

[54] **CYCLING VALVE AND VALVING ASSEMBLY FOR WATER SOFTENERS**

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[52] U.S. Cl.**137/625.29, 251/172, 251/190, 251/324, 277/178**

[51] Int. Cl.**F16k 11/07, F16k 3/24**

[58] Field of Search.....**251/325, 324, 172, 190; 277/152, 165, 178; 137/625.29, 625.69, 625.48**

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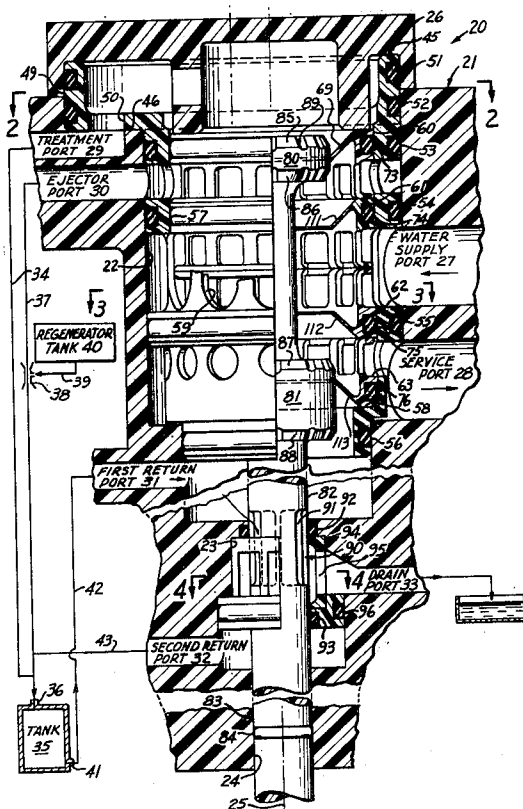
645,277	7/1962	Canada.....	625.69/
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[57] **ABSTRACT**

A cycling valve for a water treatment system wherein an axially reciprocable stem bearing a pair of sealing lands is adapted to make selective closures among four sets of lip-seals to cycle a water softener through a cycle beginning with service and extending through back-wash, brine, rinse, quick-rinse and return to service. A valving assembly for use in such a valve comprises a support ring that bears a frusto-conical web forming the lip-seal which has a circular opening which makes an interference fit with the respective land. Lip-seal elements bearing the lip-seals may be stacked inside a body to form a readily assembled device.

