Aug. 14, 1962 J. RUDELICK 3,049,239

FLUID FLOW CONTROL SYSTEM

Original Filed March 17, 1958 2 Sheets-Sheet 1

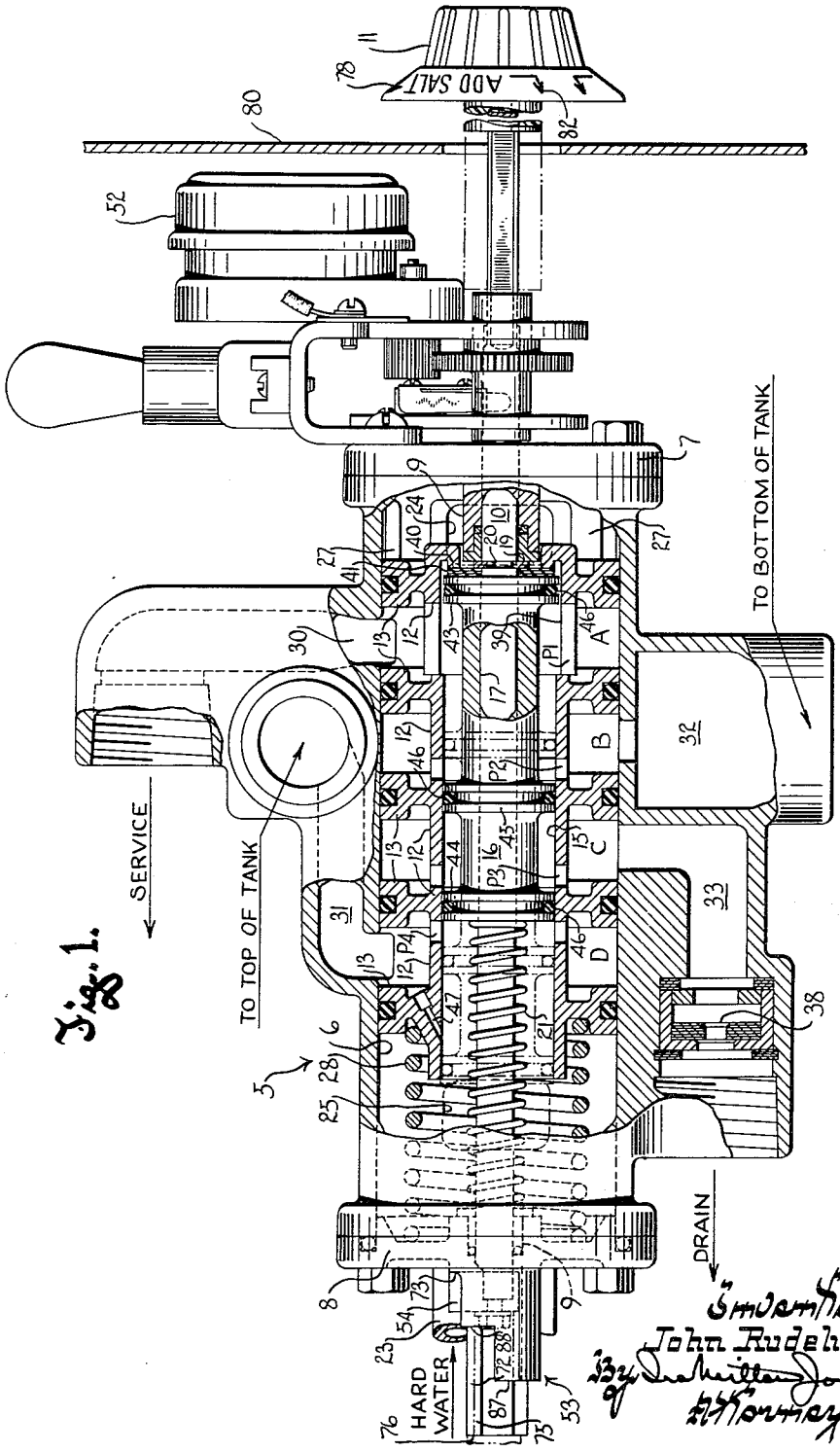


Fig. 1.

