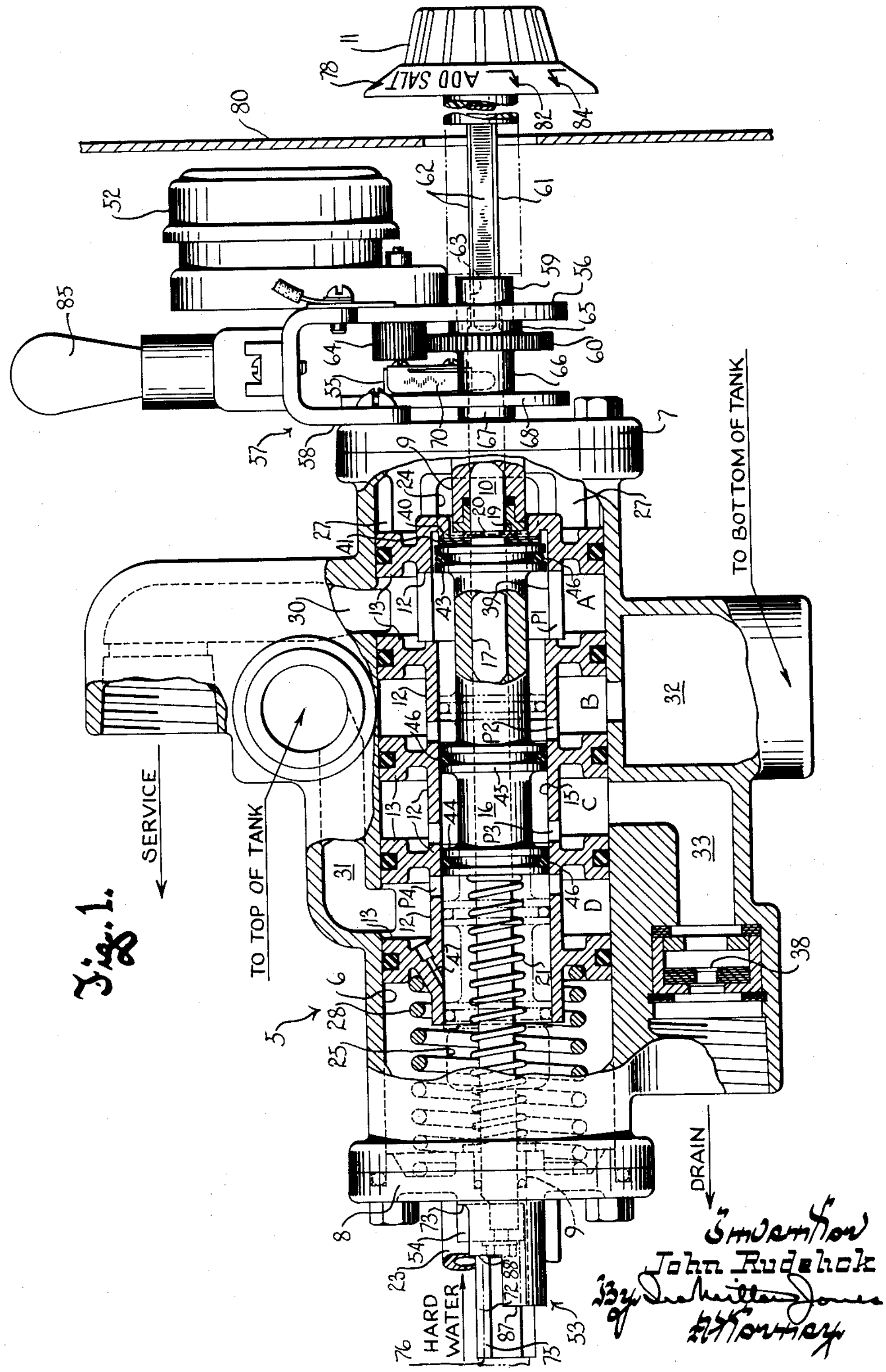
June 27, 1961 J. RUDELICK 2,989,988

FLUID FLOW CONTROL VALVE

Filed March 17, 1958 3 Sheets-Sheet 1



