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[54] **REGULATOR VALVE**
 21 Claims, 8 Drawing Figs.

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 137/614.17, 251/282, 251/324

[51] Int. Cl. **G05d 11/00**

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 505.18, 607, 613, 614.17; 251/324 (Inquired),
 282 (Inquired); 137/505.27, 505.28 (Inquired);
 251/325, (Digest); 277/71, 72, 79, 92/163

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ABSTRACT: A regulator valve operative to open and close outlet ports in accordance with a differential pressure between the inlet and outlet conduits utilizing an actuator having O-rings fitted with O-ring grooves which O-ring grooves are slightly wider than the O-rings so that the O-rings will be compressed in the grooves by the inlet pressure to a depth equal to or less than the depth of the O-ring groove so as to prevent wear on the O-rings as they pass the openings during movement of the valve actuator. The movable valve actuator with its associated O-rings is additionally designed for different types of operations controlling more than one inlet port and more than one outlet port.

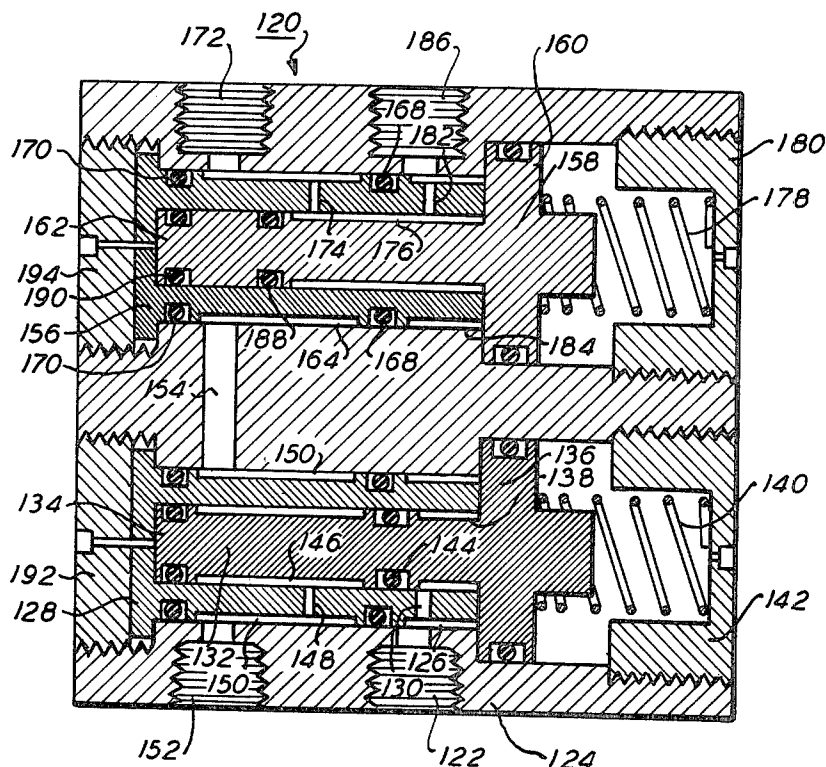


FIG. 1

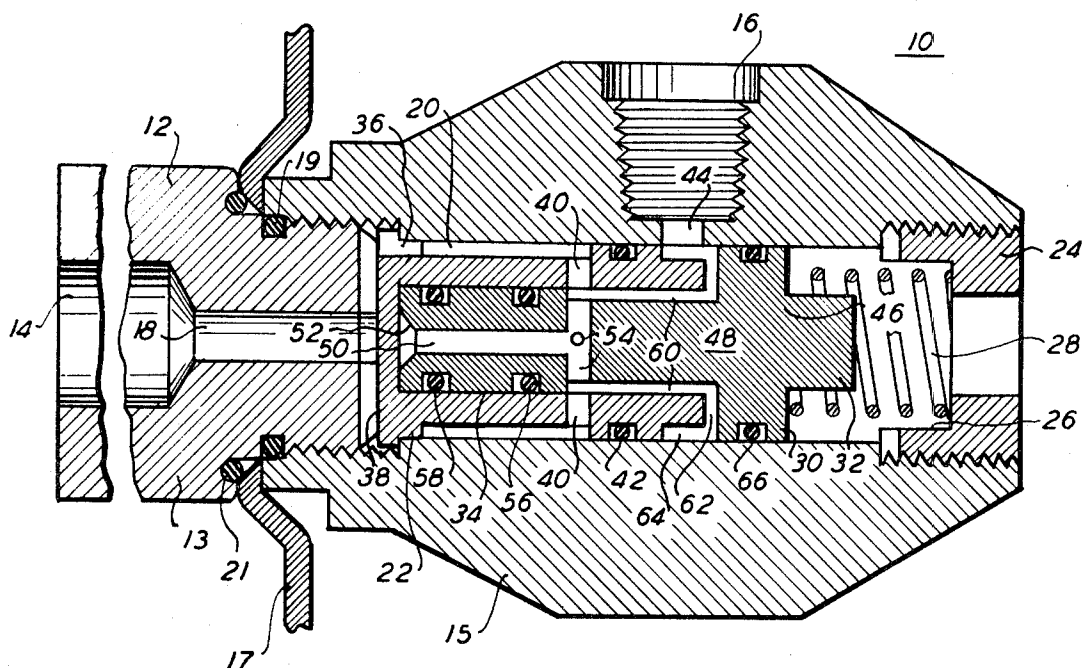
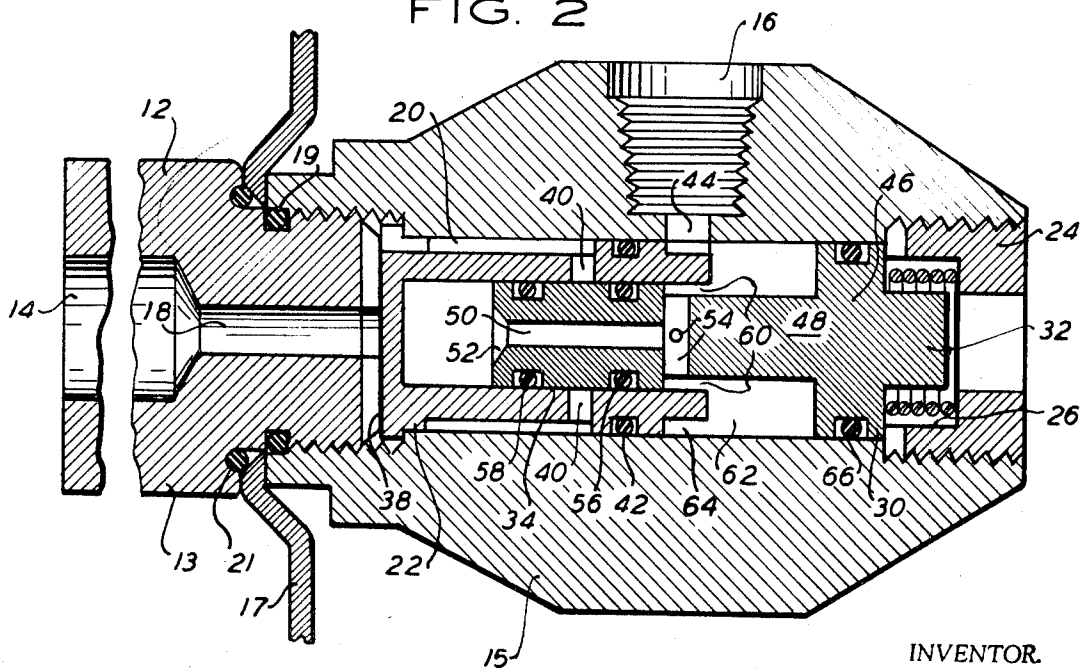


