

May 22, 1962

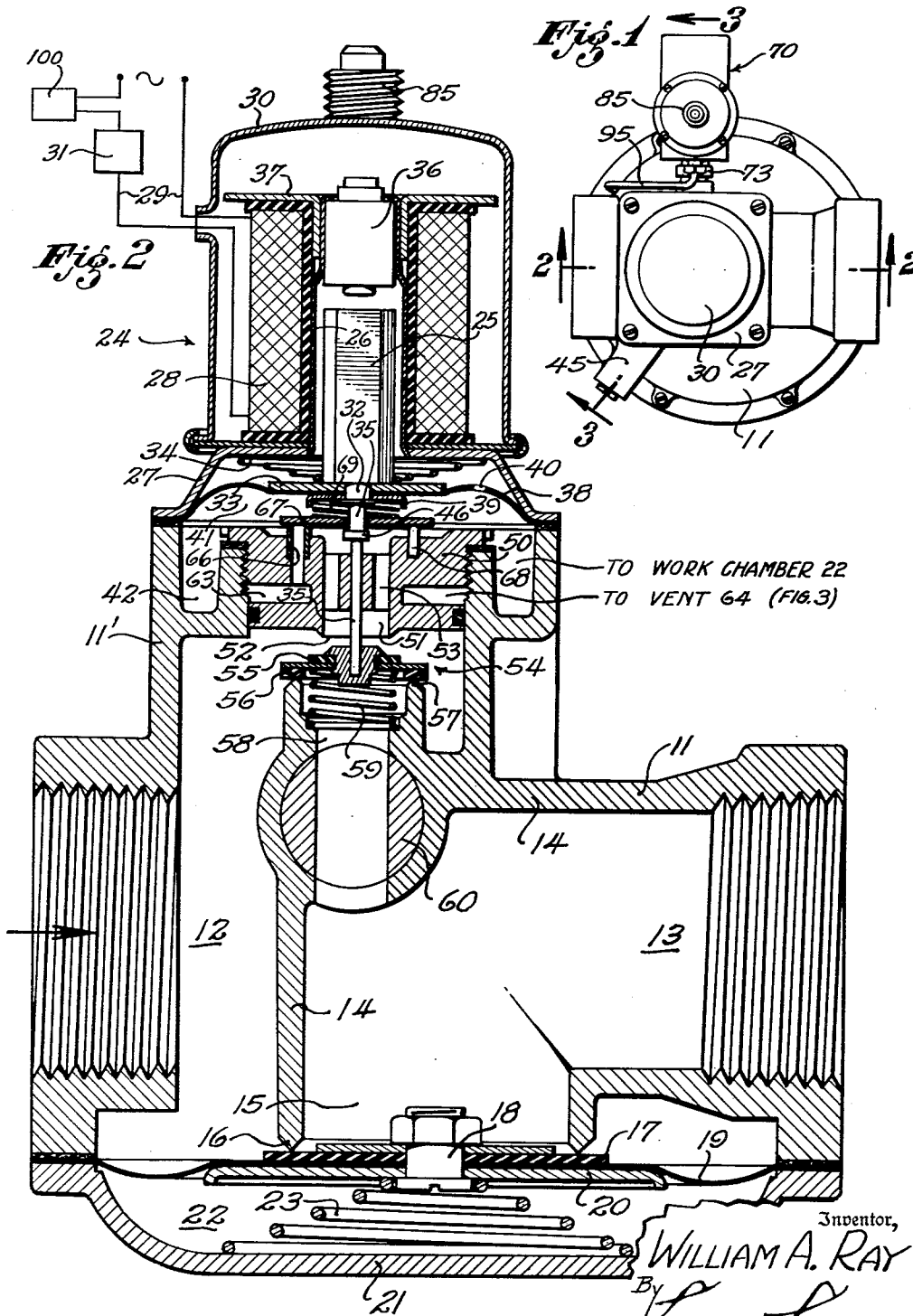
W. A. RAY

3,035,774

VALVE STRUCTURE AND SYSTEM

Filed March 31, 1959

4 Sheets-Sheet 1



Inventor,
WILLIAM A. RAY
By *Lyons & Lyons*
Attorneys

May 22, 1962

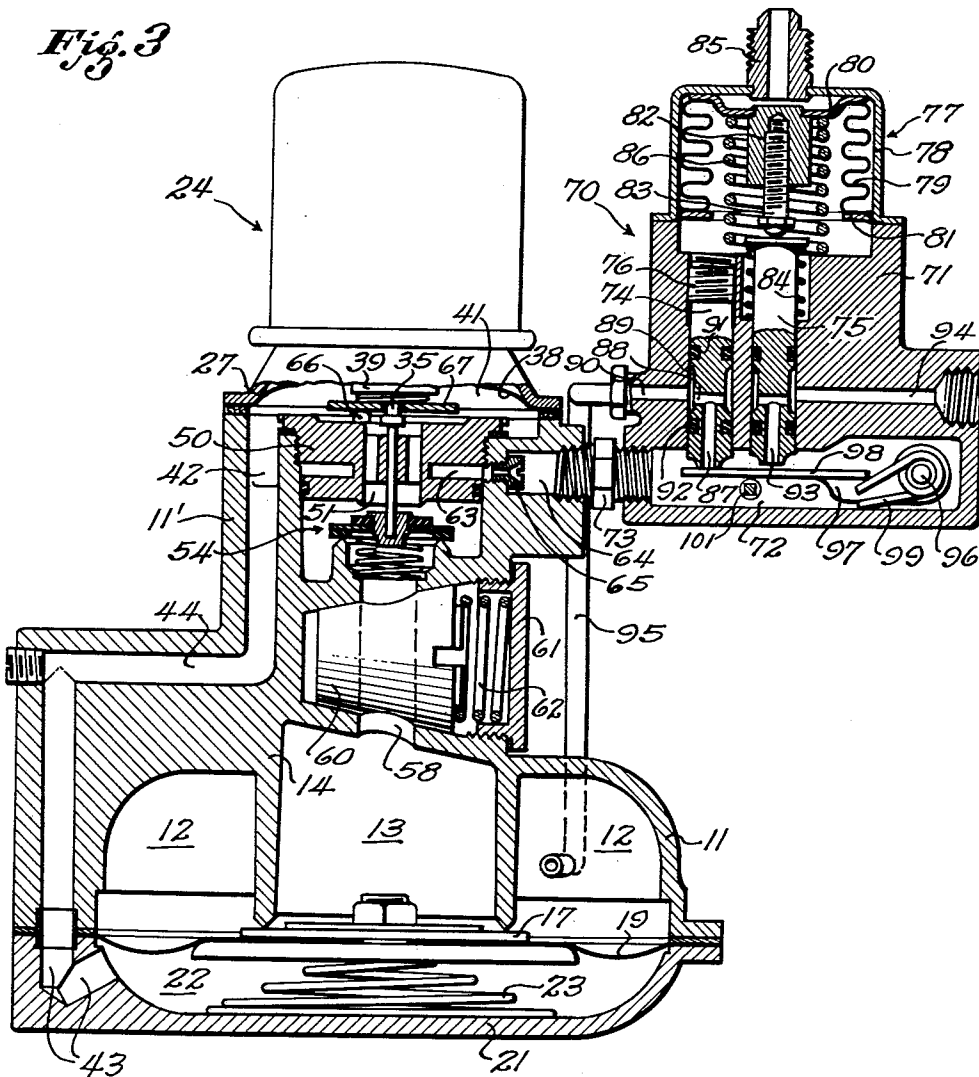
W. A. RAY

3,035,774

VALVE STRUCTURE AND SYSTEM

Filed March 31, 1959

4 Sheets-Sheet 2



Inventor,
WILLIAM A. RAY
By *Lyon & Lyon*
Attorneys

May 22, 1962

W. A. RAY

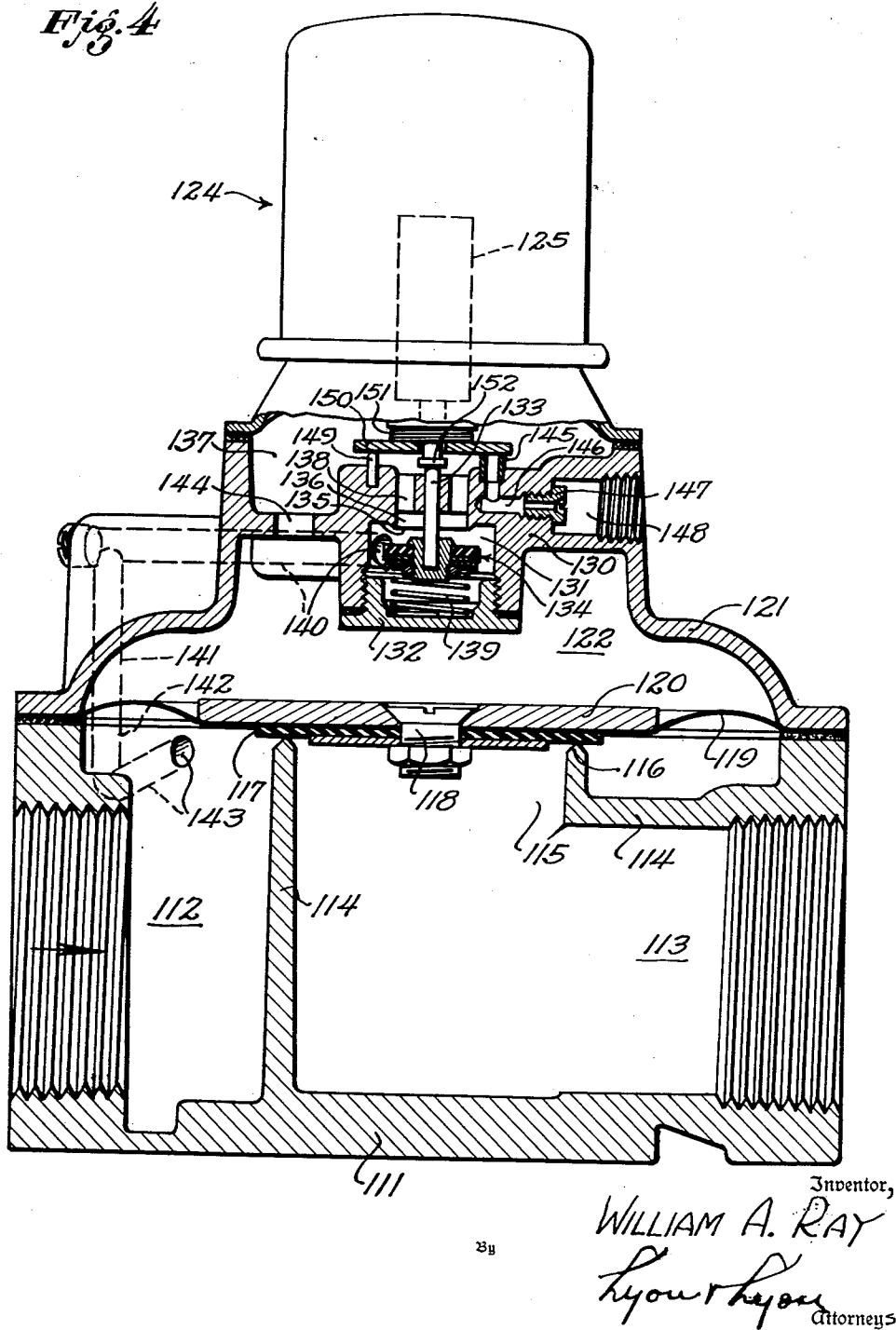
3,035,774

VALVE STRUCTURE AND SYSTEM

Filed March 31, 1959

4 Sheets-Sheet 3

Fig. 4



May 22, 1962

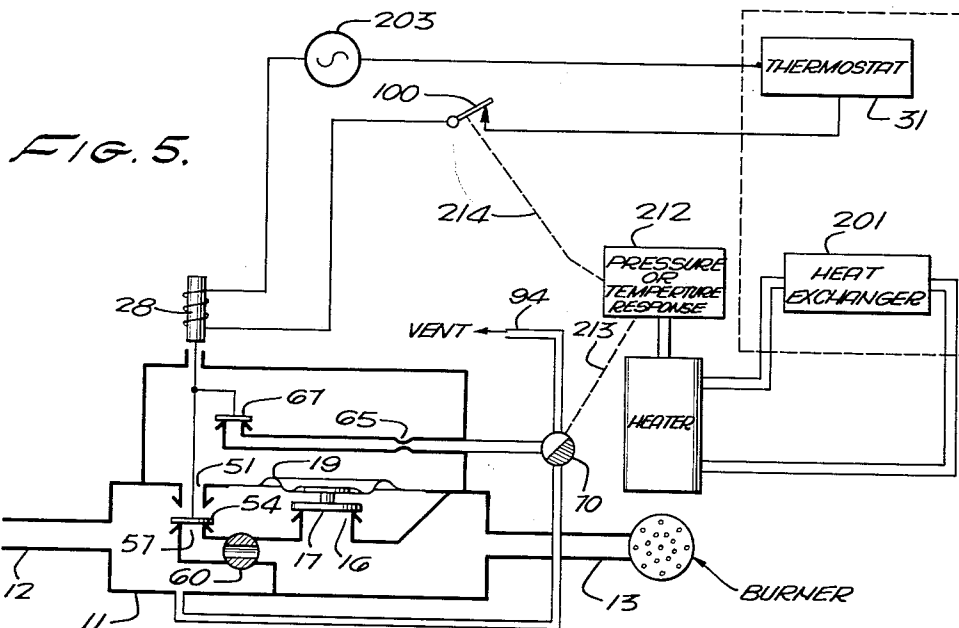
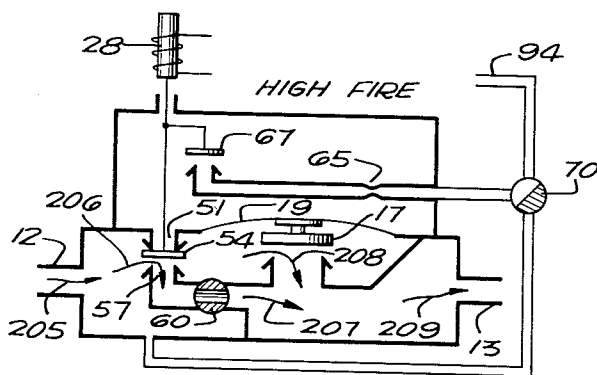
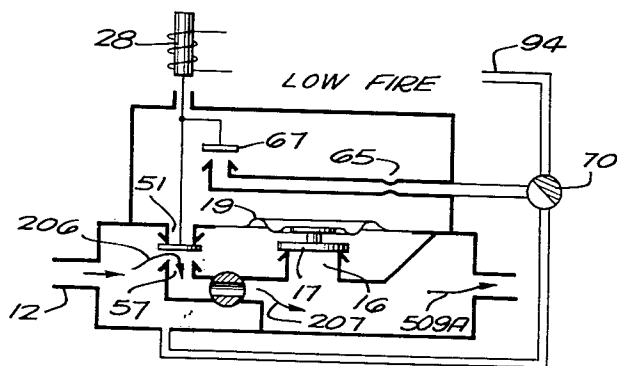
W. A. RAY

3,035,774

VALVE STRUCTURE AND SYSTEM

Filed March 31, 1959

4 Sheets-Sheet 4



INVENTOR.
WILLIAM A. RAY
BY *Lyon & Lyon*
ATTORNEY'S

1

3,035,774

VALVE STRUCTURE AND SYSTEM

William A. Ray, North Hollywood, Calif., assignor to General Controls Co., Glendale, Calif., a corporation of California

Filed Mar. 31, 1959, Ser. No. 803,312

26 Claims. (Cl. 236—80)

My present invention relates to valve structures, and more particularly to those of the type which are operated by fluid pressure under the control of a control valve.

The valve structure of this invention, while not so limited, has particular utility in connection with the supply of gaseous fuel to a furnace burner.

It is well known that initial supply of gas to a burner should be at a rate sufficient to avoid backfiring of the gas inside the burner, and consequent damage to the burner caused by formation of carbon inside it.

