Nov. 5, 1963 R. P. FLAGG 3,109,449

GAS VALVE

Filed April 3, 1961 2 Sheets-Sheet 1

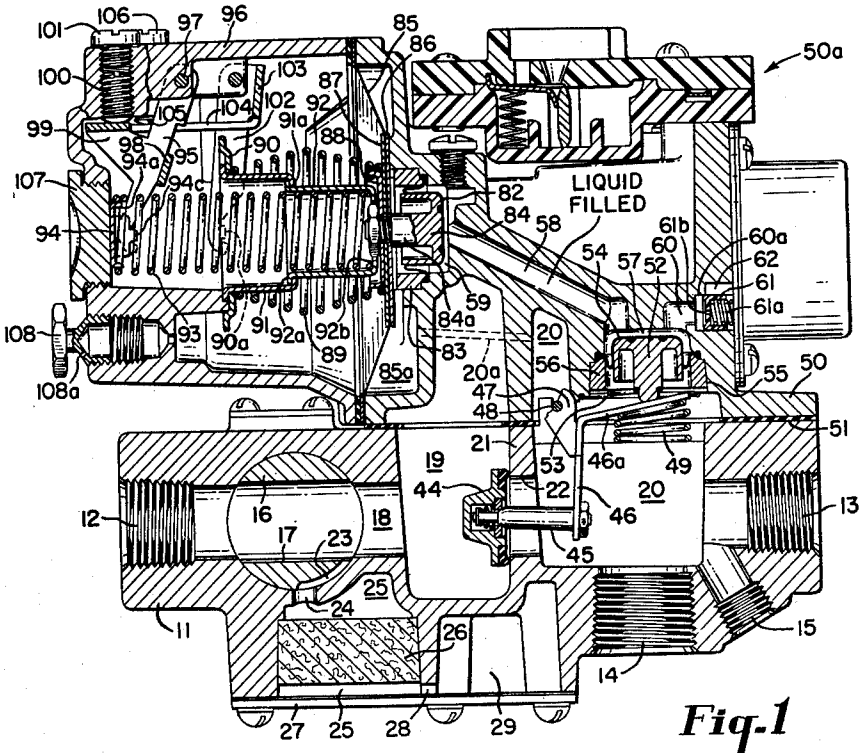


Fig-1

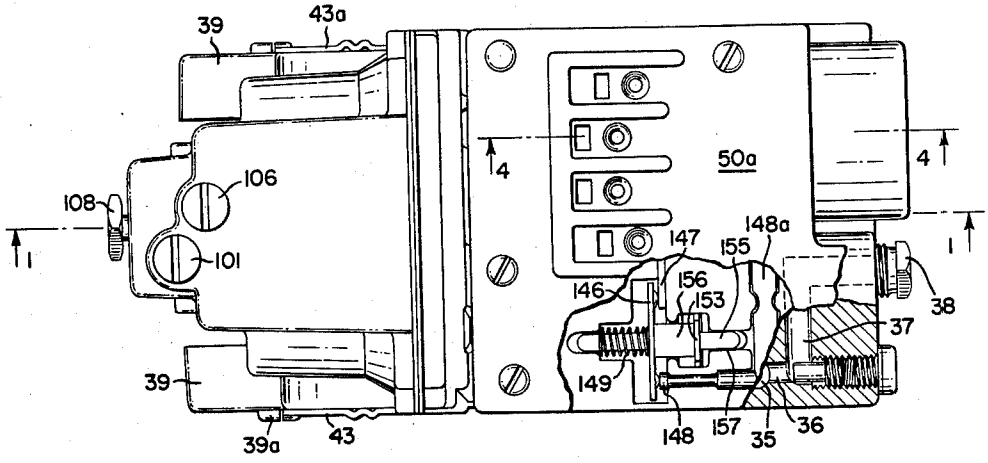

Fig-2

INVENTOR.
RAYMOND P. FLAGG
BY
Alan M. Stanley
ATTORNEY

Nov. 5, 1963 R. P. FLAGG 3,109,449

GAS VALVE

Filed April 3, 1961 2 Sheets-Sheet 2

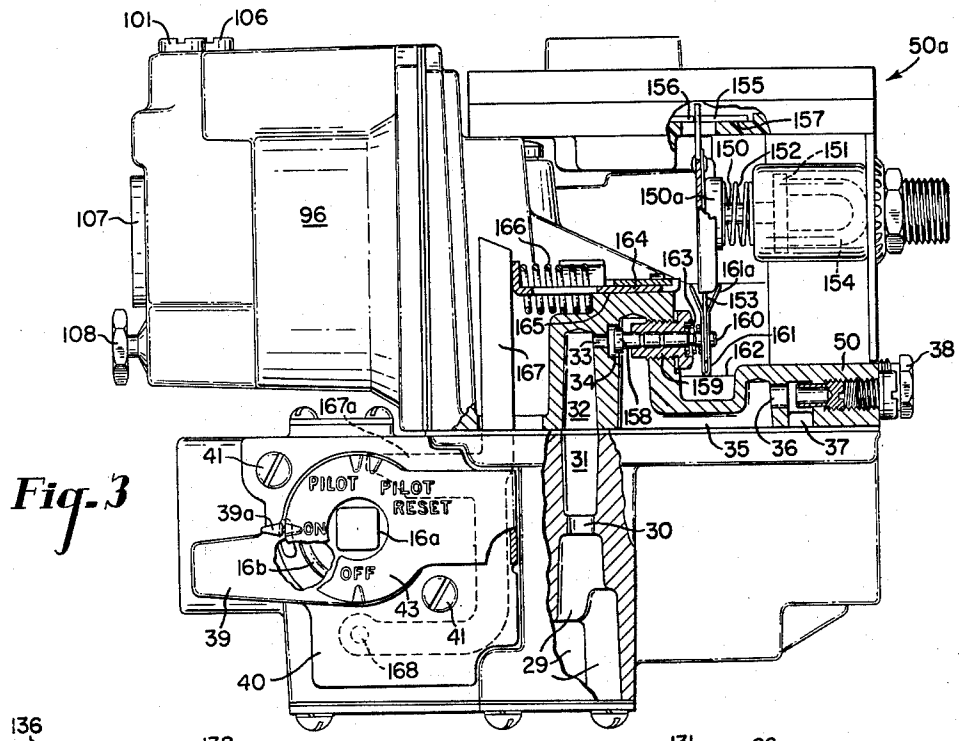


Fig-3

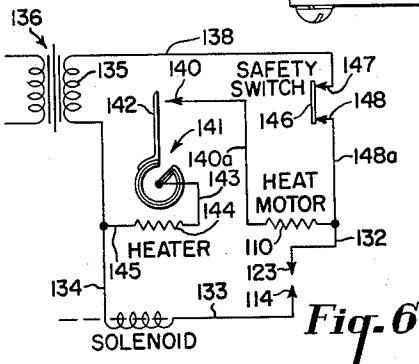


Fig-6

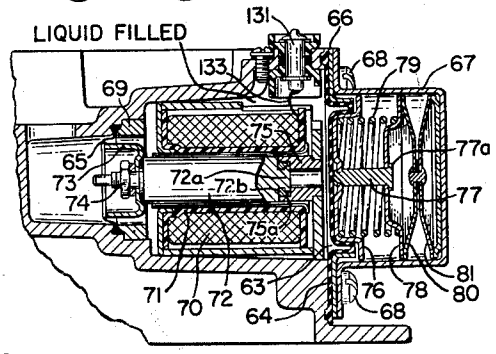


Fig-4

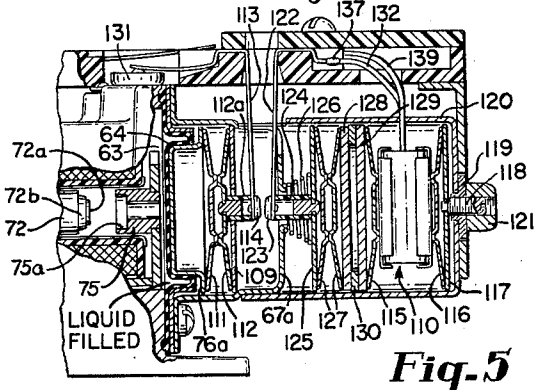


Fig-5

INVENTOR.
RAYMOND P. FLAGG
BY
Alan M. Stanley
ATTORNEY

United States Patent Office 3,109,449 Patented Nov. 5, 1963



3,109,449

# GAS VALVE

Raymond P. Flagg, Minneapolis, Minn., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

Filed Apr. 3, 1961, Ser. No. 100,202
8 Claims. (Cl. 137—495)

This invention relates to manifold or combined valves for controlling the flow of fuel, such as gas, to a heating plant. More particularly, the invention relates to a unitary control device which embodies a manually operable valve and a control valve which is actuated by a plurality of condition responsive power means so as to provide a single unit for controlling the flow of fuel to a furnace from a fuel source.