FIG. 2



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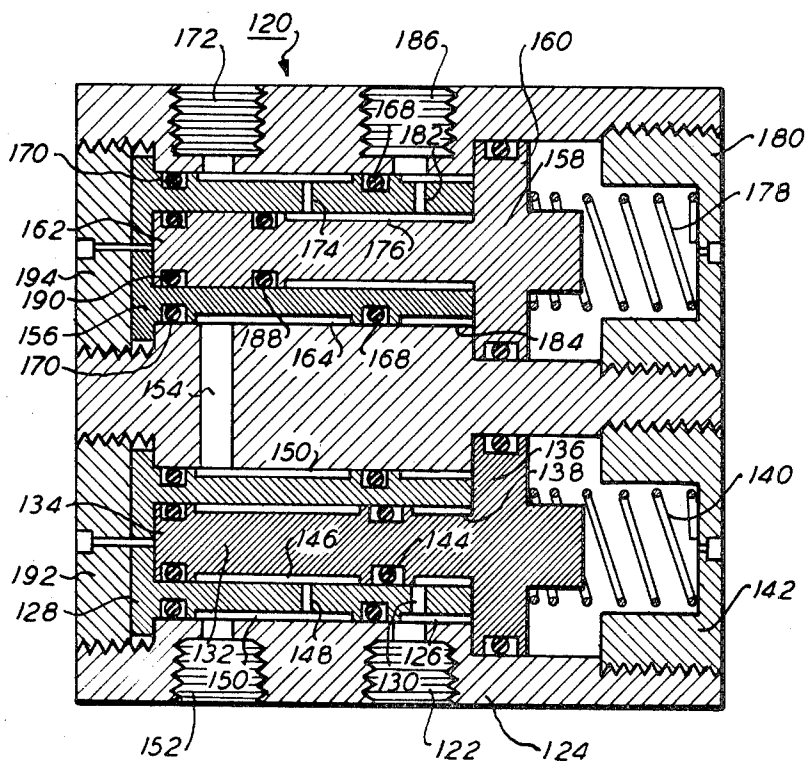
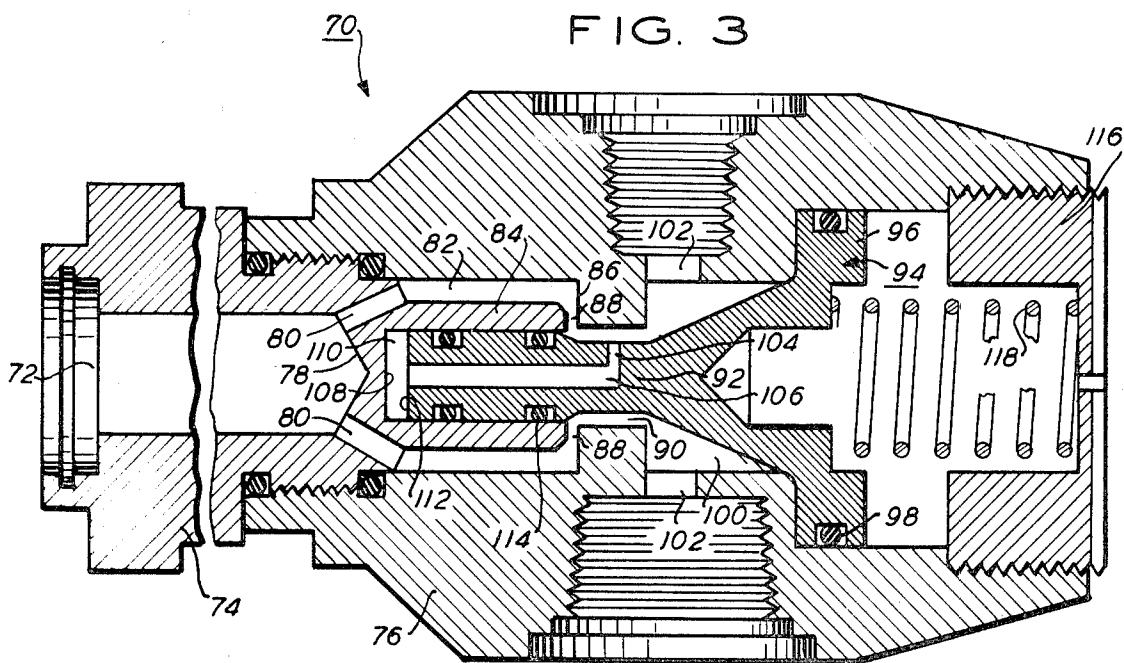
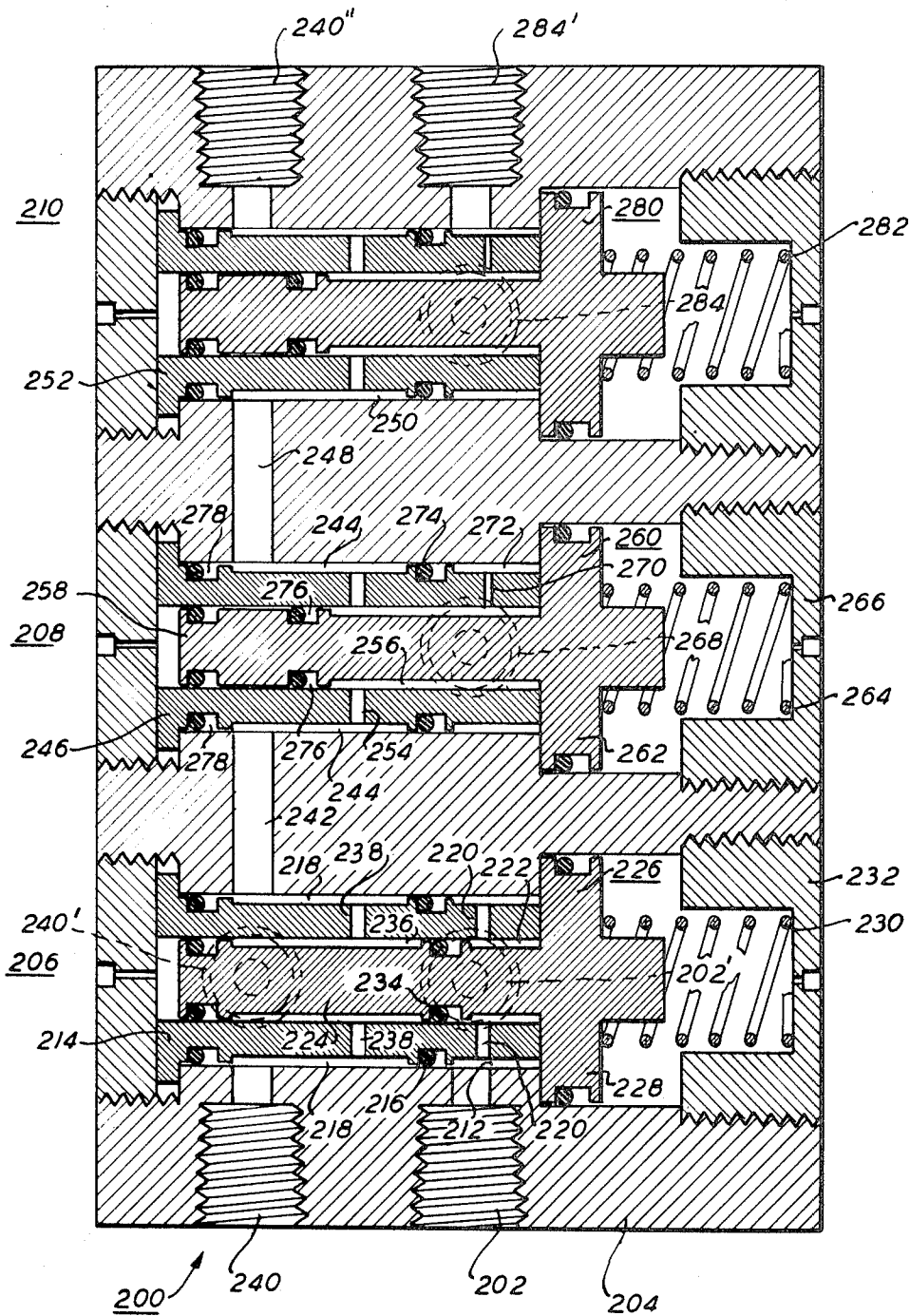