However, when the burner is inside a furnace, supply of gas to the burner at high rate should be delayed to avoid the possibility of explosive "roll-back" of the fire inside the furnace which otherwise may occur, especially if the furnace stack is cold and sufficient draft has not been established. One of the detrimental effects of this roll-back of the fire is possible extinguishment of pilot burners.

In view of the foregoing it is an object of this invention to provide a valve, operated by fluid pressure under the control of a control valve, through which fluid can flow at a relatively high (but adjustable) rate immediately upon actuation of the control valve, and later at progressively higher rate until the maximum rate of flow is achieved.

I accomplish the foregoing object by arranging so that the pressure operated valve opens only gradually upon actuation of the control valve, and by providing a supplemental passage interconnecting the inlet and outlet of the valve structure, and a supplemental valve in that passage actuated to open position concurrently with said actuation of the control valve.

Another object of the invention is to arrange the supplemental passage so that it is entirely inside the main valve structure. I accomplish this object by providing the supplemental passage in the form of a valve port directly through the partition which separates the inlet and outlet chambers of the main valve-casing.

A feature of this invention is arrangement of the chamber-partition so that the portion of it through which the supplemental port extends is adjacent and parallel to a wall of the valve casing on the outside of which the control valve is mounted, and the provision of an opening through this wall for an operative connection between the control valve and a closure for the supplemental port.

Another feature is the provision of a control valve which comprises a closure cooperable with the casing-wall opening described in the preceding paragraph.

Another feature is the provision of an additional valve for controlling operation of the pressure-operated main valve independently of the control valve, and adapted to effect closing of the main valve while said supplemental port is open under the control of the control valve.

Another object of the present invention is to provide an improved valve construction which allows its use in a new system, also embodying features of the present invention, in which the venting of a pressure-responsive valve is controlled in a novel manner.

Another object of the present invention is to provide an improved pressure-responsive valve construction of this character having an auxiliary port through which fluid may flow during the time that the main diaphragm controlled port is being opened at a controlled rate.

Another object of the present invention is to provide

2

an improved valve construction, as indicated in the preceding paragraph, in which the auxiliary port may also serve, in the operation of some systems, as a means for maintaining a "low fire" condition while the main port remains closed.

Another object of the present invention is to provide a valve construction as indicated in the preceding paragraph wherein one of such systems, in accordance with other novel aspects of the present invention, has two condition-responsive means one of which, in general, controls said auxiliary port and the other one of which, in general, controls the venting of the valve for purposes of controlling the diaphragm controlled port and also in some cases both the auxiliary and main ports to close the same when unsafe conditions are apt to occur.