14 Claims, 11 Drawing Figures



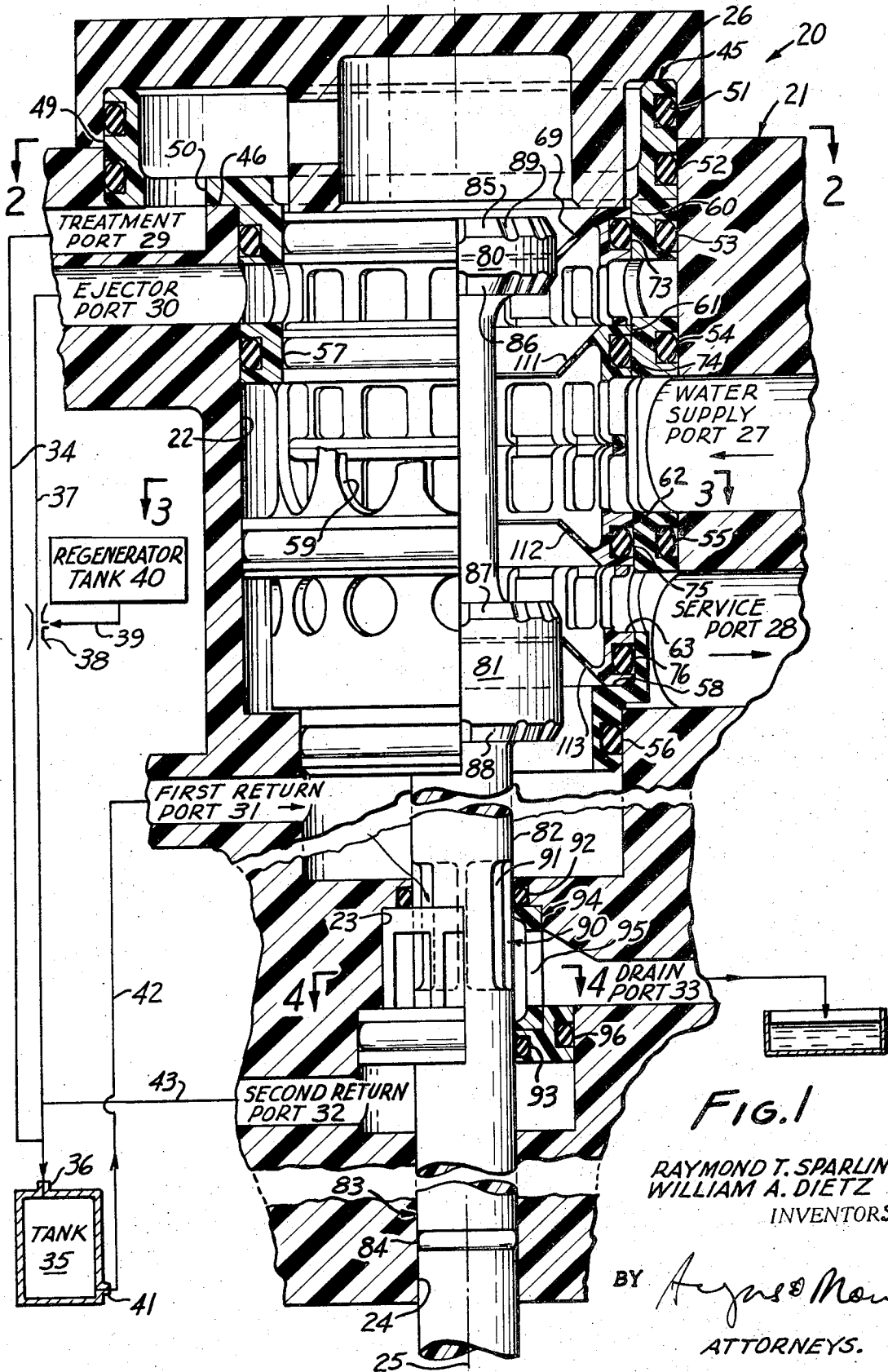


FIG. 1

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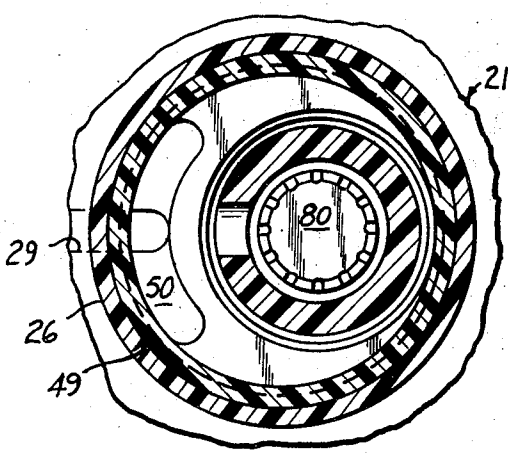