FIG. 4

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FIG. 5



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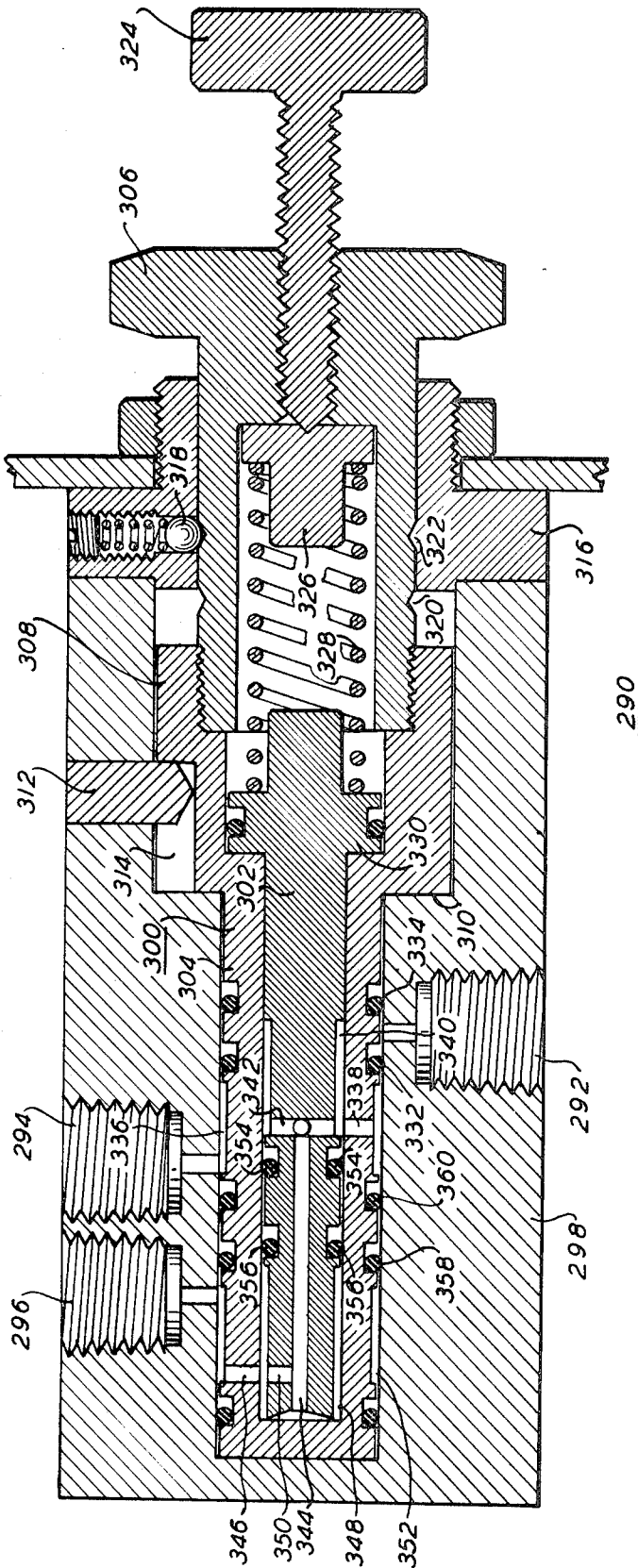
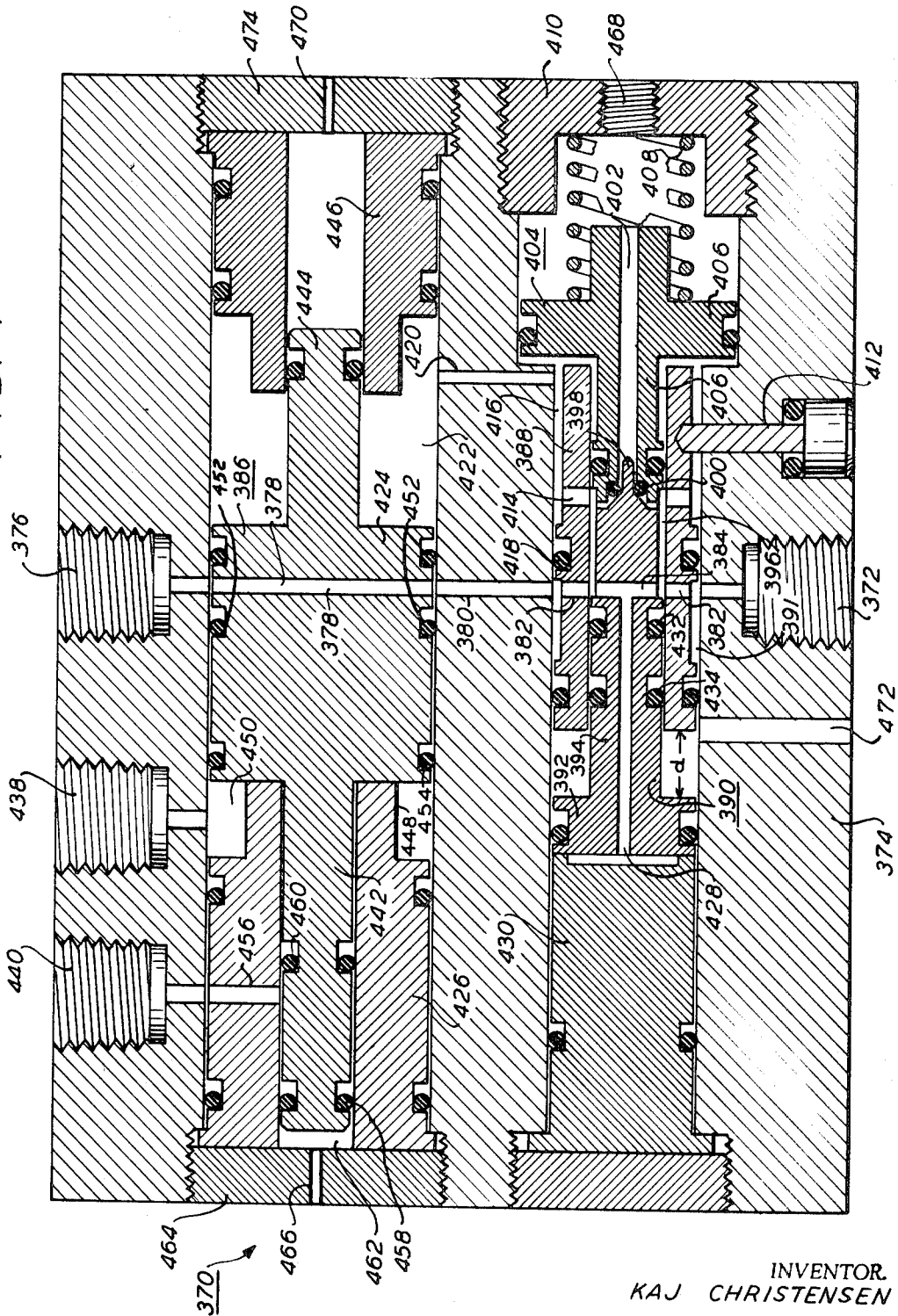


FIG. 6

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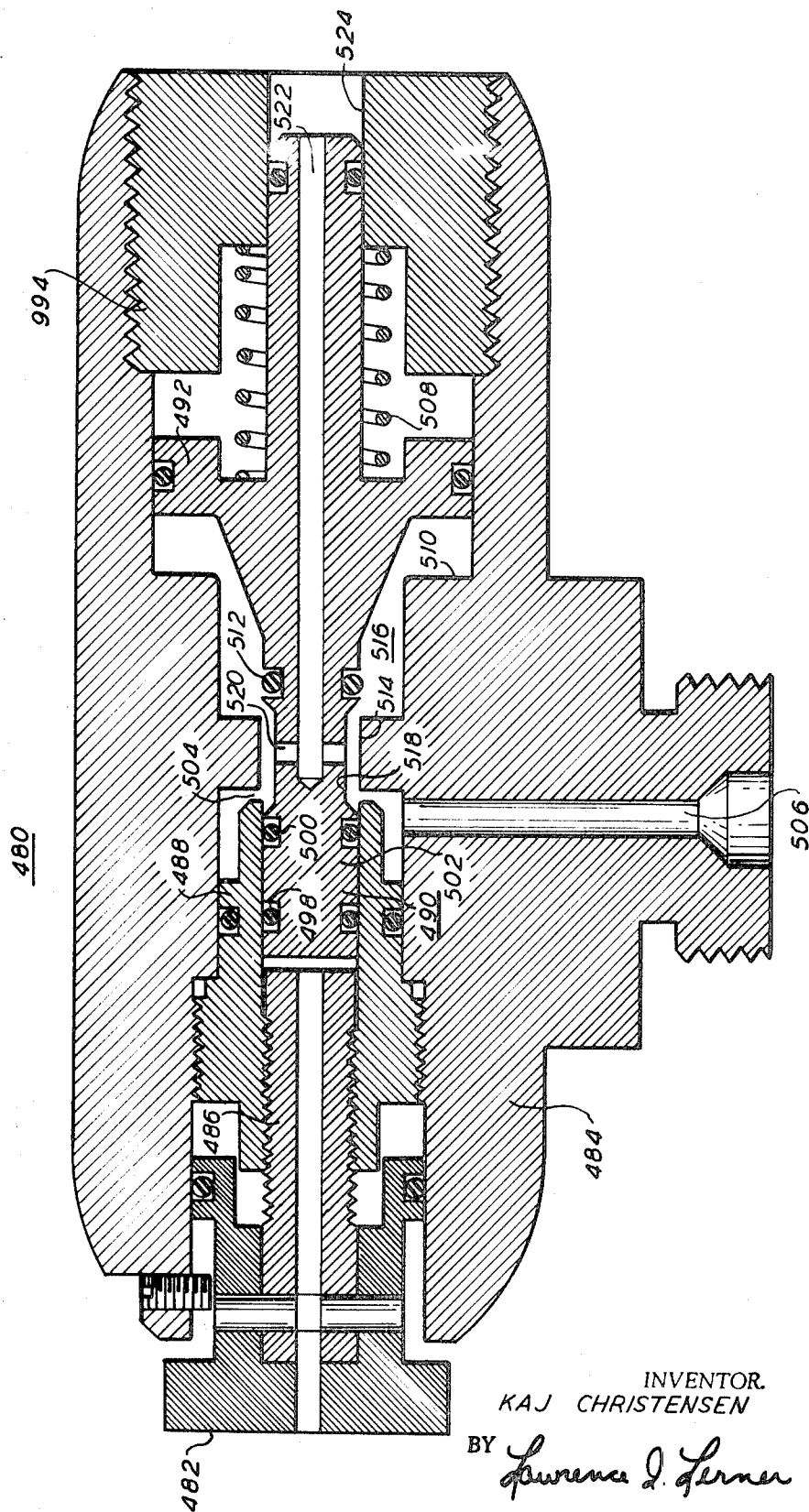
FIG. 7



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FIG. 8



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REGULATOR VALVE

In general, this invention relates to a new and improved regulator valve and more particularly to regulator valves which are self-balancing and require only a minimum differential pressure to operate and shift connections between inlet and outlet ports.