Another object of the present invention is to provide an improved heating system.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. This invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof, may be best understood by reference to the following description taken in connection with the accompanying drawings in which:

FIGURE 1 is a plan of a valve structure embodying this invention;

FIGURE 2 is a vertical section, to enlarged scale, taken along the line 2—2 of FIG. 1;

FIGURE 3 is another vertical section, to a scale somewhat smaller than that of FIG. 2, taken along the irregular line 3—3 of FIG. 1; and

FIGURE 4 is a sectional view of a modified valve structure embodying features of this invention;

FIGURES 5—7 illustrate diagrammatically systems embodying this invention in which the valve of FIGS. 1—3 may be used, FIG. 5 illustrating the Off condition and FIGS. 6 and 7 illustrating "low fire" and "high fire" conditions respectively.

Referring now more particularly to FIGS. 1—3 of the drawing, the numeral 11 indicates a valve casing having an inlet chamber 12 and an outlet chamber 13 separated by a generally right-angled partition 14. In the bottom wall of this partition is a valve port 15 surrounded by an annular downwardly-faced valve seat 16. Cooperable with this seat is a disk-shaped closure 17 which is secured by a bolt 18 to the central part of a movable wall or diaphragm 19, of flexible material such as synthetic rubber, with a backing plate 20 under the diaphragm. The diaphragm is clamped at its margin to the open bottom of the casing by a cover plate 21 which is dished to provide a pressure, or work, chamber 22 under the diaphragm. Closure 17 is biased upwardly by the force of a spring 23 compressed between plates 20 and 21.

The valve casing has a hollow upward extension 11' on top of which is sealingly mounted an electromagnetic operator generally indicated at 24. This operator is mainly of conventional construction and comprises a solenoid plunger 25 reciprocable in a guide tube 26, the plunger being generally square in cross section as is indicated by the shading. Guide tube 26 is of nonmagnetic material and is secured at its bottom, as by solder, in a central opening through a dished plate 27, preferably of magnetic material, fastened to the casing extension 11'. Around the guide tube 26 is an electromagnet comprising a solenoid coil 28 having leads 29 extending, through an opening in a housing 30 surrounding the operator, to a source of electric energy in series with a control device or switch 31, and a normally-closed switching device 100 whose function will be described later.

Fastened to the bottom of plunger 25, by means of a rivet-forming extension 32 of the plunger, is a disk 33 between which disk and plate 27 is a spring 34 biasing

3

the plunger downwardly to its normal position as shown in the drawing, downward movement of the plunger being limited by engagement of its extension 32 with the tip of a rod 35 whose function will be described later. Upon passage of current through coil 28 the plunger is attracted upwardly into engagement with a stop 36 tightly closing the reduced upper end of the guide tube and surrounded by an internally-flanged magnetic washer 37.

At the underside of plate 33 is a diaphragm 38, of flexible material such as synthetic rubber, and under this diaphragm at its center is a cupped disk 39, these parts being secured to plate 33 and to the plunger by the rivet-extension 32 of the plunger. The diaphragm 38 covers the open top of the casing-extension 11' and is clamped thereto at its margin by plate 27. This diaphragm serves as a flexible guide for the lower end of the plunger, and to screen the electromagnetic operator from fluid in the valve; there being, however, a bleed opening 40 in the diaphragm to avoid pressure changes in the space above the diaphragm when the plunger is operated.

The space or chamber 41 under diaphragm 38, which chamber is formed in part by an annular trough 42 in the upper part of casing-extension 11', is (as can be seen in FIG. 3) continuously in communication with the pressure- or work-chamber 22 at the bottom of the valve casing by way of passages 43 in a thickened wall of plate 21, and an angled passage 44 in a protruding part 45 (FIG. 1) of the casing and its upper extension, which passage 44 leads to the bottom of trough 42. The chamber 41 is therefore, in effect, part of the pressure chamber 22.

Sealingly mounted in a large opening in the top of the casing-extension 11', coaxial with plunger 25, is a screw-threaded member 50 having at its center a guide opening for the rod 35. In the underside of member 50 coaxial with rod 35 is a circular cavity or opening 51 around whose lower end is a valve seat 52; the opening 51 communicating by way of passages 53 with the chamber 41 under diaphragm 38. Secured to the lower end of rod 35 is a compound closure member 54 comprising an upwardly-faced closure disk 55 cooperable with the valve seat 52 to form a control valve 55, 52, and a downwardly-faced closure disk 56 cooperable with a valve seat 57 around the upper end of an opening or port 58, through a thickened horizontal portion of the casing-partition 14, leading to the outlet 13 of the valve.

A spring 59, inside opening 58 and bearing at its bottom on a shoulder around the opening, urges closure member 54 and rod 35 upwardly; the force of spring 59, however, being overcome by the weight of plunger 25 and the force of spring 34 acting downwardly on rod 35. Consequently, while the electromagnet is unenergized the opening 58 to the outlet 13 of the valve is closed, and the chambers 41 and 22 are in free communication with the inlet 12 of the valve by way of opening 51 and passages 53.

As is better seen in FIG. 3, the opening 58 intersects a tapered cavity forming a socket for an apertured valve-plug 60 by rotation of which the rate of flow through opening 58 can be adjusted; the plug-cavity extending to the exterior of the valve casing where it is closed by a screw-cap 61. A spring 62 compressed between the cap and the plug maintains the same seated.

In the surface of the threaded member 50 around its side is a deep recess 63 which registers with a vent opening 64 (FIG. 3) through the wall of the casing; the inner portion of opening 64 being threaded to receive an orifice member 65. Leading upwardly from recess 63 (see FIG. 2) is an opening in whose outer end a tubular seat member 66 is pressed. Cooperable with this seat member is a closure washer 67 which bears at diametrically opposite points near its edge on the seat member and on a pin 68 (FIG. 2) protruding from member 50 to the height of the seat member. Closure washer 67 fits freely around the rod 35 and is engaged (and raised from seat member

4

66) by a collar 46 on the rod when the same is raised by spring 59 upon upward attraction of plunger 25; the arrangement permitting slight tilting of the washer when it is raised so that unseating of the washer against the pressure of fluid in chamber 41 is facilitated. While the electromagnet is unenergized the closure washer 67 is maintained seated by plunger 25 acting on it through a light spring 69 under the cupped disk 39, the purpose of this spring being to ensure proper concurrent seating of closure washer 67 and the closure disk 56.

Seen in section in FIG. 3 (and in plan in FIG. 1) is an additional valve-structure, generally indicated by numeral 70, which for the sake of clarity is shown considerably larger in proportion to the main valve structure than it is in actual construction. The valve structure 70 comprises a casing 71 providing at its lower end a chamber 72 which is connected by a hollow screw-fitting 73 to the vent opening 64 of the main structure.