FIG. 2

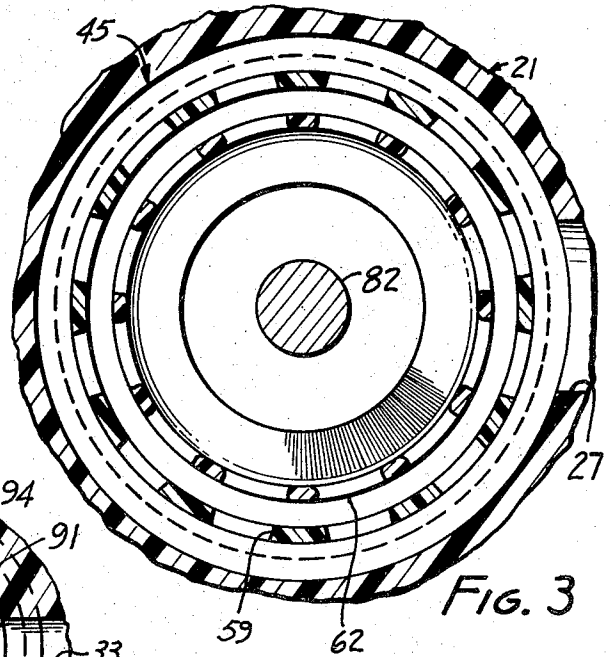


FIG. 3

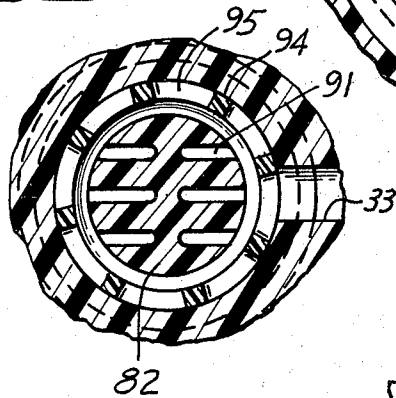


FIG. 4

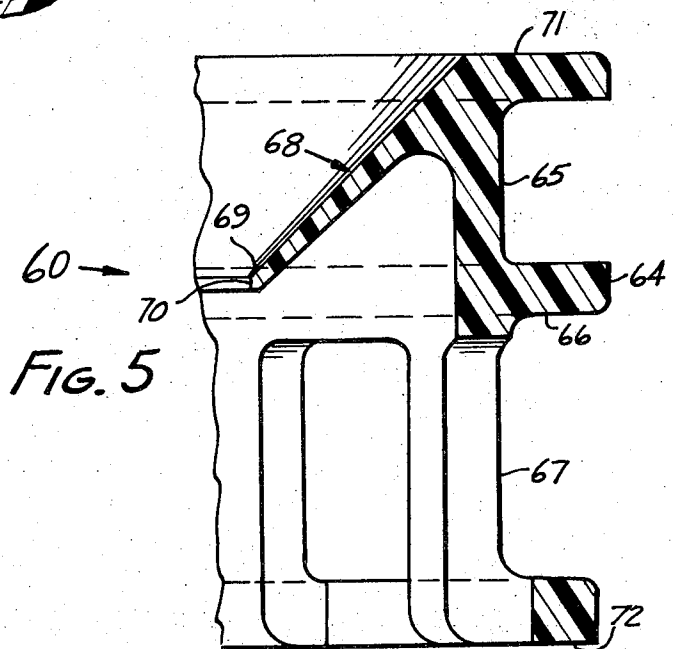


FIG. 5

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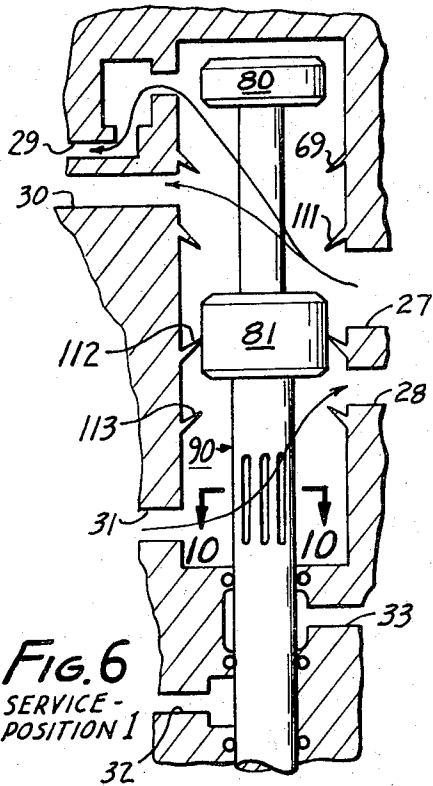