In the past, automatic regulator valves have been provided which were extremely expensive to manufacture and required large changeover pressure differentials to achieve actuation of the valve. Further, the regulator valves were not expandable in design to include a plurality of controllers each operative with a single inlet pressure to open or close output conduits with only the slightest change in pressure differential. Still further, the regulator valves of the prior art have been ineffectual in achieving a true self-balancing of the valve actuator so that the movement thereof could be made contingent upon inlet pressures in excess of a predetermined value.

Thus, the present invention is directed to a regulator valve which is operative to open and close outlet ports in accordance with a differential pressure between the inlet and outlet conduits. With the present invention, a slight change in differential pressure between inlet and outlet conduits will cause actuation of the valve to effect changeover. Still further, the present invention comprises a regulator valve operative with extremely high pressure which can be hand adjusted with little effort by reason of the self-balancing feature. Thus, the only force to overcome during such adjustment would be the frictional contact between the O-ring seals on the valve actuator and the abutting surfaces of the valve body.

The present invention is also directed to the provision of a valve regulator which can be manufactured by screw machining methods so as to keep the cost of manufacture to a minimum. Further, by the unique arrangement of O-ring grooves and the O-rings therein, it is possible to obtain a positive sealing action with a minimum of wear on the O-rings. That is, in a regulator valve which, with repetitive use, might require an O-ring to pass an inlet or outlet opening many times during a given period of use, there would normally be cutting, scrapping, or other types of frictional contact between the O-ring and the edges of the inlet and outlet openings. However, by the unique arrangement of the present invention this type of wear is substantially eliminated without loss in sealing efficiency.

By avoiding the use of diaphragms in the regulator valve of the present invention and by only utilizing O-ring seals and coil springs as the load-bearing elements of the regulator, constant design criteria can be maintained over long periods of use. Further, in the regulator valve of the present invention the valve actuator, i.e., the movable plunger, can be designed for any desired operation of the regulator, as for connecting any one of a plurality of inlet conduits to any one of a plurality of outlet conduits. By utilizing this type of valve actuator, the design consideration as to the particular mode of operation of the regulator valve can be effected by merely screw machining the proper grooves in the cylindrical movable plunger.

Further, the regulator valve of the present invention, in one embodiment, is designed in the manner whereby mere linear movement of the setting member of the regulator makes it possible to change the inlet conduit being regulated, and, further, the particular inlet being regulated can have the pressure at which it is regulated varied by a single member. That is, the single member will vary the pressure at the position set by the setting member.

Therefore, it is the general object of this invention to provide a new and improved regulator valve which is efficient in operation and can be adjusted for various pressures with little or no effort.

Still another object of this invention is the provision of a new and more efficient regulator valve, which is self-balancing and requires a minimum differential pressure to be actuated.

A further object of this invention is the provision of a new and better regulator valve capable of being utilized in a system for regulating a plurality of output pressures and, further, to regulate the input pressure with individual control for each pressure to be regulated.

A still further object of this invention is the provision of a new and better regulator valve which achieves efficient sealing of inlet and outlet ports with a minimum of wear on the sealing elements.

Other objects will appear hereinafter. For the purpose of illustrating the invention, there are shown in the drawings forms which are presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIG. 1 is a cross-sectional view of a regulator valve built in accordance with the principles of the present invention.

FIG. 2 is a cross-sectional view of the valve of FIG. 1 in the closed position thereof.

FIG. 3 is a cross-sectional view of a regulator valve similar to the valve of FIG. 1.

FIG. 4 is a cross-sectional view of a second valve regulator built in accordance with the principals of the present invention.

FIG. 5 is a third embodiment of the present invention similar to that shown in FIG. 3.

FIG. 6 is still another embodiment of the present invention.

FIG. 7 is still further embodiment of the present invention.

FIG. 8 is still another embodiment of the present invention.

In FIG. 1, there is shown a regulator valve generally designated by the numeral 10, which regulator valve is especially useful for continuous regulation of the pressure of an outlet conduit such as would be extremely useful in underwater breathing apparatus. That is, the regulator valve 10 includes a main body 12 comprising an end portion 13 and a main body portion 15 screw threaded together so as to hold the main body 12 in place on a wall 17 having a circular hole therethrough. The end portion 13 is connected to the main body portion 15 through screw threads which are sealed against leakage by reason of the O-ring seal 19. Further, the wall 17 is sealed about the end portion 13 by reason of an O-ring seal 21.

An inlet port 14 in end portion 13 is in communication through a bore 18 in end portion 13 to an axially aligned cylindrical recess 20 in the main body portion 15. The axially aligned cylindrical recess 20 has one end thereof sealed by a plug or end cap 24. The plug 24 has a recess 26 therein for seating a helical spring 28 which presses against a wall 30 of an axially aligned movable actuator 32. The axially aligned movable actuator 32 rests within a cylindrical recess 34 in a sleeve 22 fitting within the cylindrical recess 20. The sleeve 22 has grooves 36 extending axially on the surface thereof from the flat-face 38 of this sleeve 22 opposite the recess 18 to a point central of the length of the sleeve 22. A plurality of radial holes 40 extends from the grooves 36 into the cylindrical recess 34 of the sleeve 22. The sleeve 22 is sealed by O-ring seals 42 placed in grooves on the circumference of the sleeve 22 to prevent leakage of air from grooves 36 into a bore or port 44 in main body 15 extending between the cylindrical recess 20 and outlet opening 16.

The movable valve actuator 32 has an enlarged head portion 46 and a reduced diameter end portion 48. The reduced diameter portion 48 extends from the enlarged head portion 46 axially toward the closed end of the cylindrical recess 34. The reduced diameter portion 48 has an axial passageway 50 extending from a tapered recess end wall 52 to a point central of the reduced diameter end portion 48. At the last-mentioned central portion, a plurality of radial passageways 54 extend outwardly from the axially passageway 50 and, in the position shown in FIG. 1 are aligned with the radial passageways 40 in sleeve 22. The reduced diameter end portion 48 has a pair of spaced O-ring seal members 56 and 58 positioned respectively on the periphery of reduced diameter portion 48 adjacent radial passageway 54 and tapered recess end wall 52. An annular groove 60 extends from the radial passageways 54 to the enlarged head portion 46 along the reduced diameter portion 48. In the position shown in FIG. 1, it can be seen that the annular groove 60 extends so as to define an annular passageway 62 between the annular groove 60 and a second annular groove 64 on the outer edge of the

sleeve 22 which, as shown, is in communication with the port 44. The enlarged head portion 46 has a suitable O-ring seal 66 which prevents the leakage of air from the passageway 62 and assures that all of the air will be transmitted to the port 44.

The operation of the regulator valve shown in FIGS. 1 and 2 is as follows:

Air enters the regulator valve 10 at inlet port 14 and passes through bore 18. The, the air is forced through the passageways 36 on the periphery of cylinder 22, through the radial passageways 40, annular groove 60, annular passageway 62, to port 44 and to the outlet opening 16. This continues until the pressure at the outlet opening 16 as provided from the inlet port 14 exceeds the spring pressure exerted by the coil spring 28. Then, the air pressure which has built up within the sleeve 22 by reason of the air passing through the radial passageways 54 and axial passageway 50 to the tapered recess end face 52 of the movable plunger 32 will be greater than the spring pressure exerted by the spring 28, thus causing the plunger 32 to move toward the right as shown in FIG. 2. It will be noted that, when in the position shown in FIG. 2, if the outlet pressure at the opening 16 drops below the spring pressure, the spring 28 will force the movable plunger 32 back to the position shown in FIG. 1. Accordingly, there will be regulation of the pressure at the outlet opening 16 in accordance with the pressure of the spring 28. The only differential pressure required to move the plunger 32 is that necessary to overcome the friction of the plunger 32 as it moves axially within the valve regulator 10.

It should further be noted that whenever the O-ring seal 56 passes the radial holes 40, air pressure is forcing the O-ring gasket 56 against the groove on the outer surface of the reduced diameter portion 48. Accordingly, the O-ring gasket seal 56 will not be cut by the edges of the radial holes 40, and, accordingly, the life of the O-ring gasket seal is considerably extended. In fact, it has been found that by placing the seals on the outer surface of the moving plunger so that air pressure is always forcing the gasket seal against the groove when the O-ring seal passes a passageway, the wear on the O-ring gasket seal is virtually negligible.

It will also be understood that the pressure at which the valve regulator 10 operates can be simply and easily varied by merely rotating the insert 4 to reduce the pressure on the spring 28.

It should further be noted that all of the parts of the valve regulator 10 can be screw machined and, thus, the cost of manufacturing the valve regulator is considerably reduced.

By avoiding the use of diaphragms, and only using O-ring seals and coil springs as the load-bearing elements of the regulator 10, constant design criteria can be maintained over long periods of use.