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FLUID FLOW CONTROL VALVE

Filed March 17, 1958 3 Sheets-Sheet 2

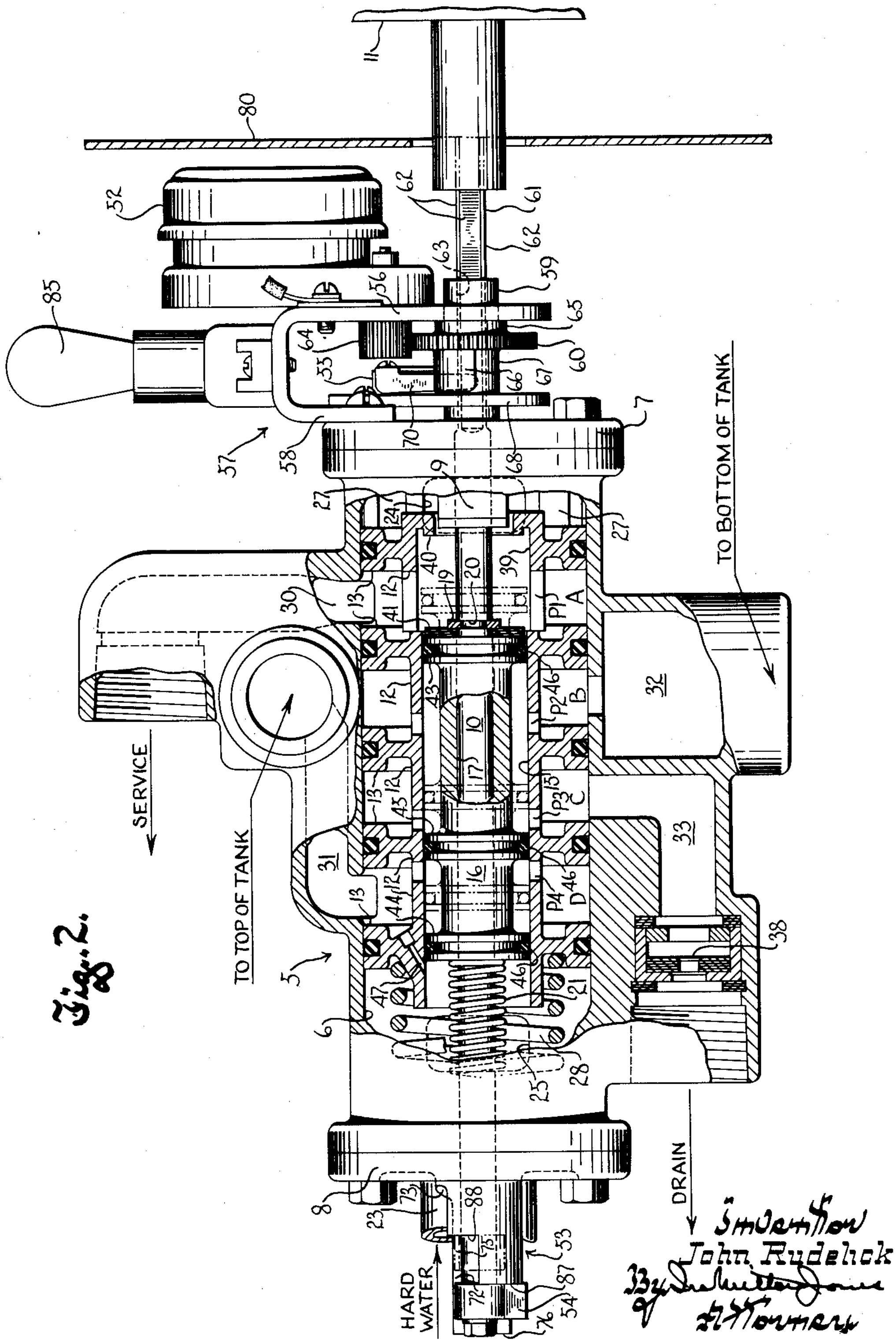

Fig. 2.