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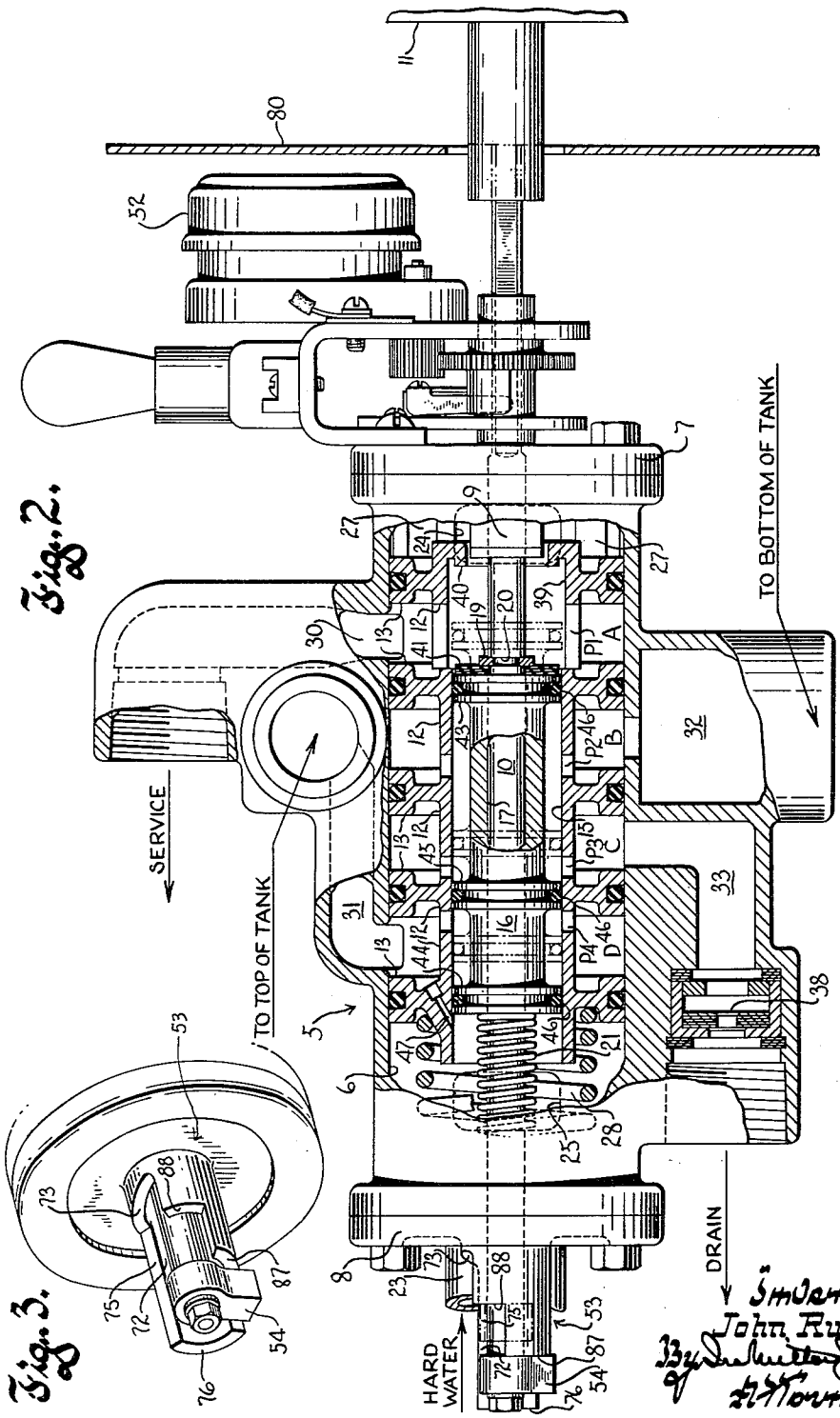


Fig. 2.