FIG. 6
SERVICE-
POSITION 1

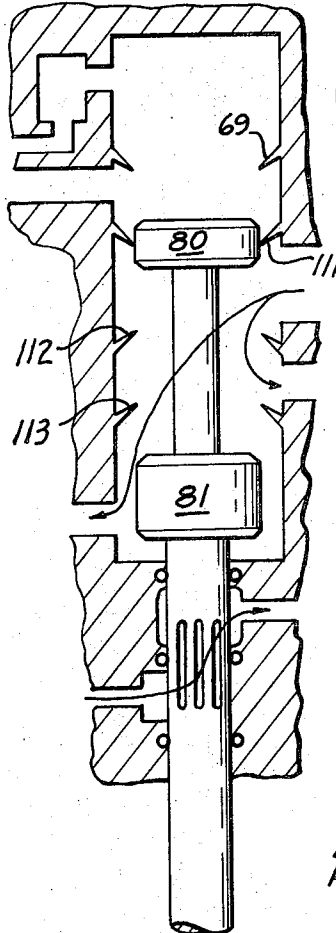


FIG. 7
BACKWASH-
POSITION 2

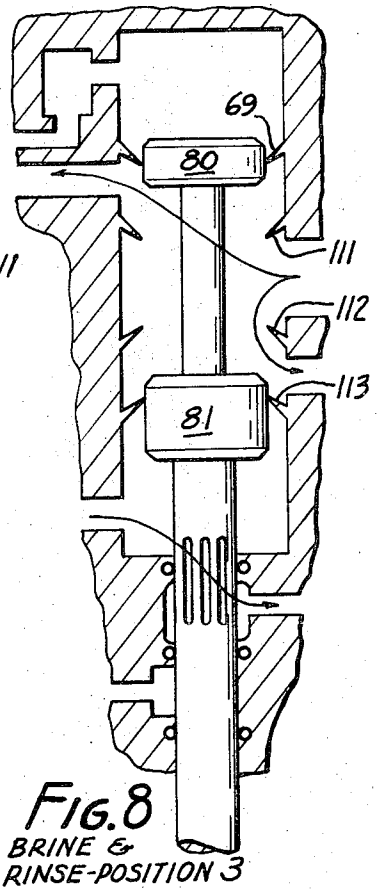


FIG. 8
BRINE &
RINSE-POSITION 3

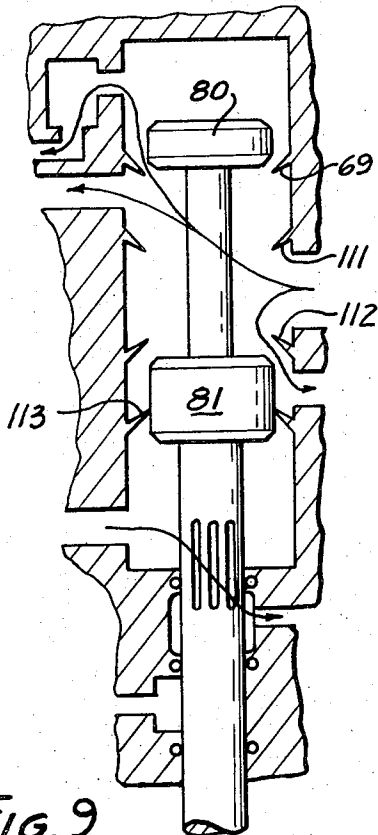


FIG. 9
QUICK RINSE-POSITION 4

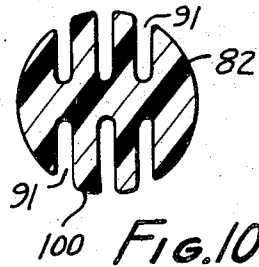


FIG. 10

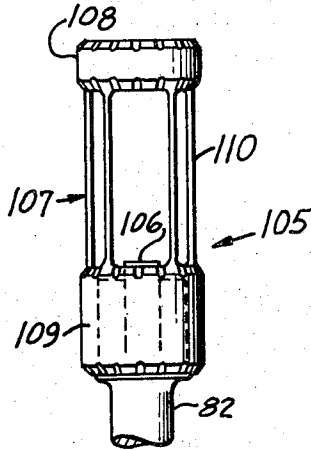


FIG. 11

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CYCLING VALVE AND VALVING ASSEMBLY FOR WATER SOFTENERS

This invention relates to valves for the cycling control of water softeners.

Cycling valves for the control of water softeners are well known. A valve generally similar in functional purpose is shown in Whitlock et al. U.S. Pat. No. 3,237,640. The class of valve shown in the Whitlock patent and the valve described herein is known as a five-cycle valve. In the instant valve, the valve assumes four unique positions and performs five functions.

Such a system customarily includes a water supply line from the water supply, a service line to the house or other using point, a drain line to sump or sewer, a regenerator tank with an ejector connected to it for evacuating its contents at one condition and a treatment tank in which an ion exchange resin is contained and through which the water to be softened is passed on its way to the service line. The maintenance of a system of this sort includes the functions of directing the water through the treatment tank to the service line in normal service position, back-washing the bed in the treatment tank by causing reverse flow from the water supply line to the bottom of the treatment tank and out the drain so as to flocculate the bed and purge particulate impurities from it, passing first brine and then clear water through the treatment tank from top to bottom in order to regenerate and then wash the ion exchange resin, followed by a quick rinse further to purge the system of sodium chloride, followed by a return to the service position. Such cycling is known in the art. It is an object of this invention, however, to provide a readily and inexpensively-manufactured, durable and reliable valve to accomplish the cycling functions.

A cycling valve according to this invention includes a body having an aligned primary bore, secondary bore and shaft passage, the primary bore terminating near an end of the body. Within the primary bore there are disposed four frusto-conical flexible lip-seals which are adapted variously to make contact with a pair of sealing lands on an axially shiftable selector element so as selectively to direct fluid which enters the body between various ones of the lip-seals. There is further provided a drain valve in the secondary bore which controls flow of fluid to the drain line.

According to a preferred feature of this invention, the lip-seals are formed as part of a lip-seal member that includes a support ring which carries perforations in its wall to pass fluid therethrough, an external flexible seal to make a fluid seal around the same, and a frusto-conical web to form the lip-seal. A plurality of identical ones of these members may be stacked to form the working parts of the valve.

According to still another preferred feature of this invention, the lands and the lip seal are made of the same material which has a low coefficient of friction in water.

The above and other features of this invention will be fully understood from the following detailed description and the accompanying drawings in which:

FIG. 1 is a side view, partly in axial cutaway cross-section and partly in schematic notation, showing a valve according to the invention and the system in which it functions;

FIGS. 2, 3 and 4 are cross-sections taken at 2—2, 3—3, and 4—4 respectively of FIG. 1;

FIG. 5 is a partial axial cross-section of a portion of FIG. 1;

FIGS. 6, 7, 8 and 9 are fragmentary axial cross-sections showing the device of FIG. 1 in four sequential positions;

FIG. 10 is a cross-section taken at line 10—10 of FIG. 6; and

FIG. 11 is a fragmentary side view of another embodiment of selector element useful in the valve of FIG. 1.