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FLUID FLOW CONTROL VALVE

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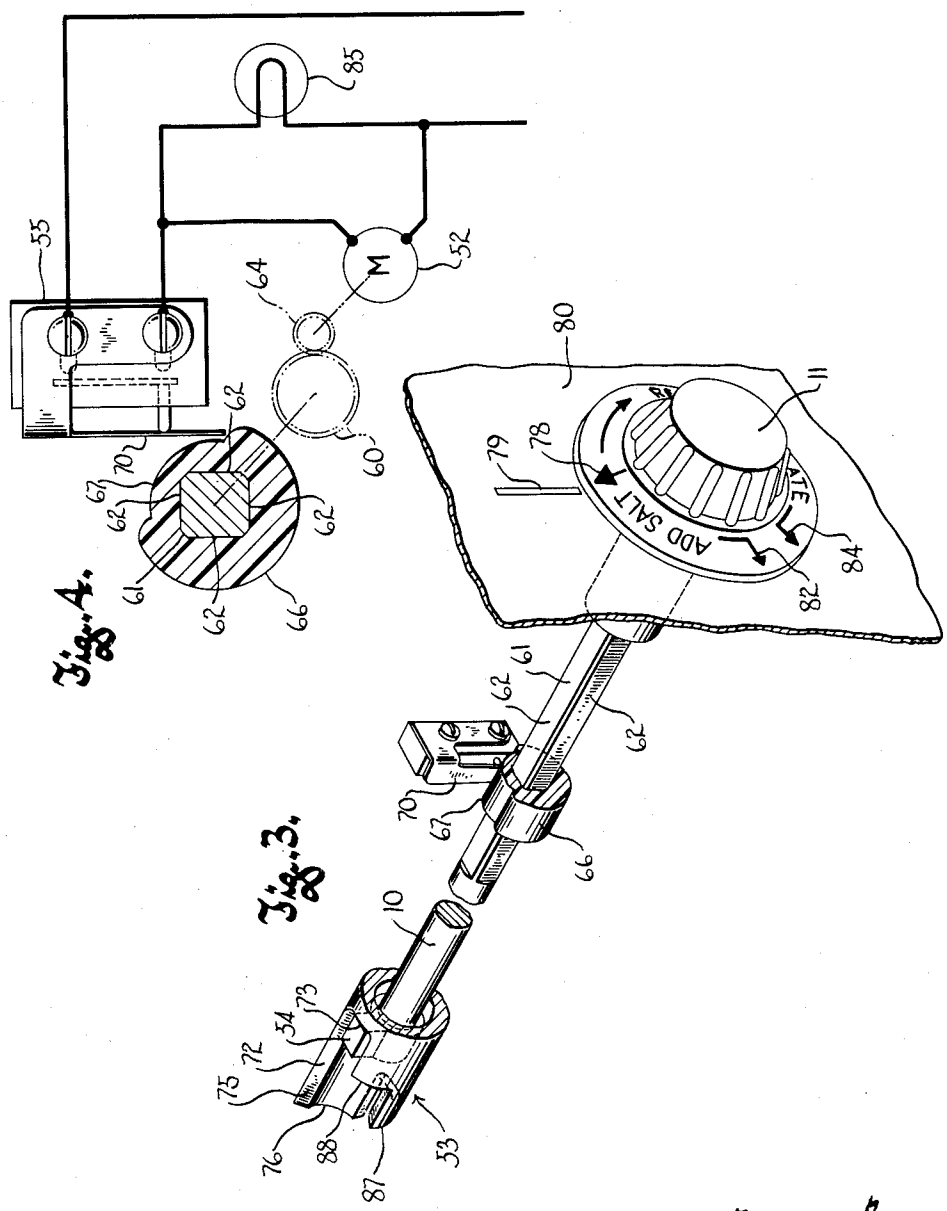

Fig. 4.

Fig. 3.

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FLUID FLOW CONTROL VALVE

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12 Claims. (Cl. 137—624.19)

This invention relates to fluid flow control valves and 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 semi-automatic control valve which, for example, is ideally suited for use with softeners of the salt-in-head type, and by which regeneration of the softener involves initial manual actuation of the control valve.

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, which valve is semi-automatic in operation in that it requires manual actuation by the operator on but a single trip to the softener, and is thereafter actuated automatically to its different regenerating positions and finally returned to its normal soft water position at the conclusion of regeneration. As an example, the operator need only actuate the valve at the time he adds salt to the water softener tank and after such actuation of the valve the operator need not return again to the softener until the next time it must be regenerated.

More specifically, it is an object of this invention to provide a fluid flow control valve of the character described wherein manual actuation of the valve to its regenerating position after salt has been charged into the softener sets simple but reliable automatic control instrumentalities into operation which thereafter take over actuation of the valve at precisely timed intervals to effect the different regenerating steps and finally return of the valve to its normal operating position.

In this respect, it is a further object of this invention to provide a semi-automatic fluid flow control valve of the character described with automatic control instrumentalities including a small electric motor, and which instrumentalities are so designed as to permit entirely manual operation of the valve in the event of failure of the motor for any reason; and to permit the operator to manually reset the valve for automatic repetition of any part or all of the regenerating cycle if he so desires.

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 claims, it being understood that such changes in the precise embodiment

of the hereindisclosed invention may be made as come within the scope of the claims.