FIG. 3 shows a valve regulator 70 which is substantially similar to the valve regulators of FIGS. 1 and 2 except for small design variations. That is, the valve regulator 70 has an inlet passageway 72 therethrough for receiving air. Passageway 72 is in the combined head and cylinder member 74 which is screw threaded into securement with the main body 76. The passageway 72 ends at a wall 78 through which are drilled passageways 80 which extend into the recess 82 formed by the reduced diameter cylinder portion 84 of the member 74. The main body 76 has an end wall 86 perpendicular to the axis of the valve regulator 70 which, in cooperation with the end wall of the cylinder portion 84 forms an annular passageway 88 for allowing air from the inlet passageway 72 into an annular recess 90 formed between the reduced diameter portion 92 of the main valve actuator 94 and the main body 76. It will be immediately obvious that by merely screw threading the element 74 with respect to the main body 76 it is possible to vary the width of the passageway 88. Accordingly, the inlet passageway 88 can be formed without the need for drilling extremely small diameter holes as was required in the embodiment of FIGS. 1 and 2. This is especially useful where miniaturization of the valve regulator 70 is required.

The movable plunger 94 has an enlarged head portion 96 sealed by reason of O-ring seals 98. The enlarged head portion 96 is tapered to meet the reduced diameter portion 92, and, accordingly, to form a recess 100 which allows air to pass to an outlet passageway 102. In FIG. 3, there are two outlet passageways, 102, and it will be understood that one of these outlet passageways 102 will be utilized for the placement of a pressure gauge.

The reduced diameter portion 92 is similar to the reduced diameter portion 48 of the valve regulator 10 in the FIGS. 1 and 2 and, accordingly, has radial passageways 104 and an axial passageway 106. However, the enlarged head 96 prevents the reduced diameter portion 92 from reaching the back wall 108 of the recess 110 of the cylindrical portion 84 so that the air can act fully against the back face 112 of the movable actuator 94. Of course, O-ring seal 114 on the surface of the reduced diameter portion 92 acts in the same manner as O-ring seal 76 in valve regulator 10 in that air pressure through the annular opening 88 is always forcing the O-ring 114 against its groove as the O-ring seal passes by the annular passageway 88. The valve regulator 70 operates similarly to the valve regulator 10 and, accordingly, rotation of the insert 116 in the head 76 varies the pressure on the spring 118 which spring is biased against the enlarged head 96 of the axially movable actuator 94.

Again, it should be noted that all of the parts can be screw machined and, further, all of the other advantages discussed with respect to FIGS. 1 and 2 are applicable. Further, as was stated previously, the size of the annular passageway 88 can be varied and there is no need for drilling small diameter holes in the valve actuator.

In FIG. 4, there is shown a valve regulator 120 built in accordance with the principles of the present invention which regulator is intended to regulate two output conduits at individually controllable pressures. That is, air, under pressure is supplied to an inlet portion 122 in the main body 124 of the regulator valve. Air enters the inlet conduit 122 and through an annular groove 126 on the outer peripheral surface of a cylindrical cup-shaped insert 128. The air, also enters through a radial hole 130 in the wall of the cylindrical cup-shaped insert 128 adjacent to the annular groove 126. Within the recess of the cup-shaped cylindrical insert 128, there is positioned an axially movable valve actuator 132 having a reduced diameter portion 134 and an enlarged head portion 136. Adjacent to the enlarged head portion 136, the reduced diameter portion 134 has an annular groove 138 which extends between the enlarged head portion 136 and the radial passageway 130 in the cylindrical insert 128 when the enlarged head portion 136 abuts the open end walls of the cylindrical insert 128.

The enlarged head 136 is held against the cylindrical insert 128 by a spring member 140 whose tension is controlled by a screw-threaded plug or end cap 142. It will easily be understood that the valve actuator 134 will not move axially until the pressure at the inlet port 122 exceeds the preset pressure of spring 140. When that occurs, the valve actuator 132 moves against the spring 140 compressing the same, and forcing O-ring seal 144 positioned on the reduced diameter portion 134 past the radial passageway 130. The O-ring seal 144 divides and spaces annular groove 138 from a second annular groove 146 on the reduced diameter portion 134. Thus, when the air pressure at the inlet port 122 exceeds the preset pressure, air is supplied from the the inlet port 122 through radial passageway 130 to the annular groove 146. Adjacent the annular groove 146 there is provided a second radial passageway 148 through the cylindrical insert 128 leading to a second annular groove 150 on the periphery of the cylindrical insert 128.

The second annular groove 150 is in communication with a first outlet port 152 which, as can be seen, is controlled by the actuator 134. It will be seen that this outlet port can have a minimum pressure therein, but no maximum pressure. For example, the minimum pressure could be set for 60 pounds per square inch (hereinafter called p.s.i.).

The annular groove 150 is in communication with a passageway 154 leading to the other half of the valve regulator 120 which, includes, a second cylindrical cup-shaped insert 156 having axially disposed therein a second valve actuator 158 having an enlarged head portion 160 and a reduced diameter portion 162.

The air passing through passageway 154 enters a space formed by an annular groove 164 on the outer surface of the cylindrical insert 156 which annular groove is sealed by O-ring seals 168 and 170. The annular groove 164 is in communication with a second outlet 172 which will have the exact same pressures as are received on the first outlet 152. In fact, one of the outlets 152, 172 is normally utilized for receiving a manometer or other pressure gauge.

A radial passageway 174 in the cylindrical insert 156 adjacent the annular groove 164 allows air to pass into the recess within cylindrical insert 156 formed by reason of an annular groove 176 on the reduced diameter portion 162. The enlarged head portion 160 is biased against the cylindrical insert 156 by a coil spring 178 whose pressure is controlled by end cap 180. Air in the annular groove 176 passes through a second radial passageway 182 in the cylindrical insert 156 which extends to a second annular groove 184 on the outer surface of the cylindrical insert 156. Annular grooves 164 and 184 are kept separate by reason of the O-ring seal 168. The annular passageway 184 is in communication with a third outlet port 186. It will be understood that the pressure on the outlet port 186 will be maintained above the pressure set by spring 140 and, below the pressure set by the spring 178. That is, in the position shown in FIG. 4, if actuator 134 has moved to the right so that air pressure is supplied to outlet ports 152 and 172, it will also be supplied through radial passageway 174, annular groove 176 and radial passageway 182 to outlet port 186. However, if the air pressure exceeds a preset valve higher than the pressure on actuator 132, this pressure is supplied against the enlarged head portion 160 of the valve actuator 158. When this air pressure exceeds the pressure set by the spring 178, O-ring seal 188 and O-ring seal 190 on reduced diameter portion 162 will effectively seal the radial passageway 174 and prevent any additional air pressure being supplied to the outlet conduit 186. Should the air pressure drop below the value set by spring 178, the valve actuator 158 will move back to the original position shown in FIG. 4 and, accordingly, the radial passageway 174 will again be in communication with the annular groove 176. In a specific embodiment, the pressure on spring 178 was set at 80 p.s.i. and, accordingly, outlet ports 152 and 172 were regulated to supply air pressure only at values above 60 p.s.i. whereas outlet port 186 supplied air pressure at values between 60 p.s.i. and 80 p.s.i.

It will be understood that the particular pressures at which regulation is effected can be simply controlled by variation of the end caps 142 and 180.

It should also be noted that the cylindrical inserts 156 and 128 are secured in place by end caps 192 and 194 respectively. All of the end caps 142, 180, 192, and 194 and the cylindrical inserts 128 and 156 have bleed holes therethrough, in order to allow any air passing by the O-ring seals within the valve regulator 120 to escape to the atmosphere.

It should further be noted that all of the O-ring seals 188 and 144 which pass by the radial passageways 130 and 174 are operative to have the air pressure force them down against their grooves so that there will be little or no wear thereon. Further, it should be noted that once the valve actuator reaches the pressure exerted by its associated coil spring, it is only necessary to provide an additional differential pressure equal to the frictional forces on the valve actuator to effect movement thereof.

Still further, it should be noted that the valve regulator 120 can be easily assembled and that all of the parts can be screw machined so that the cost thereof can be held to a minimum.

Still further, it should be noted that the ports 152 and 172 and the passageway 154 are aligned so that they can be formed by simply drilling straight through the main body 124.

In FIG. 5, there is shown still another embodiment of the present invention generally designated by the numeral 200 the regulator valve 200 is similar to the embodiment shown in FIG. 4 with the exception that three outlet ports are to be regulated by three separate valve actuators. Thus, the valve regulator 200 includes an inlet port 202 which extends through the main body 204 in which are positioned three valve-regulating sections 206, 208, and 210. The regulating section 206 also includes a second inlet port 202', it being understood that only one inlet port is necessary. The inlet ports 202 and 202' are in communication with an annular groove 212 on the outer surface of a tubular insert 214 and, additionally, the tubular insert 214 has a seal 216 thereon for dividing and separating the annular groove 212 from a second annular groove 218. A radial passageway 220 passes through the tubular insert 214 adjacent the annular groove 212 so as to communicate with an annular recess 222 on the outer surface of the reduced diameter portion 224 of a movable valve actuator 226. The actuator 226 has an enlarged head portion 228. The enlarged head portion 228 is biased against the tubular insert 214 by a coil spring 230 held in place by an end cap 232 which can effectively vary the pressure exerted by the spring 230 of the valve actuator 226. When the pressure at the inlets 202 and 202' exceeds the preset pressure of spring 230, the valve actuator 226 moves axially to the right until O-ring seal 234 passes over radial passageways 220 to communicate the radial passageways 220 with a second annular groove 236 on the reduced diameter portion 224. Then, the radial passageways 220 will be in communication with a second set of radial passageways 238 which communicate with the second annular grooves 218. Annular grooves 218 are in direct communication with first outlet ports 240 and 240'. It will be noted that output ports 240 and 240' will receive pressure above the preset pressure of spring 230, but not below this preset pressure. Further, it will be noted that annular groove 218 is in direct communication with still another port, i.e., outlet port 240'' through passageway 242 communicating between annular groove 218 and a similar annular groove 244 on tubular insert 246, a second passageway 248 communicating between annular groove 244 and an annular groove 250 on a third tubular insert 252 completing the communication with an outlet port 240''. From this, it can be seen that once the pressure at the inlet 202 exceeds the spring pressure of spring 230, air is supplied to both sections 208 and 210 through their respective annular grooves 244 and 250.