One of the objects of this invention is to provide in a single unit, a manually operable plug valve, a control valve in series with said plug valve, a hydraulic actuator means for the control valve, a solenoid actuator for the operation of said hydraulic means, a pressure regulator for also operating said hydraulic actuator means, a heat motor also operable on said hydraulic actuator means, and a safety switch responsive to the presence of a pilot flame for controlling the energization of the solenoid and a switch operable by the heat motor for also controlling the energization of the solenoid.

Another object of the invention is to provide a manifold valve which provides a step opening of a control valve therein so that the control valve will open to a minimum flow position for fuel igniting purposes and thereafter move through a plurality of control positions in response to the demand of a condition responsive actuator for the control valve.

A still further object of the invention is to provide a hydraulic valve actuating means for a control valve wherein solenoid means is adapted to act on said hydraulic valve actuating means between the solenoid and a control valve in conjunction with a hydraulic accumulator and a check valve to provide step opening of the control valve.

A still further object of the invention is to provide, in a manifold valve, a control valve having means that is adapted to provide step opening of the control valve so that a minimum flow position of the control valve will be regulated at a low pressure and then regulated at a higher pressure when the control valve is moved to a wider open position.

A still further object of the invention is to provide pressure regulating means for controlling the outlet pressure of a control valve at a low flow rate and also control, at a much higher pressure, the outlet pressure of the control valve when it is providing a higher rate of gas flow.

Still further objects of the invention will become apparent upon reading the following detailed description of the invention in conjunction with the accompanying drawings wherein:

FIGURE 1 is a vertical sectional view of the preferred embodiment of the invention;

FIGURE 2 is a top plan view of the manifold valve with portions thereof broken away;

FIGURE 3 is a side elevational view of the invention with portions thereof broken away;

FIGURE 4 is a fragmentary, cross-sectional view of one form of the invention, showing the solenoid actuator and hydraulic accumulator associated therewith in cross section;

FIGURE 5 is a view, similar to that of FIGURE 4, of a modification of the invention which shows a smaller part of the solenoid, a switch for controlling the energization of the solenoid and a heat motor for actuating the switch and then the hydraulic means; and



FIGURE 6 is a schematic showing of the electric power elements and the control circuit therefor.

As can be best seen in FIGURE 1 of the drawing, the manifold valve comprises a main valve body **11** having a threaded inlet **12** and a threaded outlet **13**, along with alternate threaded outlets **14** and **15**.

Positioned inwardly of the inlet **12**, is a conventional plug type of manually operable valve **16** having a transverse bore **17** therethrough for establishing communication between the inlet **12** and an outlet passage **18** leading from valve **16** to a control valve chamber **19**.

Positioned between the chamber **19** and an outlet chamber **20** is a partition wall **21** having a bore **22** therethrough. A valve seat surrounds the inlet end of the bore.

The plug valve **16** has an arcuate groove **23** therein that extends from the outlet end of the bore **17** through an angle of approximately 50 degrees to a transverse opening **24** that leads to a filter chamber **25**. A filter **26** is located in the chamber **25** and is retained in said chamber by means of a cover plate **27**. Gas is adapted to flow from the chamber **25** through a groove **28** to a recess **29**, both of which are also closed by the plate **27**, and then flow from recess **29** (see FIGURE 3), through passages **30**, **31**, **32** and **33**, valve seat **34**, recess **35**, valve passage **36**, passage **37**, connector fitting **38**, and through a conduit (not shown) to a pilot burner of a heating installation.

The plug valve **16** is adapted to be actuated externally of the valve body by means of a handle **39** secured to the square stem **16***a* extending from the top of the valve **16** and through a cover plate **40**. The cover plate is secured to the body **11** by means of screws **41** and has an L-shaped extension **42** and **43** so proportioned that the portion **43** overlies the handle portion **39** and provides "on," "off," "pilot" and "pilot reset" indicia thereon to cooperate with a pointer **39***a* on the handle **39**, to indicate the various positions of the plug valve. The plug valve, which is of conventional frusto-conical shape, is resiliently biased into seating engagement with its accommodating recess by means of a coil compression spring **16***b* positioned between the upper end of the plug valve and the cover plate **40**.

To enable the plug valve to be operated from either side of the valve body, a second handle **39** is connected to a square stem projection (not shown) similar to the projection **16***a*. The second handle is also retained on the stem by means of an indicating arm **43***a*, similar to the arm **43**.