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;

FIGURE 3 is a more or less diagrammatic fragmentary perspective view of a portion of the instrumentalities which govern automatic acutation of the valve; and

FIGURE 4 is a diagrammatic view illustrating the manner in which the electric motor is controlled.

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 central 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.

In many respects the body of the valve of this invention is similar to that of the control valve disclosed in the copending application of John Rudelick and Vernon J. Palmer, Serial No. 618,788, filed October 29, 1956, which has matured into Patent No. 2,920,652. For instance, 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** likewise 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**.

As in the aforesaid copending application, the rim por-

tions 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 is 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 **30** 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.

If 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 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 intiate regeneration.

Such regeneration is commenced when the control spool **16** is shifted forwardly to its 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** to be washed over the salt charged into the softener tank. The resulting brine is then flushed 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. Inas-

much as ports P2 and P3 are now in communication with one another, the effluent is directed into the drain passage 33 and flows 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 ports P1.

The flow of fresh hard water into the top of the softening tank during the brining step is preferably continued for a period of time after all of the salt has been dissolved, so as to effect rinsing of brine from the mineral in the most efficacious manner 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 the brining and rinsing steps have been completed in this manner, the control spool 16 may be moved forwardly to a backwash position seen in broken lines in FIGURE 2, to effect more rapid but reverse flow of fresh water through the conditioner tank. 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 and by agitation of the material flushes any sediment or foreign matter from 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 is 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, automatically operated means takes over the actuation of the spool 16 necessary to carry out the described steps of the regenerating cycle once the spool has been manually actuated to its regenerating position by an operator of the valve. This automatically operated means includes an electric clock motor 52 drivingly connected with the operating stem to impart rotation in one direction thereto at a slow rate of speed, 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 different operating positions of the spool 16, and an electric switch 55 for governing operation of the electric motor in accordance with the angular position of the operating stem about its axis of rotation.

The electric motor 52 is mounted on the longer front leg 56 of a bracket 57 of inverted U-shape, the shorter leg 58 being secured to the front cover 7 of the valve body. The leg 56 projects downwardly in spaced relation to the front of the valve body and has an aperture therein to rotatably receive the forward hub portion 59 of a driven gear 60 mounted on and constrained to rotate with the operating stem. For that purpose, the front end portion 61 of the operating stem is reduced in diameter and it has opposite flat sides 62 which are received in a correspondingly shaped non-circular hole 63 in the hub portion 59 of the driven gear, to provide a slidably splined driving connection between the stem and gear. The drive gear 64 of the clock motor meshes with the driven gear 60 and whenever the clock motor is in operation imparts rotation to the operating stem in a clockwise direction as viewed in FIGURES 3 and 4, but at a substantially slow rate of speed.

The driven gear 60 is restrained against axial movement along the operating stem by means of an enlargement 65 on its hub bearing against the rear face of the front leg 56, and a cam 66 formed as a radial enlargement of a rear portion 67 of the hub. The rear end of the cam cooperates with the front face of a plate 68 secured to the front cover 7 to limit rearward motion of the driven gear along the stem. The plate 68 also serves to mount the switch 55 on the front of the valve body with its actuating lever 70 extending downwardly alongside the hub portion 67 of the driven gear to be engageable by the cam 66 thereon during a predetermined part of a cycle of rotation of the operating stem.

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, and the cam 66 on the driven gear is out of engagement with the actuating lever 70 of the switch 55 by which the electric motor 52 is controlled. Since the electric switch is of the normally open type as indicated in FIGURE 4, the electric motor 52 will be deenergized at this time, and it can only be energized upon clockwise rotation of the operating stem through an angle of slightly greater than 90° to bring the cam 66 on the stem into switch closing engagement with the lever 70 of the switch. After such energization, the electric motor 52 slowly drives the operating stem in a clockwise direction, as viewed in FIGURES 3 and 4, until the cam 66 is again disengaged from the lever 70 of the electric switch. At that time, the angular position of the operating stem again will be as shown in all except FIGURE 2 of the drawings.