Fig. 3.

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United States Patent Office 3,049,239 Patented Aug. 14, 1962

3,049,239

FLUID FLOW CONTROL SYSTEM

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Original application Mar. 17, 1958, Ser. No. 722,093, now Patent No. 2,989,988, dated June 27, 1961. Divided and this application Mar. 4, 1960, Ser. No. 12,795

1 Claim. (Cl. 210—275)

This invention relates to fluid flow control valves, and like my copending application Serial No. 722,093 filed March 17, 1958, now Patent Number 2,989,988 of which this application is a division, has more particular reference to control valves of a type suited especially, though not necessarily exclusively, for use with water conditioning and treating apparatus such as water softeners.

As is well known water softeners comprise a tank containing a base exchange material which must be regenerated from time to time to preserve its efficacy. For that purpose, a water softener is usually provided with control valve means by which raw or unsoftened water is normally routed through the softener tank and thereafter made available to the desired service lines. While some of these control valves are designed to function entirely automatically, this invention concerns a less expensive type of control valve which, for example, is ideally suited for use with softeners of the salt-in-head type, and which features simplicity of construction and an arrangement of spool controlled ports such as to adapt the valve to either manual operation, or semi-automatic operation in the manner described and claimed in my aforesaid copending application Serial No. 722,093.

A salt-in-head type water softener is one in which the salt employed to effect regeneration is charged directly into the top of the softener tank. For this purpose, salt-in-head softeners are always provided with a removable top cover and, of course, the softener tank must be shut off from the raw water supply and soft water service lines whenever the cover is to be removed to enable salt to be charged into the softener.

The primary purpose of this invention resides in the provision of an improved fluid flow control valve for water softeners of the character described, and which valve features a body with a series of passages and ports arranged in such a way that a spool slidable axially in the body between four operating positions effects normal service operation of the softener in one extreme position of the spool, closes off the softener from service and supply lines in the other extreme or add salt position of the spool, and respectively effects brining and backwashing in two intermediate positions during stepwise return of the spool to its service position.

More specifically, it is a purpose of this invention to provide a control valve for water softeners and the like wherein three operating positions of the spool are spaced different distances in one direction from a service position of the spool and each is defined by means which holds the spool against axial return movement toward its service position but which is releasable as a consequence of rotation of a part connected with the spool through a predetermined angle.

With the above and other objects in view which will appear as the description proceeds, this invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described and more particularly defined by the appended claim, it being understood that such changes in the precise embodiment of the hereindisclosed invention may be made as come within the scope of the claim.

The accompanying drawings illustrate one complete example of the physical embodiment of the invention constructed according to the best mode so far devised for the

practical application of the principles thereof, and in which:

FIGURE 1 is a side elevational view of the control valve of this invention, parts thereof being broken away and shown in longitudinal section;

FIGURE 2 is a view similar to FIGURE 1 but showing the control valve in another position; and

FIGURE 3 is a fragmentary perspective view of the rear portion of the valve.

Referring now more particularly to the accompanying drawings, in which like reference characters have been applied to like parts throughout the several views, the numeral 5 generally designates the body of the control valve of this invention. The body is of hollow construction and formed to provide an elongated cylindrical chamber 6 opening to the front and rear ends of the body. Detachable front and rear covers 7 and 8, respectively, are provided to close the opposite ends of the chamber 6 and these covers have cenrtal holes providing coaxial bearings 9 concentric to the chamber 6 to endwise slidably receive an operating stem 10. The stem projects entirely through the covers 7 and 8 to the exterior of the body at each end thereof, and it has a knob or dial 11 fixed to its forward extremity.

The endwise abutting hubs 12 of a number of annular coaxial inserts or glands 13 having their peripheries in sealing engagement with the wall of chamber 6 define a bore 15 in which a spool type control plunger 16 is endwise slidably received. The spool or control plunger 16 has a bore 17 extending lengthwise therethrough to rotatably receive the operating stem 10. The stem, however, is connected to the spool to move back and forth therewith but is free to rotate relative to the spool and to the valve body.