In the top wall of chamber 72 is a pair of vertical bores for cylindrical valve-jet members 74 and 75. The jet member 74 fits snugly in its bore and is stationary during operation of the additional valve, a screw plug 76 in the upper end of the bore determining the adjusted position of this jet member. The other jet member 75 is reciprocable in its bore, a fluid pressure motor 77 being provided for its operation.

The motor 77 comprises an inverted cup-shaped housing 78 secured by its flanged rim to the open top of casing 71 and coaxial with jet member 75. Inside this housing is a corrugated tubular bellows 79, of thin metal, which is sealingly joined, as by solder, at its top to the margin of a disk 80 and at its bottom to a ring 81 welded to the housing. Secured to the underside of disk 80 at its center is a nut-like part 82 in which a screw 83 is adjustably threaded, the jet member 75 being maintained in engagement with the head of this screw by the force of a spring 84 in an upper enlargement of the bore of this jet member.

The inner surface of housing 78 and the outer surfaces of bellows 79 and disk 80 define a chamber adapted to be subjected, through a hollow fitting 85 in the top of the housing, to fluid pressure from a controlling source—such as, for example, the pressure of steam in a boiler heated by fuel-gas supplied through the main-valve casing 11. Compression of the bellows 79 under such pressure, and resultant downward movement of jet member 75, is opposed by the force of a spring 86 compressed between casing 71 and the bellows-head or -disk 80.

The fixed jet member 74 has an axial opening 87 joined at its top by a transverse opening 88 leading to a shallow recess 89 around the side of the jet member, which recess registers with a passage 90 through the left side of the casing; sealing rings 91 and 92 being provided in grooves above and below recess 89. The movable jet member 75 is similarly constructed and arranged and has an axial opening 93 communicating with another casing-passage 94. The passage 90 is connected by a pipe 95 to the inlet 12 of the main valve, and the passage 94 leads to the atmosphere, the outer end of passage 94 being formed for connection of a vent pipe if desired.

Inside chamber 72, and pivoted on a pin 96 fixed to the casing, is an arm 97 having on its free end a flat portion 98 cooperable with the bottom surfaces of jet members 74 and 75 and biased by the force of a torsion spring 99 toward seating engagement therewith. The arm portion 98 is cooperable also with an arm 101, under it, which extends sealingly through the back wall of the casing and is there operatively connected to a normally-closed switch. This switch is not shown structurally but is indicated diagrammatically by numeral 100 at the top of FIG. 2.

Operation of the valve structure of FIGS. 1-3 will first be described independently of that of the additional valve 70 which has no effect while it remains in its unoperated condition, as shown, since the vent opening 64

5

of the main valve structure is then in communication with the atmosphere through the unobstructed opening 93 of jet member 75 and the passage 94.

With the parts in the positions shown in FIGS. 2 and 3, closure 55 being unseated the pressure chamber 22 is in free communication with the inlet of the valve, as has been described, so that the fluid pressure on opposite sides of diaphragm 19 are substantially equal and the force of spring 23 is therefore effective to maintain seating of the main closure 17 carried by the diaphragm.

When the solenoid operator 24 is energized the resultant upward movement of plunger 25 effects seating of closure 55 and uncovering of the seat member 66 so that communication between the pressure chamber 22 and the inlet of the valve is obstructed and the fluid compressed in this chamber escapes to the atmosphere through vent 64 (and the additional valve 70), the inlet pressure acting downwardly on the diaphragm then being effective to unseat the main closure. Since the closures 55 and 56 are directly interconnected, unseating of closure 56 occurs concurrently with the seating of closure 55 so that fluid flows through the valve structure by way of the opening, or supplemental port, 58 at a rate determined by the adjusted setting of the valve plug 60.

Opening of the main closure 17 by the diaphragm is gradual because of the restricted venting of the pressure chamber through orifice member 65. Since the closure 56 is opened to full extent substantially instantaneously upon energization of the electromagnet, the initial flow through the valve structure is by way of the supplemental port 58 only; full flow through the main port 15 occurring only after a period determined by the flow capacity of the particular orifice member 65 selected.

When the electromagnet is deenergized to shut-off the flow, the supplemental port 58 is closed immediately by closure 56, and the main port 15 is closed quickly because of the large flow-capacity of openings 51, 53 through which fluid from the inlet passes to the pressure chamber 22 to effect equalization of the pressures on opposite sides of the diaphragm and consequent seating of the main closure.

The operation of the valve structure as described has particular advantage in connection with supply of fuel gas to a furnace burner. Initial flow of gas through the supplemental port serves to establish immediately a predetermined low-fire condition of the burner, thus avoiding the possibility of backfiring in the burner as might occur if the initial supply of gas were at low rate. Further, the retarded opening of the main port prevents the possibility of roll-back of the fire in the furnace as might occur if the initial supply of gas were at high rate. Also, the quick shut-off of the gas when the electromagnet is deenergized again prevents backfiring in the burner.

While three valves comprising valve 56, 57, valve 55, 52 and valve 66, 67, as shown, for controlling the operation of the main-valve pressure motor is preferred, the vent-valve 66, 67 could be eliminated and a restricted opening for bleeding the pressure chamber to atmosphere substituted; the bleed gas, which then flows continuously through the pressure chamber while the pilot-valve closure 55 is open and the main flow to the burner is obstructed, conveniently being employed for supplying a pilot burner for the main burner. For purposes of definition, the valve 55, 52 is referred to herein as a control valve since it controls the flow of fluid from the inlet chamber 12 to the underside of diaphragm 19.

In connection with the foregoing description of the operation of the valve structure (disregarding the additional valve 70) it may be assumed that energization of the electromagnet is under the control of a thermostat, indicated at 31 in FIG. 2, responsive to the temperature of a space heated by the furnace.

Operation of the valve structure may be modified by employing the pressure-operated additional valve 70, details of which are shown only in FIG. 3. This valve may

6

be employed, for example, in connection with a heating system which includes a boiler heated by the gas furnace referred to above, the valve 70 then being connected by fitting 85 to the boiler so that the space above and around the outside of bellows 79 is subjected to the pressure of steam in the boiler. When the steam pressure is low the jet member 75 operated by the bellows is in its raised position so that chamber 72 of valve 70 is in free communication with the atmosphere and the operation of the system is as was described above.