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; and it will be noted that the bottom 73 of the notch has a slight inclination along which the arm rides upon initial clockwise rotation of the operating stem out of its normal position. The cam-like inclination 73 causes 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 extermity 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 79 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 79 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 remains in its "add salt" position the electric motor 52 is maintained deenergized by reason of the fact that the cam 66 on the stem has not yet been rotated far enough to depress the actuating lever 70 of the switch 55. Consequently the operator may then 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, regeneration may be commenced automatically. This is effected as a consequence of manual rotation of the operating shaft in a clockwise direction to a "regenerate" position at which the radial arm 54 on the operating stem occupies a position near the end of the arcuate abutment 76 remote from the edge 75 of the notch in the stop member, and the cam 66 on the stem is operatively engaged with the switch actuating lever 70. This regenerating position of rotation of the operating stem is indicated to the operator upon registry of another arrow 84 on the control knob with the marker 79 on the panel, and also by the energization of a signal lamp 85 as the result of closure of the electric switch 55 by the cam 66 on the operating shaft. The signal lamp 85, of course, is energized concomitantly with energization of the clock motor 52 at the time the cam 66 effects closure of the switch, and the control circuits for the motor and lamp are shown diagrammatically in FIGURE 4.

From this time on, regeneration of the water softener takes place automatically, and the operator's presence is not required until the next time regeneration of the softener becomes necessary.

As soon as the motor 52 is energized in the manner described it imparts rotation in the clockwise direction to the operating shaft at a uniform slow rate of speed, to slowly advance the radial arm 54 on the operating stem along the abutment 76 until it rides off of the end of the abutment and frees the stem and the spool connected therewith for spring propelled forward motion to the next regenerating position of the spool shown in solid lines in FIGURE 2, and defined by the engagement of the radial arm 54 with a second arcuate abutment 87 on the stop member. The abutment 87 is angularly adjacent to the abutment 76 but spaced axially therefrom in the direction of spring propelled motion of the spool 16.

When the spool is thus shifted the first step toward its normal or soft water position, a metered flow of unsoftened water is 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 flush the resulting brine downwardly through the tank. The effluent is returned to the control valve and is routed thereby to the drain passage. This brining operation should continue for a predetermined period of time sufficient to assure that all of the salt will be dissolved and washed through and rinsed from the tank, and its duration is determined by the arcuate length of the abutment 87 along which the radial arm 54 on the operating stem travels during motor produced rotation of the operating stem in a clockwise direction. Hence, it will be seen that the second arcuate abutment 87 holds the spool against return toward its normal position during a second fraction of a cycle of rotation of the operating stem.

At the conclusion of this regenerating step, the arm 54 rides off of the end of the abutment 87 to permit the return spring 21 to shift the connected spool and stem forwardly, toward normal but such spring propelled motion of the spool is again arrested by the engagement of the radial arm 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 indicated in broken lines in FIGURE 2, at which fresh water flows through the 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 thus determines the duration of the backwash step in the regenerating cycle. Its length is so related to the speed at which the stem is rotated by the electric motor 52 as to assure rinsing of any residual brine and all of the sediment from the base exchange material in the softener tank before the radial arm rides off of the end of the abutment 88 to free the spool for spring propelled motion to its normal position at the completion of regeneration. As soon as the radial arm 54 is thus disengaged from the abutment 88, it is returned to its normal position at the bottom of the notch 72 in the stop member, and the cam 66 on the operating stem shortly thereafter rides off of the actuating lever 70 of the switch to effect opening of the switch and deenergization of the electric motor 72 and the signal lamp 85.

This normal position of rotation of the operating shaft and the cam 66 thereon is shown best in FIGURES 3 and 4, where it will be noted that the large arrow 78 on the skirt of the control knob 11 has been brought into registry with the marker 79 on the panel 80 to indicate the soft water position of the control valve.

It will be seen, therefore, that once the operating stem has been actuated manually to dispose it in a position at which it effects energization of the electric clock motor 52, the spool 16 of the valve is automatically advanced stepwise to each of its regenerating positions and finally returned to normal, but is held in each of said regenerat-

ing positions for predetermined periods of time necessary to assure proper regeneration of the water softener.

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 semi-automatic control valve for water softeners and the like which features simple and reliable automatic control instrumentalities which take over the task of effecting shifting of the control spool of the valve to each of its regenerating positions and finally return of the spool to its normal position following manual actuation of the valve to a predetermined shut-off or "add salt" position.