The presently-preferred embodiment of cycling valve 20 according to this invention is shown in FIG. 1. It includes a body 21 having a primary bore 22, a secondary bore 23, and a shaft passage 24. These are co-axially aligned along axis 25. An end cap 26 is attached to and forms part of the body so as to close one end of the primary bore.

The following ports enter through the wall of the body and open into the primary bore: water supply port 27, service port 28, treatment port 29, ejector port 30, and first return port 31. The following ports pass through the wall of the body and enter the secondary bore opening on the internal wall thereof; second return port 32 and drain port 33. Supply port 27 is adapted to be connected to the water supply line, and service port 28 is adapted to be connected to the house line. Drain port 33 is adapted to be connected to a sump or sewer. Conduit 34 directly interconnects treatment port 29 to treatment tank 35. This tank customarily contains a bed of ion exchange resin and filtering material (not shown) in accordance with conventional water softener operation.

Conduit 34 is connected to top opening 36 which enters the treatment tank at its top, i.e., above the treatment material. Conduit 37 connects ejector port 30 to the top opening 36 via an ejector 38. The inlet of ejector 38 is connected by conduit 39 to the bottom of a regenerator tank 40 in which brine is formed and from which it is latter removed.

Treatment tank 35 has a bottom opening 41 below the bed of treatment material. Bottom opening 41 is connected by conduit 42 to first return port 31. Top opening 36 is connected by conduit 43 to second return port 32.

A sleeve 45 fits in the primary bore and rests against shoulder 46, the primary bore thereby being stepped. The sleeve has an eccentric upper flange 49 with a passage 50 therethrough to connect the treatment port to the upper end of the primary bore. Seals 51, 52 seal between the sleeve and the body at this end. Additional seals 53, 54 make seals on opposite sides of ejector port 30, and seals 54 and 55 make seals on opposite sides of supply port 27, while seals 55 and 56 make seals on opposite sides of service port 28.

An internal cylindrical wall 57 is formed throughout the major length of the sleeve. It has a base 58 near one end thereof. Perforations 59 are formed through the wall of the sleeve so that water may flow to and from the lines and conduits between which respective lip-seals function.

Within the internal cylindrical wall 57 there is provided a plurality of lip-seal members 60. There are four of these lip-seal members, namely 60, 61, 62 and 63, these being referred to as the first, second, third and fourth lip-seals respectively. A preferred but optional

feature of this invention is that these lip-seal members are identical and they may simply be stacked in the valve, thereby providing a very accurately-dimensioned structure which can be inexpensively made and assembled. Because the lip-seal members are all identical, only member 60 is shown and described in detail.

Reference is now made to FIG. 5 for details. This drawing shows a support ring 64 which is annular and which has an external ring groove 65 to receive an O-ring as will later be described. Another recess 66 is formed peripherally around the outside of the support ring, and through the base of this recess perforations 67 are formed to pass fluid from the outside to the inside of the support ring.

A web 68 forms a lip-seal 69 on the inside of the support ring. The term "web" is used herein to mean a structure that is relatively thin compared to its length, but which still is shape-retentive and stiffly flexible. For example, the free length of the web is about 0.250 inches, the thickness at its lip about 0.010 inches, and the thickness at its base about 0.100 inches. As can be seen in the drawings, the web is generally frusto-conical and inclined at approximately 45° to the central axis of the support ring. It is firmly supported by its integrity with the base ring, and tapers gradually to a tip 70 which is somewhat flattened in an axial direction so as to form a slight cylindrical portion on the tip with an axial length of about 0.014 inches. The diameter of this cylindrical portion is somewhat less than that of a land which is to fit into it so as to form an interference fit.

End faces 71, 72 are formed flat and accurately spaced apart so as properly to locate the lip and the other parts relative to the body. It will now be seen that the four lip-seal members may simply be stacked into the inside of the insert without any special care, and the parts are accurately placed. Alternatively, it will be noted that one could have eliminated the sleeve, but simplicity of design is attained by the use of it, because identical lip-seal members are more easily accommodated with its use.

The functions of seals 73, 74, 75 and 76 generally correspond to those of seals 53, 54, 55, and 56. It will now be seen that the various ports and lines have access to the insides of the lip-seal members at respective points relative to the lip-seals themselves.