Positioned over the inlet end of the bore **22**, is a disc valve **44** that is resiliently and swivelly connected to the end of a stem **45** which, in turn, is bolted to the free end of a lever **46**. The lever **46** is pivotally connected to the valve body **11** by means of two transversely extending and parallel arms **47** pivotally connected to a fixed transverse pivot **48**. The lever has a transversely extending arm **46***a* that is normally biased in a counterclockwise direction by means of a coil compression spring **47** extending from a recess in the valve body. The open tops of the recesses **19** and **20** are sealed by means of a housing **50** that is secured to the valve body **11**, with a sealing gasket **51** therebetween, by means of bolts (not shown) or any other suitable means.

The valve **44** is actuated by a bellows operated pin **52** which bears against the lever arm **46***a* on the opposite side thereof from the coil compression spring **49**. A centering spring **53** exerts a slight bias on the pin **52** against diaphragm **54**. The diaphragm **54** is clamped against a shoulder of a recess **55** in the lower surface of the housing **50** by means of a ring **56**. The chamber **57** between the diaphragm **54** and the upper end of the recess **55** is filled with oil or any other suitable liquid and communicates

through passage 58 with a chamber 59 and through a passage 60, check valve 61 and passage 62 with a chamber 63. Like chamber 57, all of the passages and other chambers just mentioned are also filled with oil so as to form a completely liquid filled and constant volume motion transmitting chamber.

One end of the chamber 63 is sealed with a diaphragm 64 while the other end of the chamber 63 is sealed by a diaphragm 65. The marginal edge of the diaphragm 64 is clamped to the housing 50 by means of a flanged sleeve 66 and cover 67, having bolts 68 extending therethrough and into the housing 50, while the diaphragm 65 has its marginal edge clamped to a shoulder of the chamber 63 by means of a clamping ring 69.

A solenoid coil 70 and a tube 71 are fixedly mounted in the chamber 63 and have a plunger 72 extending therein with one end of the plunger connected to the diaphragm 65 by means of a threaded pin extending through the diaphragm and through a backing cup 73 for the diaphragm, with a nut 74 threaded onto the threaded extension. An apertured stop 75, at one end of the solenoid tube, limits the movement of the solenoid plunger. The aperture in the stop permits the flow of oil from the plunger tube to chamber 63.

Positioned within the cover 67 and backing up the diaphragm 64, is a cup-shaped member 76 which has a centrally disposed stem 77 affixed at one of its ends to the member 76 and extending through a spring retainer disc 78 at its other end, and having a headed portion 77*a* limiting relative movement between the stem 77 and retainer 78. A coiled compression spring 79 extends from the spring retainer 78 and the bottom of the cup-shaped member 76. It will be noted that in the normal position of the spring 79, the head 77*a* of the stem 77 abuts the spring retainer 78 to establish a normally fixed relationship between the member 76 and 78 until the spring is compressed to move these two members closer together. The spring 79 is stronger than the spring 49 so that if there is no obstruction to liquid flow between the chamber 63 and the chamber 57, the spring 49 will yield before the spring 79.

Positioned between the spring retainer 78 and the outer end of the cover 67, are two bimetallic members 80 and 81. These two bimetal members are so arranged in the space to variably position the end of the diaphragm assembly 76, 77 and 78 to compensate for changes in the volume of the oil in the chamber 63 and communicating chambers and passages with changes in ambient temperature.

The elements of the appartus shown in FIGURE 4 of the drawing are in the poistions they assume when the heating system in which the manifold valve is located is in its operating "on" condition. That is, the solenoid valve has pulled in in response to thermostat demand and the control valve is in an open position.

The outlet pressure in chamber 20 is regulated by means of a spring loaded diaphragm 82 forming a movable wall for the chamber 59. The marginal edge of the diaphragm is anchored against a shoulder of the recess 59 by means of a clamping ring 83. A backing plate 84, against which the diaphragm 82 presses in response to outlet pressure, has a stem portion 84*a* that is bolted to a pressure responsive diaphragm 85 and to its backing plates 86 and 87 on opposite sides thereof.

A spring retainer 88 is also bolted by the same stem 84*a* against the backing plate 87 and positions one end of compression spring 89. The other end of compression spring 89 bears against a washer 90 which, in turn, surrounds a movement limiting sleeve 91 having an inwardly extending flange 91*a* intermediate the length of the compression spring 89. A second motion limiting sleeve 92 has an outwardly extending flange 92*a* that normally engages the inwardly extending flange 91*a* but has relative movement with respect thereto. The other end of the sleeve 92 has an inwardly extending flange 92*b* that is engaged by a



compression spring 93. The other end of the spring 93 bears against a U-shaped yoke 94 having centrally disposed arms 94*a* that center the compression spring 93 on the yoke and has arms that straddle the spring 93 with transversely and outwardly extending lugs 94*c* that are engaged by the free ends of a pair of lever arms 95 for adjusting the position of the end of the spring 93. The lever arms 95 are pivoted on a housing 96 for the springs by means of pivot 97, crossbars 98 and 99 make the lever arms 95 a rigid unit while the crossbar 99 also serves as abutment means for an adjustment screw 100 that is adjustably threaded in the housing 96. A sealing plug 101 closes the opening to the adjustment screw 100.