What is claimed as my invention is:

1. In a fluid flow control valve of the type having a body provided with a bore, and a spool shiftable axially in the bore from a defined normal operating position to a plurality of other operating positions spaced in one direction from normal to effect change in communication between passages in the body which have ports opening radially into the bore at axially spaced locations: a spool actuator connected with the spool to move back and forth therewith and providing for manual shifting of the spool in said direction to one of said other operating positions thereof, past an intermediate operating position of the spool; spring means acting upon the spool to yieldingly resist shifting thereof out of normal; cooperating members carried by the body and the spool for relative rotary movement, one of said members having abutments each corresponding to one of said other operating positions of the spool, said abutments being arcuately elongated and angularly adjacent to one another with respect to the axis of relative rotation of said members but spaced apart lengthwise of said axis, and the other member having a single abutment which is successively engageable with said spaced abutments under the action of said spring means as a consequence of relative rotary movement of the members in one direction; a motor carried by the valve body; a driver connecting the motor with one of said members to effect relative rotary movement of said members in said one direction whenever the motor is in operation; and control means governed by said driver to effect starting and stopping of the motor in accordance with the angular position of said driver, and to maintain the motor operative throughout all but a substantially small portion of a cycle of relative rotation of said one member during a part of which small portion the spool is in its normal position.

2. In a fluid flow control valve having a body provided with a bore and having passages which lead to ports that communicate with the bore at different locations lengthwise of the bore: a spool shiftable axially back and forth in the bore between a normal position and a plurality of operating positions spaced in one direction from normal to effect change in communication between the ports and the passages which lead thereto; spring means acting on the spool to yieldingly resist shifting thereof out of its normal position; an operating stem by which the spool may be shifted out of its normal position; means mounting the stem on the body for endwise back and forth motion and for rotation relative to the body; means connecting the stem with the spool for back and forth movement therewith; an abutment fixed on a portion of the stem; and means for effecting timed stepwise return of the connected stem and spool to said normal position of the spool after it has been manually shifted to an operating position remote from normal, comprising a stop member fixed on the body and concentrically surrounding said stem portion, a plurality of abutments on said stop member each corresponding to one of said operating positions of the spool, said plurality of abutments having surfaces of predetermined arcuate length which are angularly adjacent to but spaced from one another along the axis of stem rotation and substantially normal thereto, and arranged to be successively engaged by the stem abutment upon rotation of the stem in one direction to arrest spring propelled return motion of the spool and the stem at each of said operating positions of the spool for a period of time determined by the speed of rotation of the stem and the arcuate lengths of said plurality of abutments, an electric motor mounted on the valve body and connected with the stem for rotating the same in said one direction at a uniform slow rate, a normally open switch carried by the body, for governing the operation of the electric motor, and switch actuating means fixed on the operating stem to rotate therewith and operable to maintain the switch closed throughout all but a substantially small portion of a cycle of rotation of the stem during which the stem abutment is disengaged from the abutment which defines the operating position of the spool closest to its normal position.

3. The control valve of claim 2, further characterized by: the provision of means on the stop member cooperable with the stem abutment to prevent rotation of the operating stem to a switch closing position except upon endwise motion of the stem to shift the spool out of its normal position to its operating position most remote from normal.

4. In a fluid flow control valve: a body having a bore and having passages therein which lead to ports that communicate with the bore at different locations lengthwise of the bore; a spool shiftable axially in the bore between a plurality of operating positions, for controlling communication between ports and the passages which lead thereto; a spring acting on the spool to urge the same in one direction in the bore; an operating stem projecting coaxially through the spool and connected thereto for rotation relative to the spool but for endwise back and forth motion with the spool; an arm fixed to one portion of the operating stem and projecting radially therefrom; an annular stop member on the body concentrically surrounding said portion of the stem; an arcuately elongated abutment on said stop member engageable by said arm on the stem to define one of the operating positions of the spool and to hold the spool against spring propelled motion in said direction out of said one operating position until the stem has been rotated far enough in one direction to disengage its arm from said abutment; cooperating means on the spool and the body engageable under the action of the spring means on the spool to limit spring propelled motion of the spool in said direction at a normal operating position of the spool; another arcuately elongated abutment on said stop member axially spaced from said first named abutment in the direction of spring produced motion of the spool and so arranged as to be engageable by said arm on the stem upon such disengagement of the arm from said first named abutment to arrest spring propelled motion of the spool at a second operating position intermediate its normal and said one operating positions and to hold the spool against spring propelled motion to its normal position when engaged by the stem arm until the stem has been rotated far enough in said one direction to disengage its arm from said other abutment; an electric motor carried by the valve body and connected with said stem for imparting rotation thereto in said direction at a uniform slow rate of speed; switch means carried by the body for controlling the motor; and switch actuating means on the operating stem for rendering said motor inoperative when the stem reaches a position of rotation at which the spool is released for spring propelled motion to said normal position thereof.