In order to accomplish the cycling operation, a first land 80 and a second land 81 are formed as enlargements on a shaft 82 of a selector member 83. Between the lands, the diameter of the shaft is smaller than that of the lands in order to permit water to flow between them. The selector member is coaxial with axis 25, is axially reciprocable, and fits in the shaft passage 24, making a sealing fit therein by means of seal 84. These lands are cylindrical and their outer diameter makes an interference fit with the lips of the lip-seals. The interference is overcome by the axial thrust of the selector member, the webs being stiffly flexible. A tight fluid-sealing fit readily can be attained with this construction. This seal is best obtained by the seal's pointing toward the direction of higher pressure, rather than in the opposite direction, although the opposite arrangement will also provide a reasonably good seal. Chamfers 85, 86, 87, and 88 are formed on the ends of the lands to aid in the expansion of the lip-seal.

Scallops 89 are formed in the edges of the lands so as to give a metered or somewhat throttled opening and closing action of the valve rather than an abrupt action such as would occur were the ends to be circular and lie in a plane. A drain valve 90 is formed in the secondary bore by means of a plurality of slots 91 which extend axially along the shaft. First and second secondary drain seals 92, 93 are placed in the secondary bore and are axially spaced apart. It will be seen that the slots have an axial length and may provide for a flow as a function of overlap of either of these secondary seals. When in contact with the cylindrical part of the shaft, first secondary seal 92 seals against direct flow between the primary and the secondary bore.

Convenience in design is provided by a two-piece insert 94 which fits into the secondary bore having perforations 95 in its side and an external sealing ring 96 seated in a peripheral groove.

The problem of conventional valves of shortened lives of O-ring seals such as seals 92 and 93 in valve 90 is in part derived from their being punched back into their recesses each time the shaft is moved so that the O-ring passes from a position overhanging a groove to one embracing the shaft. In this device, a peripheral groove is not used. Instead, a plurality of slots is formed, leaving support surfaces 100 (FIG. 10) by which the O-rings are supported when they overlay a slot. Then when the selector member is moved, the O-ring simply rides from the support surface onto a cylindrical portion of the shaft. The gaps between the support surfaces are not large enough to permit sufficient droop of the O-ring into the slot to make pinching a problem.

FIG. 11 shows construction for a selector member 105 which may be used instead of and in place of member 83. Only those parts which differ from member 83 will be shown in detail. Shaft 82 is shown, but its upper portion terminates at two flexible hooks 106, (only one being shown) which pass through the end of a shaft extension 107 so as to hold the extension firmly onto the remainder of the shaft. This enables the extension and remainder of the shaft to be made separately, and provides a less expensive molded selector member. However, the two parts may, if preferred, be cast integrally, or joined by cementing or otherwise if preferred.

First and second lands 108, 109, identical to lands 80 and 81, are connected to each other by ribs 110 instead of by a central reduced portion of the shaft. The ribs leave a flow channel between themselves, and the lands extend radially beyond them. The ribs are, in effect, a continuation of the shaft.

For convenience in disclosure, the lip-seals of the second, third, and fourth lip-seal members are denoted by numbers 111, 112 and 113, respectively, the lip-seal of the first lip seal members 60 being denoted by number 69.

The foregoing completes the description of construction of the valve. The means to actuate the selector member are of no interest to this invention. Such may be a rotary member with a crank arm, or it may instead be a linear actuator as preferred. In any event, the function of the actuator will be to shift the selector member axially so as to make various combinations of contacts between the lip-seals and the lands, and settings of the drain valve so as to secure the design function.

The cycling operation of the valve is shown in FIGS. 6-9. FIG. 6 illustrates the service position wherein the first land 80 leaves the first and second lip-seals 69 and 111 open and in which the second land 81 closes third lip-seal 112 and leaves open lip-seal 113. The flow pattern in this position is from the water supply port 27 through both the treatment and and ejector ports to the top of the treatment tank, through conduit 42, first return port 31, past lip-seal 113 and out service port 28. It will be noted that there is also flow through conduit 37, but because of its parallelism with line 34 (which is generally larger than line 37), there will be insufficient velocity through the ejector to remove brine from the regenerating tank 40. Alternatively, if desired, a valve may be placed in conduit 39 to exert a further restriction on removal of the brine. In the first position, axial slots 91 are disposed out of communication with the drain port 33 so the drain valve is closed.

Position 2 (backwash) is shown in FIG. 7 wherein first land 80 closes lip-seal 111. This also blocks flow past lip-seal 69, while the second land 81 leaves the third and fourth lip-seals 112 and 113 open. Axial slots 91 bridge second secondary drain seal 93 so as to open the drain port to the second return port 32. Now the flow pattern is from water supply port 27 past lip-seals 112 and 113 (note the simultaneous service by-pass directly from port 27 to port 28) out first return port 31 to bottom opening 41, out top opening 36, through conduit 43 to second return port 32, through the drain valve and out drain port 33.

