tank and a distributing head comprising a cluster of branch pipes connected thereto, said cluster being removable from the exterior of the tank.

25. In a water-softening apparatus, a storage tank adapted to contain a regenerating fluid to be drawn off and supplied to the softening apparatus, means for admitting water to the tank to replenish the supply of fluid therein, means for controlling the withdrawal of regenerating fluid and the admission of water to said tank, and means for flushing one of said last-mentioned means with fresh water whereby to prevent the incrustation or corrosion of the same.

26. In a water-softening apparatus, in combination, a pressure storage tank adapted

to store a quantity of water therein under air pressure, and means responsive to both the pressure of the air in said tank and the level of the water therein for venting surplus air to the atmosphere.

27. In a water-softening apparatus, in combination, a pressure storage tank adapted to store a quantity of water therein under air pressure, and means responsive to both the pressure of the air in said tank and the level of the water therein for venting surplus air to the atmosphere, said means comprising a plurality of ports arranged in series and adapted to be controlled by valves, one of said valves being controlled by the level of the water in said tank and the other being controlled by the air pressure therein.

28. Water-softening apparatus comprising a water-softening tank, means providing for the flow of water through the apparatus, water motor means operatively associated with said means and responding to the flow of water therethrough for controlling the operation of the water-softening apparatus to provide a water-softening period of operation and a regenerating period of operation, a plurality of mechanisms operable alternately by said water motor means, one for controlling the duration of the water-softening period and the second for controlling the duration of the regenerating period, and manually operable means for adjusting the effect of said water motor means on said one mechanism while the adjustment of said second mechanism remains constant.

29. Water-softening apparatus comprising a water-softening tank, means providing for the flow of water through the apparatus, water motor means operatively associated with said means and responding to the flow of water therethrough for controlling the operation of the water-softening apparatus to provide a water-softening period of operation and a regenerating period of operation, a plurality of mechanisms operable alternately by said water motor means, one for controlling the duration of the water-softening period and the second for controlling the duration of the regenerating period, manually operable means for adjusting the effect of said water motor means on said one mechanism while the adjustment of said second mechanism remains constant, and means automatically operated by said one mechanism at the end of the water-softening period for starting operation of said second mechanism by said water motor means.

30. Water-softening apparatus comprising a water-softening tank, means providing for the flow of water through the apparatus, water motor means operatively associated with said means and responding to the flow of water therethrough for controlling the operation of the water-softening apparatus to provide a water-softening period of operation and a regenerating period of operation, a plurality of mechanisms operable alternately by said water motor means, one for controlling the duration of the water-softening period and the second for controlling the duration of the regenerating period, said water motor means comprising a reciprocating member, each of said mechanisms having a device operable step by step by said reciprocating member, said one mechanism which controls the water-softening period having a manually adjustable stop for controlling the amount of movement of its operable device during each reciprocation of the said reciprocating member, means controlled by said one mechanism for automatically starting the operation of said second mechanism at the end of the water-softening period, and means controlled by said second mechanism for automatically starting the operation of said first mechanism at the end of the regenerating period.

31. Water-softening apparatus comprising a softening tank having connections adapted to be connected with supply, service, regenerating and drain lines, a source of regenerating liquid, means for passing regenerating liquid from said source through said tank, means for purging said tank of regenerating liquid by a flow in a downward direction and then purging with a flow of soft water in an upward direction whereby to condition the tank to supply soft water to the service line immediately upon a demand therein, means for replenishing said source, and means automatically controlled by the replenishing operation for controlling the duration of said purging.

In testimony whereof I hereto affix my signature.

ANTHONY G. HORVATH.