This connection between the spool and the operating stem comprises a C-washer 19 sprung into a circumferential groove 20 in the stem adjacent to the front end of the spool, where it is cooperable with the front of the spool to translate rearward endwise motion of the stem into corresponding rearward motion of the spool in its bore. A coiled compression spring 21 encircling the rear portion of the stem and confined between the rear cover 8 and the rear end of the spool at all times urges the spool toward engagement with the C-washer stop 19 on the opposite end portion of the stem. Consequently, the engagement of the C-washer 19 on the front portion of the stem with the adjacent front end of the spool constrains the spool to slide rearwardly with the stem upon manual actuation thereof, while the compression spring 21 acting upon the rear of the spool and holding its front end engaged with the abutment 19 assures forward endwise motion of the spool and stem in unison.

At its rear, the body is provided with an inlet 23 for water to be softened, and this inlet is part of a manifold (not shown) extending along the far side of the body and having branches opening to the chamber 6 through front and rear ports 24 and 25, respectively, adjacent to the ends of the bore 15.

The rim portions of the annular inserts or glands 13 are held spaced apart substantially uniform distances along the wall of chamber 6 with which they have sealing engagement, by means of the endwise abutting hubs 12 on the inserts. Moreover, the group of inserts is located and firmly held at a predetermined position intermediate the ends of the chamber 6, by means of inwardly projecting abutments 27 on the front cover 7 which define the forward position of the group of inserts, and a relatively strong compression spring 28 confined between the rear cover 8 and the rearmost insert 13. Consequently, the inserts or glands in the present case cooperate with the wall of the chamber 6 to define four axially spaced annular chambers A, B, C and D reading from front to rear

of the body. A series of circumferentially equispaced notches through the hubs of the inserts provide ports P1 in radial communication with the chamber A, P2 in communication with the chamber B, P3 in communication with the chamber C, and P4 in communication with the chamber D.

The valve body 5 is provided with four control passages, namely a service passage 30, a first tank passage 31, a second tank passage 32, and a drain passage 33. The service passage 30 leads to the annular chamber A, and its outer end is adapted to have a service line connected thereto. The first tank passage 31 leads to the annular chamber D, and its outer end may be connected by a pipe with the upper portion of a water softener tank. The second tank passage 32 leads to the annular chamber B, and its outer end may be connected by a pipe with the bottom portion of a water softener tank. The drain passage 33 leads to the annular chamber C and its outer end is adapted to be connected with a drain line. In addition, the drain passage 33 has a flow metering restriction 38 therein to limit the rate of flow of waste fluid from the softener tank to the drain line.

The hub of the foremost insert or gland 13 has a slightly enlarged bore 39, and it has an inturned annular flange on its front end providing an annular valve seat 40 which encircles the operating stem 10 and faces rearwardly to be engageable by the front end of the spool 16 to close off communication between the forward inlet port 24 and the front end of the bore 15. If desired, a washer of rubber or other elastic material may be confined between the stop 19 on the stem and the front end of the control spool 16 to provide a sealing disc 41 to engage the seat 40 and assure against leakage of water rearwardly past the seat when the control plunger or spool 16 is in its normal position seen in solid lines in FIGURE 1. Consequently, the engagement of the seat 40 by the front of the spool defines the normal position of the spool, toward which it is yieldingly urged by the spring 21.

The control plunger has three lands or circumferential enlargements thereon, a front land 43, a rear land 44, and an intermediate land 45, somewhat closer to the rear land than to the front land. Each of these lands has a circumferential groove therein to retain an O-ring seal 46, and these seals fit snugly but slidably inside the hubs of all of the inserts 13 except that of the foremost insert having the larger bore 39.

In its normal or soft water position seen in solid lines in FIGURE 1, the lands of the control plunger or spool 16 are so located that the rearmost land 44 is positioned intermediate the ports P3 and P4, the intermediate land 45 is positioned intermediate the ports P2 and P3 and the foremost land 43 is forwardly of the ports P1. Consequently, the service passage 3 is closed off from the inlet port 24 at the front of the valve body but is communicated with the tank passage 32 through ports P1 and P2. At this time also the drain passage 33 is closed by the lands 44 and 45 but the tank passage 31 is in communication with the rear inlet port 25 through the ports P4.