The left-hand end of the compression spring 89 is similarly adjusted by means of a pair of levers 102 bearing against outwardly extending lugs 90*a* extending diametrically from the periphery of the washer 90. A crossbar 103 rigidly connects the two levers 102 and has an arm 104 that is engaged by an adjusting screw 105 also threaded in the housing 96 and covered by a sealing plug 106.

Access to the springs is provided by a sealing plug 107 threaded into the housing 96 while atmospheric air has access to the interior of housing 96 through a hollow sealing plug 108 having a bleed orifice 108*a* therein. A chamber 85*a*, between the diaphragms 85 and 82, is connected to outlet chamber 20 through passage 20*a*.

The pressure regulating units are so designed that when the solenoid is energized and the valve 44 is opening, the diaphragm 85 moves slightly to the left, as viewed in FIGURE 1, to provide a gap of about .060 of an inch between the spring retainer 88 and the inwardly extending flange 92*b*, to provide pressure regulation of about one inch water column pressure for the outlet gas pressure. When the diaphragm 85 is loaded still more by further opening of the control valve, the member 88 engages the flange 92*b* and moves the sleeve 92 toward the left and thereby additionally picks up the loading of spring 93. With both springs 89 and 93 acting against the diaphragm 85, the outlet gas pressure in chamber 20 will be maintained at about three and one-half inches water column pressure.

The above mentioned step opening of the control valve 44, to provide stepped pressure operation, is the result of the use of the check valve 61 in the passages 62 and 60 leading from the chambers 63 around the solenoid and the chamber 57 over the diaphragm actuator for the control valve 44, the chamber 57 being directly connected with the chamber 59 at the pressure regulator through passage 58. The check valve 61 is normally held in the position shown in FIGURE 1 of the drawing by means of compression spring 61*a*. As shown in the drawing the front end of the cup-shaped check valve 61 is in line with the right hand end of the enlarged diameter bore 60*a* of passage 60 so that initial flow from the chamber 63 will first cause the cup-shaped check valve 61 to move to the left-hand end of the bore 60*a*, where it will be stopped from further movement, and then the oil from chamber 63 must pass through the small orifice 61*b* in the check valve 61 to cause slow movement of oil from the solenoid chamber.

It is thus seen that initial energization of the solenoid will cause quick movement of the control valve to a slightly open position to provide a minimum flow of gas for igniting purposes, to prevent flashback or roll-out, and then move at a slower rate to a wider open position of the control valve for normal "low fire" operation.

By the provision of the accumulator spring 79, the solenoid plunger is able to move to its full extent into the solenoid tube, to develop its maximum power, without developing an over pressure in chamber 63. The spring 79, which exerts a minimum force of 2.15 p.s.i as compared with a minimum closing force of 1.30 p.s.i. on the closing spring, provides the means for continuing the flow of oil through the orifice 61*b*, which has a diameter of 0.020 of an inch.

While in some valve designs it might be possible to rely on the spring rate of the bimetallic members **80** and **81** as accumulator springs, there are three advantages in the use of the overpressure spring **79**. First, it allows the solenoid to pull in within two seconds, since the spring rate is lower than the bimetals. Second, it exerts 2.15 p.s.i. to 2.5 p.s.i., as compared to nearly 8 p.s.i. when using the bimetals, to cause the oil to flow through the check valve orifice at a slower rate and, thereby, giving more time on the step. Third, it reduces the load or pressure on the sleeve bellows or pressure diaphragms to prevent damage thereto.

A modification of the invention, shown in FIGURE 5 of the drawing, shows no overpressure spring associated with diaphragm **64** and its back-up plate **76***a* to provide gas accumulation thereby, but makes use of a solenoid similar to that shown in FIGURE 4 but having a shorter travel for the solenoid plunger. In this arrangement, the plunger moves only sufficiently to cause the movement of the control valve to its "low fire" rate position and relies on a heat motor **110** to provide the additional movement of the control valve to its "high fire" operating positions. A pair of bimetallic members **111** and **112** provide ambient temperature compensation to maintain an effective constant volume to the oil in the motion transmitting passages and chambers, while one of the bimetallic members **112** has a contact engaging member **112***a* thereon that slides through an apertured guide plate **109** and bears against a flexible blade **113** carrying a contact **114** at one end thereof.