Air supplied to annular groove 244 passes through radial passageway 254 in tubular insert 246 to communicate with an annular groove 256 on the reduced diameter portion 258 of a second section movable actuator 260 having an enlarged head 262 which is spring biased by a spring 264. The spring 264 has its pressure controlled by an end cap 266. Further, annular groove 256 is in communication with outlet port 268 and, further, through a second radial passageway 270 through tubular insert 246 with a second annular groove 272 separated from annular groove 244 by O-ring seal 274.

It would be thus obvious that once valve actuator 226 has moved to the right due to the air pressure from inlet port 202 exceeding the pressure of spring 230, air pressure is supplied to the outlet port 268 in the manner discussed above. However, as the air pressure builds up, a pressure in excess of the spring pressure of spring 264, will cause movable valve actuator 260 to move to the right and, accordingly, O-ring seals 276 and 278 on reduced diameter portion 258 of valve actuator 260 will seal radial passageway 254. Thus, no additional air pressure will be supplied to the outlet port 268. The outlet port 268 will be maintained at this upper limit of pressure determined by the spring 264 until the air pressure at inlet port 202 drops below the value set by spring 264. Further, it should be noted that the pressure at the outlet port 268 will maintain at the upper pressure limit so long as the pressure at the inlet port 202 is above the upper pressure limit.

For example, the spring 230 can be set for 60 p.s.i. and spring 264 set for 90 p.s.i. so that section 208 will regulate its outlet port 268 between 60 and 90 p.s.i. whereas section 206

will regulate its outlet ports 240, 240' and 240'' to supply air pressure above 60 p.s.i.

The air supplied to annular groove 250 section 210 is operative to control section 210 in the same manner as was discussed with respect to section 208. That is, movable valve actuator 280 which has a preset pressure exerted thereon by spring 282 will control the air pressure at its outlet ports 284 and 284' above the air pressure set by spring 230 and below the pressure set by spring 282. Accordingly, if spring 282 is set for 80 p.s.i., section 210 will allow air pressure at its outlet ports 284 and 284' between 60 and 80 p.s.i.

It will be understood that the valve regulator 200 can be expanded to add additional sections, and that all of the advantages discussed previously with respect to the O-ring seals of each movable valve actuator 226, 260, and 280 passing its associated radial passageway in a manner whereby air pressure forces the O-ring seal against its groove so as to prevent wear thereon is present, and, further, all of the parts for manufacturing the valve regulator 200 can be screw machined and, by reason of the end caps, the parts thereof can be simply and easily assembled. Further, by merely rotating the end caps associated with the springs 230, 264, and 282 it is possible to vary the spring pressures and, accordingly, vary the air pressures being regulated.

Still further, it can be seen that the ports 240, passageways 242 and 248, and ports 240'' are aligned for easy formation of the passageways 246 and 248.

In FIG. 6, there is shown a third embodiment of the present invention generally designated by the numeral 290. The embodiment of FIG. 6 is intended as a regulator valve operative to selectively regulate pressure supplied to a single outlet port from two inlet ports. Thus, the valve regulator 290 has a first inlet port 292 and a second inlet port 294 which are selectively connected to supply a regulated output to a single outlet port 296. The ports 292, 294, and 296 are, of course, formed in the main body 298 of the valve regulator 290, which main body is cup-shaped. Within the cup-shaped main body 298 there is provided an axially movable communication member 300 which receives the movable valve actuator 302. The axially movable communication member 300 includes a cup-shaped member 304 screw threaded into engagement at its open end with a movable handle 306. The cup member 304 has an enlarged head portion 308 which in the position shown in FIG. 6 abuts an end wall 310 on the main body 298. Further, a key member 312 extends through the main body 298 into a keying slot 314 on the surface of the enlarged head portion 308, which keying slot extends, as shown in FIG. 6, from the face of the enlarged head portion, adjacent the end wall 310 to a point immediately beyond the keying member 312.

The main body 298 includes an end closure member 316 through which passes a spring-biased ball member 318 which is adapted to fit within spaced parallel radial grooves 320 and 322. It will easily be seen that axial movement of the handle 306 will pull the ball 318 out of groove 322 and into groove 320. Such movement is intended to control the particular inlet which is to be regulated as will be shown hereinafter. Within the handle 306 there is provided an axially positioned screw member 324 which is operative to control the position of a regulating piece 326 abutting coil spring 328. Spring 328 presses against the enlarged head 330 of movable actuator 302. Accordingly, the pressure on the enlarged head 330 of movable actuator 302 can be controlled by rotation of the screw 324.

As shown in FIG. 6, inlet 292 is closed and is not being regulated by the regulator 290 as it is effectively sealed by O-ring seals 332 and 334 on opposite sides of axially movable communication member 300. However, inlet 294 is in communication with an annular groove 336 on the outer surface of communication member 300 which annular groove is in communication with the radial passageway 338. Radial passageway 338 connects annular groove 336 with an annular groove 340 on the surface of the actuator 302. The annular

groove 340 has extending therefrom radially inwardly of actuator 302 a plurality of radial passageways 342 in communication with an axial passageway 344 which extends to the back surface of the movable actuator 302. Axial passageway 344 is further in communication with a radial passageway 346 in communication member 300 by reason of a second annular groove 348 on the end of movable actuator 302 and a radial passageway 350 connecting axial passageway 344 and annular groove 348. Radial passageway 346 in communication member 300 extends to an annular groove 352 which in direct communication with the outlet port 296.

When the pressure on the inlet port 294 is below the spring pressure exerted by spring 328, air is directly supplied to the outlet port 296. However, if the air pressure through inlet port 294 exceeds the spring pressure exerted by spring 328, the air forced through the axial passageway 344 acts against the backwall of the movable plunger 302 and forces the movable plunger to the right until the O-ring seal 354 passes radial passageway 338 and, O-ring seal 354 in cooperation with a second spaced parallel O-ring seal 356 will seal the radial passageway 338 to prevent a flow of air to the outlet port 296 until the pressure at the outlet port 296 drops below the pressure exerted by the spring 328. Here again, it should be noted that as the O-ring seal 354 passes the radial passageway 338, air pressure is exerted thereon to force the O-ring seal. In operation, this is substantially similar to the operation of the valve regulator 10 of FIG. 1.

When it is desired to control the inlet port 292 rather than the inlet port 294, the handle 306 is pulled outwardly until ball 318 falls within groove 320. When this occurs, inlet port 292 will be in communication with radial groove 336 and inlet port 294 will be sealed by reason of spaced parallel O-ring seals 358 and 360 on the outer surface of the communication member 300. Then, the regulation of inlet port 292 is exactly similar to that discussed with respect to inlet port 294. It will be noted that the annular groove 352 allows the port 296 to always be in communication therewith even after the axial movement of handle 306 to place spring-biased ball member 318 in groove 320 rather than 322. The keying member 312 merely prevents swiveling of the handle 306 during use, although such swiveling would not in any way affect the operation of the valve regulator.

Further, it should be noted that at each inlet, the screw member 324 can be moved to vary the pressure for which the particular inlet is to be regulated.

Accordingly, by a mere linear movement of the setting member or handle 306 of the regulator 290 it is possible to change the inlet being regulated and further, the particular pressure at which the inlet is regulated can be varied, with all these operations being accomplished with a single member, i.e. the handle with its associated screw.

Still further, it should be noted that all of the components of the valve regulator 290 can be screw machined for simplicity and lowered cost of manufacture.

In FIG. 7, there is shown still another embodiment of the present invention generally designated by the numeral 370. The regulator 370 is intended to be utilized in a system such as is installed to regulate the pressures in a plurality of truck tires. That is, in such a system it is desirable to maintain tire pressure within certain limits, and, to vary these limits upon changes in conditions such as increased load on the truck which, will of course, necessitate higher pressures in the truck tires.

The system of FIG. 7 is operative in the following manner. Air is supplied through an inlet 372 formed on one side of the main body 374 of the regulator and is intended to be delivered to an outlet 376 on the opposite side of the main body 374. The inlet and outlet passageways 372 and 376 are aligned and are further aligned with passageways 378, 380, 382, and 384 in second section actuator 386, main body 374, tubular insert 388, and the first section of actuator 390. Further, tubular insert 388 has an annular groove 391 opposite port 372 so that even with movement of movable actuator 390, inlet port 372 will be in communication with outlet port 376.