With rise of steam pressure the jet member is forced downwardly so that its tip engages the closure portion 98 of pivoted arm 97, communication of chamber 72 with the atmosphere by way of the jet-passage 93 then being obstructed. Slight continued downward movement of jet member 75 effects rocking of arm 97, 98 out of seating engagement with the tip of the fixed jet member 74 so that the chamber 72 is placed in communication with the inlet 12 of the main valve structure by way of openings 87—90 and the pipe 95. Because of the high steam-pressure in the boiler it may be assumed that the main valve is then open and supplying fuel to the burner. The pilot valve is therefore in actuated condition so that the seat member 66 is uncovered and, through this seat member and the chamber-part 41, the main pressure chamber 22 is in communication with the inlet of the main valve by way of chamber 72 of the additional valve 70. As the pressure fluid from inlet 12 passes, by way of the opening 87 of jet member 74, slowly through the orifice member 65 to chamber 22, the diaphragm 19 rises and effects seating of the main closure 17. Flow of gas to the burner is then only by way of the supplemental port 58, and a low-fire condition of the burner is established.

If, due to the reduced heating of the boiler, the steam pressure then falls, the jet member 75 rises generally to the position shown in the drawing to permit venting of chamber 22 (assuming that the electromagnet is still energized and seat member 66 uncovered) and reopening of the main valve. Operation of the main valve between low-fire and high-fire producing conditions is thus achieved by means of the additional valve 70.

In the event of establishment of excessive pressure in the boiler, the resultant farther-downward movement of jet 75 causes the arm 97, 98 to rock into engagement with the arm 101 of the normally-closed switch 100 and actuate the same to open position, so that the electromagnet 24 is deenergized and supply of gas to the burner is fully obstructed.

It is apparent that the additional valve 70 could be arranged to respond to variation of temperature by providing a thermal-expansion fluid-pressure system for operating the bellows.

In the simpler form of valve structure shown in FIG. 4 the numeral 111 indicates a valve casing having an inlet 112 and an outlet 113 separated by a right-angled partition 114. In the top wall of this partition is a valve port 115 surrounded by an annular valve seat 116 with which a disk-shaped closure 117 cooperates. This closure is secured by a bolt 118 to the central part of a flexible diaphragm 119 with a plate 120 above the diaphragm, the weight of this plate biasing the closure to seated position. The diaphragm 119 is clamped at its margin to the open top of the casing by a hollow structure 121 mounted on the casing and forming a pressure- or work-chamber 122 above the diaphragm, the open top of structure 121 being closed by an electromagnetic operator 124 which may be identical with the operator 24 shown in detail in FIG. 2 and comprises a solenoid plunger 125.

The hollow structure 121 has, near its top, an integral transverse portion or wall 130. In the underside of a thickened central part of this wall, coaxial with the plunger 125, is a circular cavity 131 which is closed at its bottom by a screw-plug 132. Through wall 130, at the center of cavity 131, is a guide opening for a rod

133 which carries on its lower end a closure 134, cooperating with a seat 135 formed around a shallow circular recess 136 at the top of cavity 131, this recess communicating with the space 137 above wall 130 by way of passages 138. While the electromagnet is unenergized and plunger 125 is in its downwardly-biased position the tip of rod 133 is engaged by the plunger so that closure 134 is maintained in unseated position against the force of a bias spring 139 compressed between this closure and plug 132.

The cavity 131 communicates continuously with the inlet 112 of the valve through passages 140 and 141 in a thickened portion of the outer wall of structure 121 and through passages 142 and 143 in the casing 111. Also, the space 137 above wall 130 communicates continuously, by way of an opening 144 through this wall, with the work chamber 122 above diaphragm 119. Consequently, while closure 134 is unseated the diaphragm is subjected on both sides to the pressure of fluid in the inlet 112 and the main closure 117 is maintained seated by the weight of plate 120.

For venting the work chamber to atmosphere there is in the top surface of wall 130 a short vertical opening, in which a tubular seat-member 145 is pressed, which opening connects at its bottom to a passage 146 leading through the orifice of a member 147, in the passage, to a vent opening 148 through the side of structure 121. Seated near its edge on member 145, and near its diametrically-opposite edge on a pin 149, is a closure-washer 150 through which the upper portion of rod 133 freely extends. While the electromagnet is unenergized, this closure-washer is maintained seated by the plunger acting on it through a light spring 151 (which is the equivalent of spring 69 shown in FIG. 2).

Upon energization of the electromagnet, upward attraction of the plunger permits rod 133 to rise under the force of spring 139 so that closure 134 is brought into engagement with its seat 135; a collar 152 on the rod lifting closure-washer 150 from seat member 145. Inasmuch as the pressure chamber 122 is then in communication only with the atmosphere, the pressure of fluid in the inlet of the valve is effective to raise the diaphragm and unseat the main closure 117; the rate of upward movement of the diaphragm being determined by the flow capacity of orifice member 147. When the electromagnet is de-energized, the resultant covering of seat member 145 and unseating of closure 134 effects quick equalization of the fluid pressures on opposite sides of diaphragm 119, so that the main closure 117 seats by gravity.

FIGS. 5-7 illustrate the valves shown in FIGS. 1-3 in different operating positions in a system of the character previously indicated.

In FIG. 5, the boiler or heater referred to previously is designated at 200 and for illustrative purposes is shown supplying heat to space heating means, illustrated as a heat exchanger 201 which serves to heat an enclosure represented by the rectangle 202 and within which is located the thermostat 31 serving as a condition-responsive means.

The thermostat 31 which comprises a temperature-responsive switch is serially connected with the previously mentioned normally closed switch 100, solenoid 28 and energizing source 203 for directly controlling the condition of the valve members 54 and 67 and, indirectly thereby, the diaphragm valve member 17. As shown in FIG. 5, the thermostat switch 31 is off and valve members 54 and 17 prevent the flow of gas from the inlet 12 to the outlet of valve casing 11 represented by the heavier lines. This is particularly so since the gas pressure on opposite sides of diaphragm 19 is substantially the same.

FIG. 6 represents the "high fire" condition mentioned previously which results when the thermostat switch 31 is closed, in which case the solenoid 28 is energized to move valve member 67 to open position and to move valve member 54 to its upper position to thereby vent

the topside of diaphragm 19 to the atmosphere and allow the gas pressure acting on the bottom side of diaphragm 19 to move valve member 17 to open position. Consequently, the flow of gas is as indicated by the arrows 205-209 in FIG. 6. In this condition gas flows from the inlet 12 to the outlet 13 in "parallel" paths, one such path including the open port 57 and adjustable regulating valve 60 and another path comprising the diaphragm-controlled port 16. However, in reaching this condition illustrated in FIG. 6, while the port 57 is opened relatively rapidly, the diaphragm-controlled port 16 is opened relatively slowly due to the restricted orifice member 65 which controls the rate at which the pressure on opposite sides of diaphragm 19 may change during the transition from the condition shown in FIG. 5 to the condition shown in FIG. 6.