The heater motor **110** is positioned between two bimetallic members **115** and **116**. The position of bimetal **116** is adjustable by means of a plate **117**. The adjustment plate has an aperture therein through which a reduced diameter portion of an adjusting screw **118** extends. The screw is threaded through a stepped washer **119** which, in turn, is secured to a housing **120** by means of spot welds. A locking nut **121** holds the adjusting screw **118** in its adjusted position.

A second flexible contact arm **122** carries a contact button **123** at its free end and is adapted to be actuated by a stem **124** secured to a disc **125**. The stem extends through an aperture in the cover **67***a* and is surrounded by a coil compression spring **126** that extends between the housing **67***a* and the disc **125**. One of a pair of bimetal members **126** and **127** bears against the disc **125** while the other of said pair of bimetal discs bears against a spacer plate or disc **128**. These bimetal discs provide ambient compensation for the heater bimetal members **115** and **116**. A spacer disc **129** bears against the bimetal **115** while the two spacer discs **128** and **129** are separated by a spacer washer **130**. The discs and washer are preferably made of heat insulating material to prevent heat from the heat motor **110** from overly affecting the bimetals **126** and **127**.

The other end of flexible contact blade **113** is biased against a lead terminal **131** while the other end of contact blade **122** is soldered to lead wire **132** connected to one end of the heater wire (not shown) of heat motor **110**. Terminal **131** is connected by lead wire **133** to one end of the coil **70** of the solenoid. The other end of the coil **70** is connected by a lead wire **134** to the secondary coil **135** of a transformer **136**. Both the lead wire **132** from the heat motor and the contact blade **122** are connected by the same weld **137** to a lead bar **148***a* of contact **148**. Contact **148** is connected through a contact bar **146**, contact **147** and lead wire **138** to the other side of the secondary transformer coil **135**. A second lead wire **139** from the heat motor **110** is connected to a terminal which is connected by a lead wire **140***a* to a fixed contact **140** of a room thermostat **141**. A movable contact arm **142** of the room thermostat is connected through lead wire **143** to a heater **144** for the room thermostat, with the other end of the heater **144** connected by a lead wire **145** to the lead wire **134** through a terminal on the terminal block **50***a*.



In order to prevent unsafe operation of the control valve when there is no pilot flame to ignite the gas passing through the control valve, a safety switch, incorporating contact bar **146**, is adapted to break the connection between the two fixed contacts **147** and **148** in the line **138** to the transformer. The contact bar is normally biased against the fixed contacts by means of a coil compression spring **149** but is adapted to be actuated away from the fixed contacts by means of a headed plunger **150** connected to an armature **151**. A coil compression spring **152** normally biases the head **150***a* on the stem against a floating lever **153** to overcome the spring **149** but is adapted to be compressed to move the armature **151** into engagement with an electromagnet **154** where it will be held against the bias of the spring **152** so long as the magnet is energized. The magnet is of the type that is energized by a thermocouple heated by a pilot burner, neither of which is illustrated in the drawing. A stem **155**, having an enlarged diameter portion **156** that bears against the contact bar **146**, extends through an aperture in one end of the floating lever **153** and is guided in its movement by sliding in a groove **157** in the terminal block **50***a*.

A pilot valve **158**, adapted to cooperate with the valve seat **34** to control the flow of gas through bore **33** to a pilot burner, is slidably mounted in a sleeve-shaped bolt **159** threaded into the housing **50**. The pilot valve has a stem **160** that extends through and beyond the sleeve bolt **159** and through a U-shaped guide member **161** having outwardly flared arms **161***a* that are adapted to guide a forked end of the lever **153** between the legs of the U-shaped member so that the forks of the lever straddle the stem and fit into a groove in and near the extending end of the stem. The base of the U-shaped member **161** has sufficient width to cooperate with a shoulder **162** on the housing **50** to prevent rotation of the guide member so as to always position it to perform its function. A coil compression spring **163** normally biases the valve **158** away from the valve seat **34** but is adapted to be compressed or overridden by the spring **152** when the electromagnet **154** becomes de-energized.

The lever **153** is adapted to be actuated to open the pilot valve **158** and to set the armature **151** against the magnet **154**, while holding the contact bar **146** out of engagement with the fixed contacts **147** and **148**, by means of plunger **164** slidable in a groove **165** in the housing **50**. A coil compression spring **166** normally biases the plunger **164** away from the lever **153** but is adapted to be slid against the lever **153** to pivot the lever **153** about the head **150***a* of the armature member while simultaneously opening the valve **158** and resetting the armature against the magnet and holding the switch **146**, **147** and **148** open.