When the control valve of this invention is connected with a salt-in-head type water softener with the passage 31 communicating with the top of the tank and the passage 32 with the bottom of the tank, water to be softened enters the valve body through the rear inlet port 25 and flows into the hub of the axially rearmost gland 13 and out of its ports P4 into the chamber D and tank passage 31 from whence it may flow downwardly through the conditioner tank to be softened therein. The softened water issues from the bottom of the tank and is returned to the chamber B of the valve body through tank passage 32, and from chamber B it flows radially inwardly through ports P2 and then forwardly in the bore along the space between the lands 43 and 45 to issue from the ports P1 from whence it enters the chamber A and is free to

flow into the service passage 30 whenever a service tap is opened.

It is a feature of the control valve of this invention that raw or unsoftened water is made available to the service passage 30 whenever the control plunger or spool 16 is shifted out of its soft water position shown in solid lines in FIGURE 1, so that water from the source may be drawn at any time during regeneration. This feature results from the fact that the service passage 30 is communicated with the front inlet port 24 through the valve seat 40 and the enlarged bore 39 in the hub of the foremost gland 13 as soon as the spool 16 is moved away from its normal position.

When the water softener with which the control valve of this invention is used requires regeneration, the control spool 16 must be shifted axially rearwardly to a defined rearmost position shown in broken lines in FIGURE 1. This is effected manually by the operator of the valve through the exertion of a rearward force on the control knob 11.

In the rearmost position of the spool 16, the front land 43 thereof is interposed between the ports P1 and P2, the intermediate land 45 is at a location just rearwardly of the ports P4 but between them and the mouth of a restricted metering passage 47 which leads through the rear portion of the hub of the rearmost gland 13 to the chamber D, and the rearmost land 44 is positioned just inside the rear end of the bore, behind the mouth of the metering passage 47.

This position of the valve may be termed a shut-off position at which the water softener tank is closed off from the water source and the service lines, although the service passage 30 is in open communication with the front inlet port 24 through the ports P1 and the now open valve seat 40 to enable hard water to be drawn from any of the service taps when desired. In the shut-off position of the spool described, the softener tank is vented by the communication of both tank passages 31 and 32 with the drain passage 33, and the operator may safely remove the top cover of a salt-in-head type water softening tank (not shown) and add the proper quantity of salt thereto. When salt has been charged into the top of the tank the operator may then secure the cover of the tank in position and thereafter manually actuate the valve to initiate regeneration.

Such regeneration is commenced when the control spool 16 is shifted forwardly to a defined position shown in solid lines in FIGURE 2, with its front land 43 located just rearwardly of the service ports P1, the intermediate land 45 located intermediate the ports P3 and P4, and the rearmost land 44 interposed between the ports P4 and the mouth of the restricted metering passage 47. The metering passage 47, which is spaced rearwardly from the ports P4 and near the rear end of the hub of the rearmost gland or insert 13, serves as an alternate port for the tank passage 31. It now communicates the tank passage 31 with the open rear portion of the bore 15 and hence with the rear inlet port 25 so that unsoftened water flows into the tank passage 31 for delivery to the top of the softener tank, to wash over the salt charged thereinto. The resulting brine flows downwardly through the water softening tank in contact with the base exchange material therein and issues from the bottom of the tank for return to the chamber B in the valve body through the tank passage 32 thereof. Inasmuch as ports P2 and P3 are now in communication with one another, the effluent is directed into the drain passage 33 for flow to a suitable drain through the metering orifice 38 in the drain passage. Note that hard or unsoftened water is made available to service in this position of the control spool 16, by reason of the fact that the service passage 30 is in communication with the front inlet port 24 through the annular valve seat 40 and the port P1.