It is recalled that operation between the conditions illustrated in FIGS. 5 and 6 may be accomplished without the valve 70, since in both cases the same is open. This valve 70, as previously explained, may be controlled in accordance with a condition such as pressure or temperature in the boiler or heater 200 and while FIG. 3 shows a bellows arrangement for this purpose, the same is indicated generally in FIG. 5 as a pressure or temperature-responsive means 212 controlling the valve 70 through means represented by the dotted line 213 extending between such means 212 and valve 70. Further, since operation of the valve 70 under some conditions, as explained previously, may cause the condition-responsive switch 100 to open, the means whereby the same is accomplished is represented by the dotted line 214 extending between the means 212 and switch 100.

In the explanation of the high fire condition in FIG. 6, mention was made of two "parallel" gas paths comprising, on the one hand, port 57 and, on the other hand, the diaphragm controlled port 16. One of such "parallel" paths, namely the path comprising port 16, is closed to achieve the "low fire" condition in FIG. 7. Thus, when the pressure or temperature, as sensed by the means 212, assumes a first predetermined high value, the valve 70 is operated to a position, as shown in FIG. 7, where it closes vent line 94 and places inlet 12 in communication with the topside of diaphragm 19, thereby allowing the pressure on opposite side of diaphragm 19 to equalize at a rate controlled or determined by the restricted orifice 65; and when such pressure on opposite sides has been substantially equalized, the valve port 16 is closed and gas is supplied at a lower rate, i.e. for a "low fire" condition, through only port 57. Transitions may then be accomplished from a high fire condition to a low fire condition and vice versa; and should, under any circumstance, the temperature in enclosure 202 become more than a predetermined magnitude, sensed by thermostat 31, the system returns to the "off" condition shown in FIG. 5.

However, should the thermostat 31 fail to thus operate, or should the heater or boiler temperature or pressure rise appreciably above the previously mentioned first predetermined level and assume a second higher predetermined level, sensed also by the means 212, then switch 100 is automatically opened and the system returns to its "off" position shown in FIG. 5.

While the particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim as my invention:

1. In a valve structure: a valve body having an inlet and an outlet and a main passage therebetween; a main valve controlling flow through said main passage; means forming a supplemental passage interconnecting said inlet and said outlet; a supplemental valve controlling flow through said supplemental passage; a fluid pressure motor,

said motor having a movable pressure-responsive element, means operatively connecting said main valve and said element for operating said main valve; first conduit means extending between said inlet and one side of said movable element; a control valve in said conduit means for controlling the operation of said motor; second conduit means communicating said one side of said element to a pressure different from that existing in said inlet when said control valve is closed; and a mechanical connection between said control valve and said supplemental valve arranged so that when the control valve is actuated to effect, through said motor, opening of said main valve said supplemental valve is also opened.

2. A valve structure according to claim 1 including an additional valve in said second conduit means for controlling the operation of said motor independently of said control valve and capable of effecting, through the motor, closing of said main valve while the pilot valve is in said actuated condition and said supplemental valve is therefore open through its connection with the said control valve.

3. In a valve structure: a casing having an inlet chamber and an outlet chamber; a partition separating said chambers and having a main port and a supplemental port therethrough; a main valve and a supplemental valve controlling flow through the respective ones of said ports; a fluid pressure motor, said motor having a movable pressure-responsive element; means operatively connecting said main valve and said element for operating said main valve; first conduit means extending between said inlet and one side of said element; a control valve in said first conduit means for controlling the operation of said motor; second conduit means communicating said one side of said element to a pressure different from the pressure in said inlet chamber when said control valve is actuated; and means interconnecting said control valve and said supplemental valve and arranged so that when the control valve is actuated to effect, through said motor, opening of said main valve said supplemental valve is also opened.

4. A valve structure according to claim 3 including an additional valve in said second conduit means for controlling the operation of said motor independently of said control valve and capable of effecting, through the motor, closing of said main valve while the control valve is in said actuated condition and said supplemental valve is therefore open through its connection with the control valve.

5. A valve structure according to claim 3 wherein a fluid communicating means is between said inlet chamber and said motor for operating said motor by above atmospheric pressure of fluid in said inlet chamber, and said control valve comprises a part extending into the inlet chamber through an opening in a wall of the casing adjacent said supplemental port.

6. In a valve structure: a casing having an inlet chamber and an outlet chamber; a partition separating said chambers and having a main port and a supplemental port therethrough; a main valve-closure and a supplemental valve-closure for controlling flow through the respective ones of said ports; a motor, operated by the pressure of fluid in said inlet chamber, for operating said main closure; said motor comprising a movable wall closing an opening through a casing wall of the inlet chamber and operatively connected to the main closure for operating the same, and means at the outside of the casing defining with said movable wall a pressure chamber; said casing wall having conduit means interconnecting the inlet chamber and said pressure chamber; a control valve in said conduit means, for controlling the operation of said motor, comprising a closure controlling passage of fluid from said inlet chamber to said pressure chamber through said conduit means; second conduit means communicating said pressure chamber to a pressure different from the pressure in said inlet chamber when said con-

trol valve is operated; and a mechanical connection between said control valve closure and said supplemental-valve closure arranged so that when the control-valve closure is actuated to effect, through the motor, opening of said main closure the supplemental-valve closure is opened through said connection.

7. In a valve structure: a casing having an inlet chamber and an outlet chamber; a partition separating said chambers and having a main port and a supplemental port therethrough; a main closure for controlling flow through said main port and biased to port-closing position; a motor, operated by the pressure of fluid in said inlet chamber, for opening said main closure; said motor comprising a movable wall closing an opening through a casing wall of the inlet chamber and operatively connected to the main closure, and means at the outside of the casing defining with said movable wall a pressure chamber; there being another opening through a casing wall of the inlet chamber and aligned with the inlet-chamber end of said supplemental port; means at the outside of the casing, around said other opening, defining a part of said pressure chamber; a control valve, for controlling operation of said motor, comprising a reciprocable stem extending through said other opening in spaced relation to its sides and carrying a closure cooperable with the inlet-chamber end of said other opening; valve means operable by said stem and arranged to vent said pressure chamber when said control valve closure is operated so that pressure of fluid in the inlet chamber then effects, through said movable wall, opening of said main closure; a supplemental closure also carried by said stem and arranged so that it is moved out of closing relation to the inlet-chamber end of said supplemental port when the control-valve closure is actuated; and means for actuating said stem.