5. In a fluid flow control valve: a body having a bore and having passages therein which lead to ports that communicate with the bore at different locations lengthwise of the bore; a spool shiftable axially in the bore between a plurality of operating positions, for controlling communication between ports and the passages which lead thereto; a spring acting on the spool to urge the same in one direction in the bore; an operating stem projecting coaxially through the spool and connected

thereto for rotation relative to the spool but for endwise back and forth motion with the spool; an arm fixed to one portion of the operating stem and projecting radially therefrom; an annular stop member on the body concentrically surrounding said portion of the stem; an arcuately elongated abutment on said stop member engageable by said arm on the stem to define one of the operating positions of the spool and to hold the spool against spring propelled motion in said direction out of said one operating position until the stem has been rotated far enough in one direction to disengage its arm from said abutment; cooperating means on the spool and the body engageable under the action of the spring means on the spool to limit spring propelled motion of the spool in said direction at a normal operating position of the spool; another arcuately elongated abutment on said stop member axially spaced from said first named abutment in the direction of spring produced motion of the spool and so arranged as to be engageable by said arm on the stem upon such disengagement of the arm from said first named abutment to arrest spring propelled motion of the spool at a second operating position intermediate its normal and said one operating positions and to hold the spool against spring propelled motion to its normal position when engaged by the stem arm until the stem has been rotated far enough in said one direction to disengage its arm from said other abutment; drive means connected with said stem for imparting rotation thereto in said one direction at a uniform slow rate of speed, said drive means including an electric motor carried by the valve body; a switch controlling the operation of said motor; means mounting the switch on the body alongside the operating stem; and switch actuating means fixed on the stem to rotate therewith and operable to maintain the switch closed throughout all but a substantially small portion of a cycle of rotation of the stem during which the stem arm is disengaged from said other abutment.

6. In a fluid flow control valve: an elongated body having a bore and passages that lead to ports which open radially into the bore at axially spaced locations; an elongated stem; means on the ends of the body rotatably and axially slidably mounting the stem on the body with the stem projecting coaxially through the bore; a valve spool mounted on the stem to move axially therewith, said spool occupying a position intermediate the ends of the stem and having lands thereon which slidably engage the wall of the bore to control communication between said ports, and the spool being manually shiftable in one axial direction in the bore between defined limits from one operating position to another remote therefrom, past at least one intermediate operating position of the spool, to control communication between said ports; a spring acting upon the spool for returning the latter to said one operating position from said remote operating position thereof; a substantially radial arm fixed to one end portion of the stem; an annular stop member encircling said last named end portion of the stem, said stop member having a first abutment thereon engageable by the stem arm in said remote operating position of the spool to releasably hold the spool against return motion, the arm being disengageable from said first abutment upon rotation of the stem in one direction to release the spool for spring propelled return motion toward said one operating position thereof, said stop member having a second abutment thereon located to be engaged by the stem arm to arrest such return motion of the spool at said intermediate operating position thereof and to releasably hold the spool in said intermediate operating position until the stem is rotated farther in said one direction; and means at the exterior of the body connected with one end portion of the stem, providing a handle by which the stem may be manually rotated and also moved axially against the force of said return spring to shift the spool from said one operating position to said remote operating position thereof.

7. In a fluid flow control valve of the type having a body provided with a bore and passages having ports which open radially into the bore at axially spaced locations: a tubular spool shiftable axially in the bore from a defined normal operating position to a plurality of other operating positions spaced in one direction from normal to effect change in communication between said ports; a return spring acting upon the spool to yieldingly resist shifting thereof of its normal position; an actuating stem rotatably received in the hollow interior of the spool and projecting from opposite ends of the valve body; means connecting the stem and the spool to constrain them to shift axially in unison, without interfering with rotation of the stem relative to the spool; an annular stop member on one end of the body, concentrically encircling the adjacent projecting end of the actuating stem and having a series of axially spaced but circumferentially adjacent arcuately elongated abutments thereon each corresponding to one of said operating positions of the spool; an arm fixed to said projecting end of the actuating stem and cooperable with the abutment farthest from the valve body to define the operating position of the spool most remote from its normal operating position, whereby rotation of the stem in one direction effects engagement of said arm in turn with each of the remaining abutments under the action of said return spring; a motor carried by the valve body at the other end thereof, and drivingly connected with the stem to rotate the same in said one direction; motor control means on the body adjacent to the motor for controlling starting and stopping of the motor; and means on the stem for actuating said motor control means in accordance with the angular position of the stem with respect to the annular stop member on the body.