Movable actuator 390 has an enlarged head portion 392 and a reduced diameter portion 394. The enlarged head portion 392 is spaced a distance d from the tubular insert 388.

The reduced diameter portion 394 has an annular groove 396 extending from the radial passageway 384 to the end thereof opposite enlarged head portion 392. At the end of reduced diameter portion 394 there is provided a male extension 398 about which is placed an O-ring seal 400. The O-ring seal 400 and male extension 398 respectively seal and fit within the axial passageway 402 of a second actuator 404 having its reduced diameter portion 406 fitting within the tubular insert 388. The second actuator 404 has an enlarged head portion 406 which is pressed by a spring 408 to maintain the reduced diameter portion 406 in sealing relation with the seal 400 at the end of first actuator 390. Spring 408 can be varied by screw threaded end cap 410.

Further, it should be noted that the tubular insert 388 is held in place through a suitable key 412.

Air entering radial passageway 382 and annular groove 396 will additionally pass through a radial passageway 414 into an annular groove 416 formed on the outer surface of tubular insert 388 which annular groove 416 is sealed from radial passageway 382 and annular groove 391 by O-ring seal 418. Air entering through annular passageway 416 will also pass through a suitable passageway 420 into a recess 422 formed behind the enlarged head 424 of actuator 386, thus maintaining actuator 386 in abutment against a tubular insert 426 and, thus, maintaining radial passageway 378 in communication with outlet port 376. The air passing into annular passageway 416 additionally forces against the enlarged head 406. Air pressure from inlet 372 is additionally being forced through an axial passageway 428 extending from radial passageway 384 through reduced diameter portion 394 and enlarged head portion 392 of movable actuator 390 so that air will be placed behind the enlarged head portion 392 in a recess formed against a suitable cylindrical insert 430. Accordingly, when the pressure at inlet 372 exceeds a preset pressure as exerted by spring 408, actuators 390 and 404 will move axially to compress the spring 408 until suitable O-ring seals 432 and 434 have sealed radial passageway 382 to prevent any additional air being supplied to the movable actuator 390 and 404. However, as was stated previously, the annular groove 391 continue to supply air through passageway 380 to outlet port 376. The opening and closing of outlet port 376 is controlled by two inlet ports 438 and 440 which communicate with the tubular insert 426.

The movable actuator 386 has two reduced diameter portions 442 and 444 on opposite sides of the enlarged head portion 424. Reduced diameter portion 442 and 444 are keyed for axial movement within tubular inserts 426 and 446 respectively.

Tubular insert 426 has a reduced diameter portion 448 at the end thereof opposite enlarged head portion 424 so as to form an annular recess 450 in communication with inlet port 438. Accordingly, the air pressure at inlet port 438 will, if it exceeds the pressure in cavity 422 as provided by the regulation of valve actuators 390 and 404, force the valve actuator 386 to move axially and seal passageway 380 and outlet ports 370 by reason of O-ring seals 452 and 454. When the valve actuator 386 continues to move due to the pressure from inlet port 438, the inlet port 440 which was in communication through a radial passageway 456 with the reduced diameter portion 442, and, thus has been effectively sealed by reason by the O-ring seals 458 and 460 thereon, is then in communication with the space 462 between the reduced diameter portion 442 and the end cap 464 within the tubular insert 426. The end cap 464 has a suitable bleed hole 466 so that the air pressure within the tires can be bled out until the pressure within recess 422 exceeds the pressure within recess 450 and the actuator 386 is returned so as to seal the inlet 440. With additional further movement of the actuator 386, the actuator will be returned to the position shown in FIG. 7 and more air pressure will be supplied from the inlet 372 thereto. It will be understood that the differential pressure necessary to move the valve actuator 386 is only that necessary to overcome the friction of the O-ring seals thereon.

If it is desired to raise the pressure in the tires which are supplied air through the port 376 and which pressure is also returned to the ports 438 and 440, it is only necessary to increase the pressure on spring 408 through rotation of the screw-type end cap 410. Then the pressure within the recess 422 will be increased by operation of the valve actuators 390 and 404 as was discussed previously.

If it is desired to lower the pressure in the tires supplied from the outlet port 376, it is only necessary to unscrew the end cap 410 slightly so as to reduce the pressure exerted by spring 408. This will cause actuator 404 to separate from actuator 390 and thus allow air within recess 422 to bleed through radial passageway 420, annular groove 416, and radial passageway 414, into axial passageway 406 and out through a suitable breather hole 468 in end cap 410. As the air in recess 422 bleeds out in this manner, the valve actuators 390 and 404 will again mate with O-ring seal 400 sealing the passageway 402 to prevent further bleeding. Since the pressure behind the enlarged head 424 of actuator 386 has been reduced, the actuator 386 will move due to the pressure in recess 450 and, accordingly, the pressure in the tires will be bled from port 440, radial passageway 456, space 462, and bleed hole 466 in end cap 464. Of course, when the pressure in the tires have been reduced to the desired value the movable actuator 386 will return to seal the port 440 and the new pressure will be maintained at the outlet 376.

It will further be noted that suitable bleed holes 470 and 472 will be provided respectively in end cap 474 associated with tubular insert 446 and in main body 374 communicating with the space between enlarged head 392 and tubular insert 388.

It should further be noted that the distance between enlarged head 406 of actuator 404 and the end cap 410 is greater than the distance d as the actuator 404 will separate from the actuator 390 during the pressure-lowering procedures discussed previously.

It will be observed from the foregoing that the objects of the present invention have been achieved by a new and novel regulator valve which is always balanced with pressures on opposite sides of the actuator so that the only pressure necessary to cause a regulation function is that necessary to overcome the friction of the valve actuator which, in the present design is merely the friction of O-ring seals about the valve actuator.

Further, the valve regulator of the present invention can be manufactured through simple screw-machining techniques and assembled with little or no difficulty by reason of the straight through alignment of all of the parts thereof. Still further, wherever an O-ring seal is designed to pass an open port which might cut or in some other way wear the O-ring seal, the seal is passed under the port which is supplying air under pressure so as to force the O-ring seal against the groove in which it is seated so that O-ring seal will not be worn by contact with the edges of the passageway.

In FIG. 8 there is shown still another embodiment of the present invention generally designated by the numeral 480. The regulator valve 480 is designed for three types of uses. That is, it is designed to act as a regulator valve, in the manner discussed with respect to the valve of FIG. 7, or, in the alternative, it can be completely shut off or completely opened. The completely opened position would be extremely useful where the regulator valve was at the inlet and/or outlet of an air tank and it was desired to fill the tank, and the closed position is desirable where the tank is to be closed when not in use. Thus, the regulator valve 480 has a screw-threaded member 482 passing through the center of the main body 484 which is intended to move a screw-threaded plunger element 486 within a cylindrical fixed sleeve 488. Movement of the plunger 486 forces the valve actuator 490 forward or leaves a space between the end of the valve actuator 490 and the plunger 486. In the position shown in FIG. 8 the regulator 489 is in the regulator position. If the screw member 482 is rotated, so as to move the plunger 486 to the right as shown in FIG. 8, it will force the actuator 490 forward until the enlarged head portion 492 thereof abuts end cap 494. In this position, O-ring seal members 498 and 500 on reduced diameter portion 502

of the actuator 490 will seal an annular opening 504 which is connected to an inlet port 506. Thus, in this position, the inlet port 506 is effectively sealed.

If the screw member 482 is rotated so as to move plunger 486 fully to the left, spring 508 behind the enlarged head portion 492 will force the valve actuator 490 fully to the left until the enlarged head portion 492 abuts wall 510 and, accordingly, O-ring seal 512 will seal with inwardly extending wall 514 so that air coming from inlet port 506 and annular passageway 504 cannot enter the recess 516 which would direct pressure against the enlarged head portion 492. Accordingly, all air from the inlet 506 and annular passageway 504 would pass through an annular passageway formed by a reduced diameter portion 518 on the valve actuator 490 and through radial holes 520 into an axial passageway 522 through the actuator 490. Axial passageway 522 extends to the outlet opening 524. Accordingly, in the position discussed above, wherein plunger 486 is moved fully to the left, air from the inlet 506 will continually pass to the outlet opening 524.

When the plunger 486 is in the position shown in FIG. 8, the regulator valve 480 acts as a regulator similar to the regulator of FIGS. 1 and 7. That is, air enters through the passageway 506 annular groove 504 and the groove formed by reduced diameter portion 518 into the recess 516. There, the air bears against the enlarged head portion 492. So long as the spring 508 exerts a greater pressure against the enlarged head portion 492, the air from inlet 506 will pass through radial passageway 520 into the axial passageway 522 to the outlet port 524. However, when the inlet pressure from port 506 is greater than the pressure exerted by the spring 508 the valve actuator 490 will move to the right so that O-ring seals 500 and 498 will effectively seal the annular passageway 504 and prevent further air from being supplied to the outlet port 524.