The valve is kept in the position just described for a

period of time long enough to dissolve all of the salt in the top of the tank, and is preferably thereafter maintained in said position for an additional period during which brine is rinsed out of the mineral bed in the most efficacious manner, that is, by downflow of fresh water through the softener tank. These brining and rinsing operations of course take place at a slow rate due to the metering effect of the restricted passage 47.

After all of the salt has been converted into brine and flushed through the water softener tank, and the brine has been substantially completely rinsed out of the mineral bed, the control spool 16 may be moved forwardly to a defined backwash position seen in broken lines in FIGURE 2, to effect more rapid but reverse flow of fresh water through the conditioner tank for backwashing. In the backwash position of the spool, its lands provide communication between the tank ports P3 and P4, and also communicate ports P2 with the front inlet port 24 around the front land 43 and through the still open valve seat 40. As a result, fresh hard water entering the front inlet port 24 flows through the valve seat 40, around the land 43, and out of ports P2 into the tank passage 32 leading to the bottom of the water softener tank. The fresh hard water thus introduced into the bottom of the softener tank flows upwardly through the base exchange material therein to forcefully flush any sediment or foreign matter out of the base exchange material. The backwash effluent issues from the top of the tank and is returned to the valve through its passage 31, from whence it flows to drain through the now communicating ports P3 and P4 and the drain passage 33. The metering orifice 38 in the drain passage, however, prevents flow of backwash water through the water softener tank at too rapid a rate.

After backwashing in this manner for a suitable period of time, regeneration may be terminated by shifting the control spool 16 forwardly to its normal or soft water position shown in solid lines in FIGURE 1, where it remains until the next time the water softener must be regenerated. Since the valve seat 40 is now reclosed by the spool, only softened water can flow to the service passage 30.

According to this invention, the valve body is provided with a stop member 53 which cooperates with a radial arm or cam follower 54 on the rear extremity of the forwardly biased operating stem to define the shut-off, brining and backwash positions of the spool 16.

In the normal or soft water position of the spool and its operating stem seen in FIGURE 1, the operating stem occupies a position of rotation at which the radial arm 54 on its rear extremity projects vertically upwardly.

The stop member 53 has an annular camlike shape, and it is formed integral with the rear cover 8 of the valve body. It is coaxial with and surrounds the projecting rear of the operating stem, and it has an axial length substantially corresponding to the distance the spool travels between its normal or soft water position shown in solid lines in FIGURE 1 and its rearmost or "add salt" position shown in broken lines in FIGURE 1.

The upper side of the stop member has an axially elongated rearwardly opening notch 72 cut therein to receive the radially projecting arm 54 on the rear of the stem. The arm 54, of course, is normally held by the return spring 21 in a position contiguous to the bottom 73 of the notch, and while it may engage directly with the bottom of the notch in the normal or soft water position of the spool, a slight amount of clearance may be provided to assure closing engagement between the disc on the forward end of the spool and the annular valve seat 40 on the foremost insert or gland 13.

The arm 54, however, is narrower than the arcuate dimension of the notch 72 so as to allow a degree of clockwise rotation of the stem relative to the valve body before the arm is brought up against the stop 75 provided by one edge of the notch. The bottom 73 of the notch has a slight camlike inclination along which the arm rides upon initial clockwise rotation of the operating stem out of its normal position, to cause the stem to be cammed rearwardly a distance which is sufficient to effect a slight amount of rearward shifting of the spool 16 in its bore when the operator initially rotates the control knob 11 in the clockwise direction. This is an important feature of the control valve of this invention inasmuch as it enables the spool to be freed for axial sliding motion in its bore in the event of seizure of its O-rings 46 against the wall of the bore as a consequence of the spool remaining in its soft water or normal position for long periods of time.

As seen best in FIGURE 3, the edge 75 of the notch in the stop member toward which the arm 54 on the operating stem moves upon clockwise rotation of the stem extends axially out to the rear of the stop member and defines one end of an arcuate abutment 76 at the extremity thereof. The abutment 76 has a rearwardly facing surface which is normal to the stem axis, and its arcuate length corresponds to a predetermined fraction of a cycle of rotation of the stem.