The third position is shown in FIG. 8 (and also in FIG. 1) which is the brine and rinse portion of the cycle and in this setting the first land closes lip-seal 69 and leaves open second lip-seal 111. This puts substantial flow through conduit 37 which will generate sufficient velocity through the ejector to remove the contents of the regenerator tank and discharge them into top opening 36. Flow passes through the tank to bottom opening 41, through conduit 42 to first return port 31 which finds only drain valve 90 open to drain port 33, because the slots overlap only first secondary drain seal 92, and lip-seal 113 is closed by land 81. This action continues until the brine is entirely withdrawn from the tank and then continues with pure water from the water supply so long as the selector member remains in this position. The condition after the regenerator tank is evacuated is referred to as the rinse cycle. Also at this time there also occurs the bypass flow from water supply port 27 directly to service port 28 to provide the house with service of untreated water.

The next setting (position 4) is that of quick rinse which gives a greater flow of water through the treatment tank than in the third position in order to flush out any remaining brine. This condition is shown in FIG. 9 wherein the first land 80 leaves first and second seals 69 and 111 open and in which the second land 81 leaves open lip-seal 112 and closes lip-seal 113. Also, in this condition there is the bypass flow from port 27 to port 28 to keep the house supplied with water, but both ports 29 and 30 are open to flow, which gives an augmented rinse flow. Incidentally, at this condition the regenerator tank can begin to refill. The flow in this position is from ports 29 and 30 to top opening 36, out bottom opening 41, through first return port 31, through the drain valve, and out the drain port.

After the quick rinse, the valve is returned to its first (service) condition.

More will not be said of the properties of the lip-seal members and of their matching lands on the selector members. There have been numerous efforts made to build cycling valves wherein the sealing action has been done by various sliding motions of compressible members against a substantially solid member. However, this is not a reliable means by which to establish a closely defined cycling operation based upon the axial positions of a stem carrying laterally and axially extending lands. Quite to the contrary. This is such a limitation that this class of valve has not heretofore been salable at a favorable price in view of the maintenance which would be expected.

In the device of this invention, both the selector member and the lip-seals are preferably made of the same material, the preferred material being a stiffly flexible plastic material such as the acetyl copolymer sold by Celanese Corporation of Clark, New Jersey, under its trade mark Celcon M-90. Suitable plastic materials such as this one have the property of a substantial elongation within their elastic limits and also a low coefficient of friction, especially when wet.

In a valve in which the first and second lands have a diameter on the order of 1.000 inches, the surface 70 on the lip-seals may expeditiously be on the order of this diameter less between about 0.002 and 0.010 inches, whereby to form an interference fit which is well within the capacity of the material to be expanded and deflected so as to maintain a smooth scraping effect between the lip-seal and the land so as to make the appropriate seal. The seal is tight, and is kept clean. When the upstream pressure faces the frusto-conical web in such a manner as to force the web toward the land, then the seal will be even more reliable. In the event that the differential pressure is reversed, still this makes for a reliable sealing action because, especially for low pressures, the restorative forces of the material of the web will tend to maintain the seal closed. Of greater importance is the fact that the lands can enter the lip-seals from either direction (notice for example land 80 in FIGS. 6, 7, and 8). The valve is thereby truly bi-directional in mechanical function.

Preferably the land and the lip-seal will be made of the identical material and they will also be made of plastic materials, whose wet coefficient of friction is low, and which is self-lubricating. By self-lubricating is meant that the substance of a material will not gall or otherwise attract itself with it is drawn against the like material, so as to avoid the "stick-slip" effect, and gouging of the material. Such disadvantages would be found when materials such as lead are used. In the example given, the plastic material is self-lubricating, meaning that it has no tendency to adhere to itself, and that two contiguous surfaces will readily free themselves from adherence to each other.

This invention thereby provides a five-cycle valve wherein the device can operate to provide a cycling system of a class which is well-known in the prior art, but which valve can readily be manufactured by the use of simple molding operations. It is intuitively obvious that the lip-seal constructions shown in this invention can be made by simple and straight forward molding operations and that the device can therefore provide sophisticated functions, but with moderate costs and expenditures both in tooling and assembly costs in manufacturing the valve and system.

This invention is not to be limited by the embodiment shown in the drawings and described in the description which is given by way of example and not of limitation, but only in accordance with the scope of the appended claims.