Accordingly, the regulator valve 480 of FIG. 8 operates in a manner substantially similar to the regulator valve discussed previously, with the exception that it is possible with the configuration of FIG. 8 to fully open or fully close the regulator valve by moving the plunger 486 fully to the left or fully to the right respectively.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. A regulator valve comprising a main body, a valve actuator axially movable within said main body, said main body having an inlet and outlet port therein, said actuator being positioned within said main body to define with said main body a first chamber adjacent one force-receiving surface of said actuator and a second chamber adjacent a second force-receiving surface of said actuator, said force receiving surfaces being positioned to receive forces thereon in opposite directions to each other a bias force applying means within said first chamber for applying a predetermined force to said one force-receiving surface, said inlet port and said outlet port or being in communication with said second chamber, and sealing means on said actuator operative to seal said inlet port from said outlet port when the force on said second force-receiving surface is greater than said predetermined force exerted by said bias force applying means on said one force-receiving surface, said valve actuator having at least two spaced parallel O-ring grooves on the surface thereof in planes perpendicular to the axis of said actuator, said sealing means comprising at least two O-ring members fitted within said O-ring grooves, said O-ring members being positioned adjacent to and on the same side of said inlet port in an initial position, the axis of said inlet and outlet ports being spaced from one another, said actuator being operative to move one of said O-ring members in one of said grooves from one side of said inlet port to the other side thereof during a sealing operation and, further, being operative to return said one O-ring member to its initial position to effect communication of said inlet port

with said outlet port, said one O-ring groove being slightly wider than said one O-ring member so as to allow compression of said one O-ring member into said one groove as said one groove passes said inlet port, said one O-ring member being compressed by the pressure at said inlet port to a depth less than or equal to the depth of said one groove to prevent wear on said one O-ring as it passes said inlet port.

2. The regulator valve of claim 1 wherein said bias force applying means includes a coil spring having one end thereof abutting said one force-receiving surface, the other end of said coil spring abutting a spring pressure varying means, said spring pressure varying means being operative to preset the compressive force on said coil spring.

3. The regulator valve of claim 2 wherein said spring pressure varying means includes an end cap, said end cap being in screw-threaded relation with said main body to vary the compressive force on said coil spring in accordance with the position of said end cap with respect to said main body.

4. The regulator valve of claim 1 wherein said main body has a bore therein, said valve actuator being located within said bore, a cup-shaped member within said bore, said actuator having one end thereof mounted for reciprocal movement within the recess of said cup-shaped member, said actuator one end being integral with said second force-receiving surface and defining with said cup-shaped member said second chamber, said actuator one end having a bore therein communicating in the unsealed position of said actuator with said inlet port.

5. The regulator valve of claim 4 wherein said cup-shaped member has its open end adjacent a wall within the bore of said main body, said open end of said cup-shaped member and said wall of said main body bore forming said inlet port, said cup-shaped member being axially movable to vary the size of said inlet port.

6. The regulator valve of claim 4 including a second inlet port, said cup-shaped member having a passage therethrough in communication with said second chamber, sealing means on said cup-shaped member, means for axially moving said cup-shaped member from a first position to a second position, said first and second inlet ports being spaced on said main body positions corresponding to said first and second positions whereby in said first position said first inlet port is in communication with said cup-shaped member passageway and said second inlet port is sealed by said cup-shaped member sealing means, said second inlet port being in communication with said cup-shaped member passageway in said second position and, in said second position, said first inlet port being sealed by said cup-shaped member sealing means.

7. The regulator valve of claim 6 including a handle secured to said cup-shaped member for axially reciprocating said cup-shaped member between said first and second positions, said first chamber including a portion of said handle, and means on said handle for varying the predetermined force on said one force receiving surface.

8. The regulator valve of claim 1 including a second valve actuator axially movable within said main body, said main body having a second outlet port therein, said second actuator being positioned within said main body to define with said main body a third chamber adjacent one force-receiving surface of said second actuator and a fourth chamber adjacent a second force-receiving surface of said second actuator, said force-receiving surfaces of said actuator being positioned to receive forces thereon in opposite directions to each other, a second bias force applying means within said third chamber for applying a second predetermined force to said one force-receiving surface of said second actuator, said first-mentioned outlet port being in communication with said fourth chamber, and second sealing means on said second actuator operative to seal said second chamber from said fourth chamber when the force on said second force-receiving surface of said second actuator is greater than said second predetermined force exerted by said second bias force applying means on said one force-receiving surface of said second actuator.

9. The valve regulator of claim 8 wherein said second predetermined force exerted by said second bias force applying means is greater than said first-mentioned predetermined force exerted by said first-mentioned bias force applying means.

10. The valve regulator of claim 8 wherein second chamber is in communication with said fourth chamber through a passageway in said main body, said first-mentioned outlet port, said second outlet port, and said passageway being axially aligned through said main body.

11. The valve regulator of claim 8 wherein said first-mentioned and second bias force applying means are coil springs, said valve actuators being positioned in recesses in said main body, first and second end caps sealing off at least one end of said recesses for said first-mentioned and second valve actuators, said coil spring being mounted between their respective end caps and their respective one force-receiving surfaces, each of said end caps being adjustably positioned with respect to said main body to vary the compressive force on their associated coil springs.

12. The regulator valve of claim 8 including a third valve actuator axially movable within said main body, said main body having a third outlet port thereon, said third actuator being positioned within said main body to define with said main body a fifth chamber adjacent one force-receiving surface of said third actuator and a sixth chamber adjacent a second force-receiving surface of said third actuator, said force-receiving surfaces of said third actuator being positioned to receive forces thereon in opposite directions to each other, a third bias force applying means within said fifth chamber for applying a third predetermined force to said one force-receiving surface of said third actuator, said third predetermined force being greater than said first predetermined force, said sixth chamber being in communication with said second outlet port, said third outlet port being in communication with said sixth chamber, and third sealing means on said third actuator operative to seal said second outlet port from said sixth chamber when the force on said second force-receiving surface of said third actuator is greater than said third predetermined force exerted by said third bias force applying means on said one force-receiving surface of said third actuator.

13. The regulator valve of claim 1 including a second valve actuator axially movable within said main body, said actuator being positioned within said main body to define with said main body a third chamber adjacent one force-receiving surface of said second actuator and a fourth chamber adjacent a second force-receiving surface of said second actuator, said force-receiving surfaces of said second actuator being positioned to receive forces thereon in opposite directions to each other, a second bias force applying means within said third chamber for applying a second predetermined force to said one force-receiving surface of said second actuator, said first-mentioned outlet port being in communication with said third chamber and forming a portion of said second bias force applying means, a second outlet port, said inlet port being in communication with said second outlet port through said second valve actuator, and second sealing means on said second actuator operative to seal said inlet port from said second outlet port when the force on said second force-receiving surface of said second actuator is greater than said second predetermined force exerted by said second bias force applying means on said one force-receiving surface of said second

actuator.

14. The regulator valve of claim 13 wherein said second outlet port is connected to said fourth chamber, said second outlet port being in communication with a load to be regulated.

15. The regulator valve of claim 14 wherein said second outlet port is additionally in communication with the atmosphere through said valve actuator, said valve actuator having a third sealing means associated therewith for sealing said second outlet port from the atmosphere when the force on said second force-receiving surface of said second actuator is less than said second predetermined force exerted by said second bias force applying means on said one force-receiving surface of said second actuator, said third sealing means sealing said second port from the atmosphere when the force on said second force-receiving surface of said second actuator is greater than said second predetermined force exerted by said second bias force applying means on said one force-receiving surface of said second actuator.

16. The regulator valve of claim 15 including bleeding means for bleeding said third chamber to reduce said second predetermined force exerted by said second bias force applying means.

17. The regulator valve of claim 16 wherein said bleed means includes means for simultaneously bleeding said second chamber and said third chamber.

18. The regulator valve of claim 17 wherein said first-mentioned valve actuator includes two mating actuator members, one of said actuator members including said one and said second force-receiving surfaces for said first-mentioned actuator, the other actuator member including a third force-receiving surface defining with said main body a fifth chamber, said fifth chamber being in communication with said inlet port, fourth sealing means on said other actuator member operative to seal said inlet port from said chamber when the force on said third force-receiving surface of said other valve member is greater than said predetermined force exerted by first-mentioned bias force applying means on said one force-receiving surface of said first-mentioned actuator.

19. The regulator valve of claim 18 wherein said first-mentioned bias force applying means includes a coil spring positioned between said one force-receiving surface of said first-mentioned actuator and an end cap, said end cap adjustable with respect to said main body to vary the compressive forces on said coil springs and, accordingly, vary said first-mentioned predetermined force.

20. The regulator valve of claim 1 including positioning means, said positioning means being operative to increase the size of said second chamber, said positioning means, when operative to increase the size of second chamber allowing said bias force applying means to prevent operation of said sealing means whereby said inlet port will continuously be in communication with said outlet port.

21. The regulator valve of claim 20 wherein said positioning means is further operative to force said sealing means into position to seal said inlet port from said second chamber and, thereby, prevent communication between said inlet and outlet ports, said positioning means being selectively operable to continuously seal said inlet port, continuously place said inlet port in communication with said outlet port, and to allow said force on said second force-receiving surface to control the sealing of said inlet port.