The abutment 76 is engageable by the arm 54 on the operating stem when the latter has been shifted rearwardly and rotated sufficiently in a clockwise direction from its position seen in FIGURE 3, to define the shut-off or "add salt" position of the spool 16. The abutment thus holds the spool in the "add salt" position against the tendency of the return spring 21 to impart forward motion to the spool, but releases the stem for spring propelled forward motion of the spool when the stem has been rotated clockwise beyond said predetermined fraction of a cycle.

When the operator of the control valve desires to effect regeneration of the water softener governed by the valve, he first rotates the operating stem 10 by its control knob 11, clockwise out of its normal position identified by registry of a large arrow 78 on the skirt of the knob with a marker on a panel 80 behind the knob and fixed with respect to the valve body, until the radial arm 54 on the operating stem engages the edge 75 of the notch in the stop member 53. This, of course, frees the spool 16 for axial sliding motion in its bore in the manner described previously, and the operator then pushes the operating stem rearwardly the extent necessary to carry the radial arm 54 out to the extremity of the stop member and rotates the operating stem the slight amount necessary to hook its radial arm over the abutment 76 on the stop member. The "add salt" position of the valve which is defined by the engagement of the arm 54 with the abutment 76, is indicated to the operator when an "add salt" arrow 82 on the control knob registers with the marker on the panel.

As described hereinbefore, the spool 16 shuts off all of the water connections to the softener tank when it occupies its "add salt" position seen in broken lines in FIGURE 1, but makes hard water available to the service lines connecting with the service passage 30 in the valve body.

During the time the operating stem is thus held in its "add salt" position, the operator may remove the cover from the top of the softener tank and charge the necessary quantity of salt thereinto.

After the operator has again secured the cover in place on the top of the tank, the first actual regenerating step, namely brining, may be commenced. This is effected by movement of the stem and spool 16 of the valve to its position seen in solid lines in FIGURE 2, but it first entails manual rotation of the operating stem in a clockwise direction to a "regenerate" position, at which the radial arm 54 on the operating stem rides off of the end of the abutment 76 and frees the stem and the spool connected therewith for forward motion to the next regenerating position of the spool defined by the engagement of the radial arm 54 with a second arcuate abut-

ment 87 on the stop member. The abutment 87 is angularly adjacent to the abutment 76 but spaced axially forwardly therefrom, in the direction of spring propelled motion of the spool 16.

The spool, after release of the arm 54 from abutment 76, is thus shifted the first step toward its normal or soft water position, by the return spring 21, and a metered flow of unsoftened water is thereby cause to be routed through the alternate port 47 of the control valve to the top of the softener tank to mix with the salt charged thereinto and to wash the resulting brine downwardly through the tank, and, after all of the dissolved salt has flowed down through the tank, to rinse brine out of the mineral bed. The effluent is returned to the control valve and is routed thereby to the drain passage. The second arcuate abutment 87, of course, not only defines the brining position of the spool but releasably holds the spool against return toward its normal position.

At the conclusion of the brining and rinsing step of a regenerating cycle, the arm 54 must be rotated in the direction to carry it off of the end of the abutment 87 before the spool can be moved axially forwardly to its next regenerating position, namely the backwash position seen in broken lines in FIGURE 2. Such forward spring propelled motion of the spool is again arrested by the engagement of the radial arm 54 with a third arcuate abutment 88 on the stop member, angularly and axially intermediate the abutment 87 and the bottom of the notch 73 in the stop member. Thus, one end of the abutment 88 terminates at the notch 72 in the stop member. The engagement of the stem arm with the abutment 88, of course, defines the backwash position of the spool 16 at which fresh water flows through the softener tank in the reverse direction, namely from bottom to top, and then to drain.