8. A valve structure according to claim 7 wherein means are provided whereby venting of the pressure chamber is restricted so that opening of said main closure is retarded, and initial flow through the valve structure is by way of said supplemental port.

9. A valve structure according to claim 8 including means operatively associated with said supplemental port for adjusting the rate of flow through said supplemental port.

10. A valve structure according to claim 7 including conduit means in communication with said pressure chamber, an additional valve in the last-mentioned conduit means arranged to obstruct venting of said pressure chamber by said valve means and concurrently to supply to the pressure chamber fluid from said inlet chamber so as to effect, through said motor, closing of said main closure while said other opening is closed by the control-valve closure and said supplemental port is open.

11. In a valve structure: a casing having an inlet chamber and an outlet chamber; a partition separating said chambers and having a main port therethrough; a main valve for controlling flow through said main port; a fluid pressure motor, means operatively connecting said main valve and said motor for operating said main valve; conduit means interconnecting said motor with said inlet chamber; a portion of said partition being substantially parallel to and spaced from a casing wall of said inlet chamber, said portion having a supplemental port therethrough facing said casing wall; a supplemental closure for controlling flow through said supplemental port; said casing wall having an opening therethrough aligned with said supplemental port; a control valve in said conduit means for controlling the operation of said motor and mounted on the outside of the casing adjacent said opening; second conduit means connecting said motor to a pressure different than the pressure in said inlet chamber when said control valve is operated, and means, extending through said opening, mechanically interconnecting said control valve and said supplemental closure and arranged so that when the control valve is actuated to effect,

through said motor, opening of said main valve the supplemental closure is also opened.

12. A valve structure according to claim 11 wherein said motor includes means to effect gradual opening of said main valve, and wherein said actuation of the control valve effects abrupt and full opening of said supplemental valve.

13. A valve structure according to claim 11 wherein a fluid communicating means is between said chamber and said motor for operating said motor by above atmospheric pressure of fluid in said inlet chamber, and wherein said opening through a casing wall of the inlet chamber serves for supplying said fluid to the motor under the control of said control valve.

14. A valve structure according to claim 13 wherein said motor comprises a movable wall closing an opening through a casing wall of the inlet chamber at the side of the casing opposite the aforesaid casing wall, and means at the outside of the casing defining with said movable wall a pressure chamber for said fluid.

15. In an arrangement of the character described, a valve body having inlet means, outlet means and a chamber; two conduit means extending between said inlet and outlet means for producing parallel fluid flow between said inlet means and said outlet means, first valve means in one of said conduit means for controlling the flow of fluid between said inlet means and outlet means comprising a pressure-operated diaphragm having one side thereof exposable to the pressure of fluid in said inlet means and having the other side thereof forming a movable wall of said chamber; second valve means in the other one of said conduit means controlling the flow of fluid between said inlet and outlet means; third valve means for controlling fluid flow from said inlet means to said chamber to control operation of said first valve means; and means for operating said second and third valve means, said operating means including means for jointly operating said second and third valve means such that when said second valve means is closed, said third valve means is opened.

16. An arrangement as set forth in claim 15 in which means are incorporated for controlling the rate at which fluid from said inlet means is allowed to leave said chamber such that said first valve means is opened relatively slowly when said third valve means is opened.

17. An arrangement as set forth in claim 16 in which said rate controlling means comprises conduit means extending from said chamber having a restricted opening therein.

18. An arrangement as set forth in claim 15 in which said first valve means controls a relatively large volume of fluid flow and said second valve means controls a relatively small volume of fluid flow, and said second valve means controls the flow of fluid through said other conduit means between said inlet and outlet means with the last mentioned conduit means and means providing a restriction in the last-mentioned conduit means.

19. An arrangement as set forth in claim 18 in which means are incorporated to retard opening of said first valve means when said third valve means is operated.

20. An arrangement as set forth in claim 16 in which conduit means extends from said chamber for venting the

same; fourth valve means controlling the flow of fluid through the last mentioned conduit means; and said operating means operating said second, third and fourth valve means jointly.

21. An arrangement as set forth in claim 16 in which conduit means extends from said chamber, fourth valve means controlling the flow of fluid through said conduit means, said second, third and fourth valve means being operated jointly by said operating means; a venting conduit; and fifth valve means alternately placing said conduit means in communication with said venting conduit or said inlet means.

22. An arrangement as set forth in claim 21 including first condition-responsive means controlling said operating means; and second condition-responsive means controlling said fifth valve means.

23. In an arrangement of the character described wherein a pressure operated diaphragm valve is controlled in accordance with differential pressures on opposite sides of a diaphragm and wherein means are provided to produce a differential pressure acting on said diaphragm, the improvement which resides in providing a supplementary valve in a fluid flow path which is in parallel with the fluid flow through said diaphragm operated valve, and providing means for retarding the movement of said diaphragm operated valve to open position when said supplementary valve is opened, and providing means defining a fluid passage for intercommunicating opposite sides of said diaphragm, and common control means operated to open said supplementary valve and to substantially simultaneously close said fluid passage to prevent one side of said diaphragm from being in communication with the other side of said diaphragm.

24. An arrangement as set forth in claim 23 in which additional valve means is effective to alternately vent said one side of said diaphragm to the atmosphere or to place the same in communication with said other side.

25. An arrangement as set forth in claim 24 including a first condition responsive means, a second condition responsive means sensitive to a condition established by operation of said common control means, said common control means being operated in accordance with the condition of said first condition-responsive means and said additional valve means being operated in accordance with the condition of said second condition responsive means.

26. An arrangement as set forth in claim 25 including a third condition responsive means sensitive to a condition established by operation of said common control means, said common control means being rendered inoperative in accordance with a condition of said third condition-responsive means.

References Cited in the file of this patent

UNITED STATES PATENTS

910,092	Simonds	Jan. 19, 1909
1,888,449	Burns	Nov. 22, 1932
2,046,882	Ray	July 7, 1936
2,293,947	Persons	Aug. 25, 1942
2,317,639	Ray	Apr. 27, 1943
2,653,768	Penn	Sept. 29, 1953
2,685,411	Penn et al.	Aug. 3, 1954