8. In a fluid flow control valve for performing a number of different functions: a body provided with a bore and a number of passages that lead to ports which open radially into the bore at axially spaced locations, said body having walls which close the opposite ends of the bore, and said walls having apertures therein providing bearings which are coaxial with the bore; a manually movable stem rotatably and axially slidably supported in said bearings and projecting centrally through the bore and from the opposite ends of the body; a valve spool mounted on said stem to move axially therewith, and having lands which slidably engage the wall of the bore to control communication between said ports, said stem providing for manually shifting the spool in the bore between defined locations from one operating position at which the lands cooperate with said ports for the performance of one of said functions of the valve, to another operating position remote from said one position, and at which the lands cooperate with said ports for the performance of another one of said functions of the valve, past at least one intermediate operating position of the spool at which the lands thereon cooperate with said ports for the performance of a third one of said functions of the valve; a spring acting upon the stem and the spool for returning the latter to said one operating position from said remote operating position thereof; a substantially radial arm fixed on one projecting end of the stem; an annular stop member on the body concentrically encircling said one projecting end of the stem, said stop member having an abutment thereon engageable by the stem arm in said remote operating position of the spool to releasably hold the spool against return motion, the arm being disengageable from said abutment upon rotation of the stem in one direction to release the spool for spring propelled return motion toward said one operating position thereof; another abutment on said stop member located to be engaged by the stem arm to arrest such return motion of the spool at said intermediate operating position thereof and to releasably hold

the spool in said intermediate operating position until the stem is rotated farther in said one direction; means connected with the other projecting end of the stem by which rotation may be imparted to the stem in said one direction; and cooperating cam means on the stem and the body operable upon rotation of the stem with the spool in said one operating position thereof to impart slight axial shifting of the spool in its bore to thereby overcome any tendency for the lands on the spool to seize in the bore due to the spool remaining in said one operating position for long periods of time.

9. In a fluid flow control valve for performing a number of different functions: a body provided with a bore and having a number of passages which lead to ports that open radially into the bore at axially spaced locations; a valve spool manually shiftable axially in the bore and having a plurality of circumferentially enlarged lands thereon so related to said ports that the valve performs one of said functions when the spool occupies a defined first position, performs another one of said functions when the spool occupies a second position spaced axially in one direction from said first position thereof, and performs a third one of said functions when the spool occupies a position axially intermediate said first and second positions; means for defining each of said second and intermediate positions of the spool and for releasably holding the spool against axial motion in the opposite direction out of said second and intermediate positions thereof, said means comprising cooperating stop members one of which is carried by the body and the other of which is connected with the spool to move therewith during axial shifting of the spool in the bore, means movably mounting one of said stop members for motion relative to the other and to the spool, and a pair of abutments on one of said stop members spaced apart in the direction of the spool axis a distance corresponding to the distance between said second and intermediate positions of the spool, one of said abutments on said last mentioned stop member being engageable with its cooperating stop member when the spool is in said second position thereof, to hold the spool against axial motion toward its first designated position, said abutment being disengageable from said cooperating stop member upon motion of said movably mounted stop member a predetermined distance in one direction, relative to the spool, to permit the spool to be shifted toward said first position thereof, and the other of said abutments being so offset with respect to said first designated abutment in said one direction of movement of said movably mounted stop member that such movement of the latter the distance to effect disengagement of said first designated abutment from the cooperating stop member positions the stop members in such relation that the other of said abutments is engageable by the cooperating stop member to block axial shifting of the spool past said intermediate position thereof, and further movement of said movably mounted stop member in said one direction, relative to the spool, effecting disengagement between said second abutment and the cooperating stop member to permit the spool to be shifted further toward said first axial position thereof; and actuator means connected with said movably mounted stop member for moving the same in said one direction, relative to the spool.

10. The control valve of claim 9, wherein said actuator means comprises a rotatable stem extending lengthwise of the spool and connected therewith to impart axial motion to the spool and to rotate on its axis relative to the spool; and wherein the stop member which is connected with the spool constitutes said movably mounted stop member and has a rotation transmitting connection with the stem to be rotated thereby relative to the spool in order to effect release of the spool for axial shifting toward said first position thereof.

11. The control valve of claim 10, further characterized by the provision of means separately connecting said stem with the movably mounted stop member and with the spool so as to enable the latter to be moved lengthwise of the bore by the stem means without simultaneously imparting motion to said movably mounted stop member relative to the spool.

12. The control valve of claim 11, wherein said body carried stop member has said spaced abutments and comprises an annular member concentric with said stem, and inside a portion of which the stem rotated abutment operates.

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