The plunger **164** is actuated by means of an L-shaped lever **167** pivoted on the housing or body portion **11** by means of a pivot pin **168**. Lever **167** has an arm **167***a* extending over the plug valve **16** so as to be engaged by a lug (not shown) rotatable with the plug valve. When the plug valve is in its "pilot" position, and the plug valve is rotated from the "pilot" position to the "pilot reset" position, the lug will cause pivotal movement of the lever **167** to move the plunger **164** to the right and to actuate the pilot valve and armature. After the pilot burner has been lighted and the electromagnet **154** has been energized, return movement of the plug valve to the "pilot" or "on" position will permit the spring **149** to move the contact bar against fixed contacts **147** and **148** and to pivot the lever **153** against the bias of spring **163** to partially return valve **158** towards its valve seat **34**, but still leaving the valve **158** in an open position. It is thus seen that the spring **149** will hold the contact bar **146** against **147** and **148**, to complete the circuit from the transformer through the heat motor and to the

solenoid switch 123—114, while the spring 163 will hold the pilot valve 158 open, to provide the flow of gas to the pilot burner. However, should the handle 39 be moved to the "pilot" or "on" position prior to the pilot burner becoming properly lighted or burning a sufficient time to energize the thermocouple connected to the elecmagnet, the armature 151 will be moved out of engagement with the electromagnet by the spring 152 to open the contacts 147, 148 and 146 and close the pilot valve 158. It is thus assured that there can be no flow of main gas to the main burner unless there is a pilot burner flame of sufficient intensity to cause ignition thereof.

*Operation*

The manifold valve and its control system, embodying the design of FIGURE 5, are illustrated as being in an operating but "off" condition. That is, the plug valve 16 is in its open position, the safety valve and safety switch are in their open and closed positions, respectively. However, the room thermostat is shown in a satisfied condition which means that the solenoid coil 70 is de-energized and the heat motor 110 is also de-energized, causing contacts 123 and 114 to be separated.

Should the temperature surrounding the room thermostat drop sufficiently to cause the contact 142 to engage contact 140, the heat motor 110 will become energized to cause warping of the bimetal 115 and 116 to cause movement of the contact 123 into engagement with the contact 114. Closing of the contacts 114 and 123 causes energization of the solenoid and the movement of the solenoid plunger into the solenoid tube. Oil from the solenoid chamber will move through passage 63 to force the check valve 61 to the left, away from spring 61*a*, and force the diaphragm 54 downwardly to crack the valve 44 open and to move the diaphragm 82 to the left to slightly load the diaphragm 85 and its biasing spring 89 so that when gas pressure is present in the chamber 20, this gas pressure will pass through passage 20*a* to chamber 85*a* to provide gas pressure regulation at the very low gas pressure. This gas pressure is approximately one inch water column and is sufficient to supply enough gas to the main burner to provide proper ignition to the burner by the pilot burner. Thereafter, the heat motor, which is of the heat storage type so that it will respond to the heat demand as determined by the variations in the time on and time off cycling of the room thermostat, causes the contact member 114 to move the diaphragm 64 toward the left, the valve 44 will be moved to a wider open position causing an increase in the outlet pressure in chamber 20 with a corresponding increase in the pressure in chamber 85*a* to the right of diaphragm 85. This will cause the diaphragm 85 to compress the spring 89 and cause the diaphragm to pick up the spring 93. Thereafter, the gas outlet pressure will be regulated by the combined forces of the springs 89 and 93 to provide a gas outlet pressure of about three and one-half inch water column.

If desired, the check valve 61 may be eliminated from the modification incorporating the heat motor 110 as the travel of the plunger in that modification is only enough to move the valve to its minimum flow position and the heat motor is slow acting.

The degree of opening and closing of the valve 44 will correspond with the heat demand by the room thermostat which causes more or less heat to be thrown into the heat motor as the load increases and decreases to provide modulation of the gas flow to the main burner. As the demand for heat gradually decreases, reverse action takes place with respect to the various parts of the manifold valve described above with the exception that when the solenoid is de-energized, the spring 49 can quickly move the diaphragm 54 upwardly to permit closing of the valve 44 by moving the check valve 61 into engagement with the spring 61*a* and then against the bias of the spring



to dump the oil from passage 60 into the passage 62 and to the solenoid chamber. Thus, when the gas has been modulated down to a low gas supply pressure and to a heat demand that causes breaking of the contacts 114 and 123, the valve will close quickly and not to the cracked open position as determined by the initial opening of the valve for ignition purposes. In other words, while the valve 44 moves quickly to an ignition flow rate, followed by a slow movement from the ignition rate to a low fire rate, the valve quickly closes from the low fire rate past the ignition rate to the complete "off" position.