We claim:

1. A cycling valve for a water treatment system in which system there is included a water supply line, a service line, a drain line, a regenerator tank, an ejector connected to the regenerator tank, and a treatment tank, the treatment tank having a top opening and a bottom opening, said cycling valve comprising: a body having a primary bore, a secondary bore, and a shaft passage, each having an axis and being coaxial with the others, a supply port through the body to the primary bore for connection to the water supply line, a service port through the body to the primary bore for connection to the service line, a treatment port through the body to the primary bore for connection to the top opening, an ejector port through the body to the primary bore for connection to the top opening through the ejector a first and a second return port through the body to the primary and secondary bore respectively, connected to the bottom and top opening, respectively, and a drain port through the body to the secondary bore for connection to the drain line; a first, second, third and fourth axially spaced-apart annular frusto-conical lip seal in fluid-sealing connection with the wall of the primary bore, the treatment port opening onto the primary bore on the side of the first lip seal opposite from the second lip seal, the ejector port between the first and second lip seal, the supply port between the second and third lip seal, the service port between the third and fourth lip seal, and the first return port on the side of the fourth lip seal opposite from the third lip seal; a first and a second axially spaced-apart peripheral secondary drain seal in the wall of the secondary bore, the return ports being on opposite sides of the two secondary drain seals; and a selector member, comprising a shaft making a fluid-sealing fit in the shaft passage and extending axially into the two bores, a first and a second cylindrical land on said shaft and axially spaced-apart thereon, an axially-extending drain slot formed in said shaft, the lands being so proportioned and disposed as to cause the following combinations of fluid-sealing contact with respective lip seals in respective axial positions of the selector member:

Position	Lip Seal 1	Lip Seal 2	Lip Seal 3	Lip Seal 4
1	open	open	closed by second land	open
2	open	closed by first land	open	open
3	closed by first land	open	open	closed by second land
4	open	open	open	closed by second land

the drain slot lying entirely in the primary bore in the first position, overlapping the second secondary drain seal in the second position, and overlapping the first secondary drain seal in the third and fourth positions,

thereby shutting off the drain port from the both return ports in the first position, opening it to the second return port in the second position, and opening it to the first return port in the third and fourth positions.

2. A cycling valve according to claim 1 in which the lip seals are stiffly flexible, conical frustums which make an interference fit with the respective lands.

3. A cycling valve according to claim 2 in which the frustums are formed as webs.

4. A cycling valve according to claim 1 in which the lip seals and the lands are made of the same material, the material being self-lubricating.

5. A cycling valve according to claim 1 in which the axial edges of the lands are scalloped, whereby to provide a gradual throttling of a flow channel past the respective lip seal.

6. A cycling valve according to claim 1 in which a tubular sleeve is fitted between the wall of the primary bore and the lip seals, said sleeve carrying axially spaced-apart seal means to separate the treatment port, ejector port, supply port, service port and first return port, and having perforations between said seal means to provide fluid communication from said ports to an internal cylindrical wall in said sleeve, and in which the lip seals are each comprised of a support ring carrying an external flexible seal, said support ring being annular and having a perforation therethrough, and a frusto-conical web tapering axially and inwardly, said lip seals being stacked inside said sleeve, with the flexible seals in sealing contact with the internal wall thereof, and the perforation in the lip seal in fluid communication with a respective perforation in the sleeve.

7. A cycling valve according to claim 6 in which the lip seals are identical, and the sleeve is formed with a cylindrical internal wall to receive the lip seals as a stack.

8. A cycling valve according to claim 6 in which an insert is fitted into the secondary bore to carry the second secondary drain seal.

9. A valving assembly for a water softener valve comprising: a cylindrical land having a diameter and a central axis which is its axis of longitudinal motion, and a lip seal member comprising a one-piece monolithic peripheral support ring and an axially extending frusto-conical web having a circular hole therethrough with a diameter less than that of the land, the web being stiffly flexible and having radially internal and external frusto-conical surfaces, an external ring groove being formed in the support ring in its radially outermost axially extending surface, and a flexible peripheral seal in said external ring groove, a perforation being formed through said support ring to pass fluid radially through the ring, the land being adapted to enter and close the hole in the web in one position, and to move out of it in another.

10. A valving assembly according to claim 9 in which the web and the land are made of the same material, the material being self-lubricating.

11. A valving assembly according to claim 9 further including a sleeve having a cylindrical internal wall with a perforation therethrough to pass fluid through its wall at a selected axial location, the support ring fitting in fluid sealing relationship therein.

12. A valving assembly according to claim 11 in which a stack of identical ones of said lip seal members is disposed in the sleeve.

13. A valving assembly according to claim 12 in which a plurality of said lands is formed on a shaft for axial reciprocation relative to the webs and for engagement with them in various combinations.

14. A valving assembly according to claim 13 in which the webs and the lands are made of the same material, the material being self-lubricating.

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