The abutment 88 has an arcuate length which corresponds to the remaining portion of the cycle of rotation of the operating stem, and it holds the spool against return to its normal position until the arm 54 is rotated toward the notch 72 in the stop member and off of the end of the abutment that defines the narrow end of notch 72. Such rotation of the arm frees the spool for forward spring propelled motion to its normal position completing the regenerating cycle. As shown in FIGURE 1, the arm 54 is thus returned to its normal position at the bottom of the notch 72 in the stop member.

It will be seen, therefore, that the operating stem must be rotated manually in one direction, in order to enable it to be placed in each of its operating positions, and that the spool will be held in each of said operating or regenerating positions the periods of time necessary to assure proper regeneration of the water softener. The construction described, therefore, makes it possible to operate the valve entirely manually, or in a semi-automatic fashion by control instrumentalities including an electric motor 52 which, when energized in a manner disclosed in my aforesaid copending application Serial No. 722,093, is operable to effect shifting of the valve spool to each of its regenerating positions and finally return of the spool to its normal position following manual actuation of the spool to its shut-off or "add salt" position.

From the foregoing description taken together with the accompanying drawings, it will be readily apparent to those skilled in the art that this invention provides an improved control valve for water softeners and the like having an improved arrangement of ports, and which features an axially slidable spool and means for defining and holding the spool in each of its operating positions from which positions it may be released for axial motion to another position upon rotation of an operating stem for the spool through an arc of predetermined magnitude.

What is claimed as my invention is:

In a water softening system including a softener tank containing an ion exchange medium and having top and bottom flow ports therein, a cover at its top that can be removed to enable salt to be charged into the tank for regeneration of the ion exchange medium in the tank, and a control valve to govern service and regenerating operation of the system, characterized by: a body for the valve having a source water inlet connectible with a supply of water to be softened, and an elongated bore with a series of five axially spaced ports opening substantially radially thereinto; the center port constituting a drain port which is in communication with a drain passage in the body from which waste water issues during regeneration of the system; the two ports at axially opposite sides of the drain port constituting first and second tank ports respectively connecting with the top and bottom flow ports of the tank through first and second tank passages in the body; one of the end ports constituting a service port that leads to a service passage in the body, from which softened water may flow to a point of use; and the other end port constituting a restricted alternate port communicating with said first tank passage; passage means in the body having branches communicating the source water inlet with the bore at locations spaced axially from each end of the series of valve ports; a spool shiftable axially back and forth in the body bore and having a number of axially spaced circumferentially enlarged lands thereon which are cooperable with the wall of the bore and said valve ports in different axial positions of the spool to control the flow of fluid to and from the softener tank, said lands and ports being so arranged that service operation of the system is produced in a normal position of the spool at which its lands cooperate to close off communication between the drain and tank ports and their respective passages, to communicate the source water inlet with said first tank passage, and to communicate the second tank passage with the service passage so that source water will be directed downwardly through the softener tank and softened water issuing therefrom will be discharged through the service port and its passage for delivery to a point of use; that in a first operating position most remote from its normal position the lands on the spool cooperate to close off communication between both tank passages and the source water inlet and to communicate said second tank passage with the drain passage to effect venting of the softener tank and thereby enable its cover to be removed and salt to be charged into the top of the tank for regeneration of the ion exchange medium in the tank; that in a second operating position less remote from normal the lands on the spool cooperate to establish communication between the drain and second tank passages and to communicate the first tank passage with the source water inlet only through said alternate port so that source water is caused to enter the top of the softener tank for restricted flow through the salt charged into the softener tank to form a brine solution therewith that is carried downwardly through the ion exchange material in the tank, while the brine effluent discharging from the bottom of the tank is led through the second tank passage to the drain passage for discharge to a sewer or the like; and that in a third operating position intermediate normal and said second operating position the lands on the spool cooperate to communicate said second tank passage with the source water inlet and to establish communication between said first tank port and the drain passage so as to effect backwash flow of source water upwardly through the softener tank and delivery of the backwash effluent issuing from the top of the tank to the drain passage in the valve body; means for moving the spool in a return direction from its first operating position to its normal operating position; and means connected with the body and with the spool to arrest return movement of the spool at said second and said third operating positions thereof, respectively.

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