In the modification of FIGURE 4, wherein no heat motor is used, then the solenoid is controlled solely by the room thermostat, control valve 44 will open and close with each closing and opening of the room thermostat contacts. Also, in this modification of the invention, it is necessary that the plunger 72 move a greater distance than the plunger of the modification of FIGURE 5. In other words, since the total displacement of the valve 44 from its seat is determined by the amount of oil forced into the chamber 57, it is necessary that the plunger 72 and diaphragm 65 have sufficient movement to fully open the control valve. For this reason, it is much more desirable to have an overpressure accumulator for this modification than for the modification of FIGURE 5.

While I have described the preferred embodiments of the invention above, it is to be understood that various modifications may be made therein without departing from the spirit of the invention. Therefore, it is to be understood that the scope of the invention is to be determined from the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A valve comprising a valve body having an inlet and an outlet and valve means therebetween, power means for actuating said valve, motion transmitting means between said power means and said valve means, time delay means cooperating with said power means and said valve means through said transmitting means for causing said valve means to move quickly to a minimum-flow position and thereafter move more slowly to a wider open position, and means responsive to outlet pressure and operably connected to said valve means by said transmitting means to regulate said valve means to maintain one pressure at a minimum flow rate and a substantially higher pressure at a substantially greater flow rate.

2. A control device comprising a housing, an energy control member movable in said housing between an "off" position and a "minimum-flow" position and a plurality of "on" positions, liquid motion transmitting means for moving said energy control member, electric power means operable on said liquid motion transmitting means for moving said energy control member, said transmitting means including means associated with said electric power means to cause it to first quickly move said energy control member to a "minimum flow" position and then more slowly to a greater flow position, condition responsive means operable to first close a circuit to said electric power means and then to variably actuate said liquid motion transmitting means to vary the position of said energy control member according to the demand for said energy, and means responsive to the rate of supply of said energy and operable on said liquid motion transmitting means to variably position said energy control member to maintain a uniform energy output according to the demand of said condition responsive means.

3. A control device comprising a housing, an energy control member movable in said housing between an "off" position and a "minimum-flow" position and a plurality of "on" positions, liquid motion transmitting means for moving said energy control member, power means operable on said liquid motion transmitting means for moving said energy control member, said transmitting means including means associated with said power means

to cause it to first quickly move said energy control member to a "minimum flow" position and then more slowly to a greater flow position, condition responsive means operable to first cause operation of said power means to variably actuate said liquid motion transmitting means to vary the position of said energy control member according to the demand for said energy, and condition responsive means responsive to the rate of supply of said energy and operable on said liquid motion transmitting means to variably position said energy control member to maintain a uniform energy output according to the demand of said condition responsive means.

4. A control device comprising a fluid housing, a control valve movable in said housing between an "off" position and a "minimum-flow" position and a plurality of "on" positions, liquid motion transmitting means for moving said control valve, power means operable on said liquid motion transmitting means for moving said control valve, said transmitting means including means associated with said power means to cause it to first quickly move said control valve to its "minimum flow" position and then more slowly to a further open position, condition responsive means operable to first cause operation of said power means and then to variably actuate said liquid motion transmitting means to vary the position of said control valve according to the demand for said energy, and means responsive to fluid pressure in said valve for actuating said liquid motion transmitting means to variably position said energy control member to maintain a uniform energy output according to the demand of said condition responsive means, said pressure responsive means having a pair of normally inoperative springs which are sequentially brought into operation as said liquid motion transmitting means is actuated to provide stepped pressure regulation.

5. In a control valve, the combination comprising a valve body having an inlet and an outlet and a valve seat therebetween, a valve in said body for engaging said seat, motion transmitting means for actuating said valve, condition responsive means operable on said motion transmitting means to variably position said valve, means responsive to outlet pressure and operable on said motion transmitting means to regulate said pressure in accordance with the demand of said condition responsive means, said pressure responsive means having a first spring that is operative to regulate outlet pressure when said valve is in a "minimum-flow" position and a second spring which is inactive when said valve is in said "minimum flow" position but becomes active by being operably engaged by said pressure responsive means when said condition responsive means operates on said motion transmitting means to open said valve wider and to compress said first spring an additional amount.



6. In a control valve, the combination comprising a valve body having an inlet and an outlet and a valve seat therebetween, a valve in said body for engaging said seat, liquid motion transmitting means for actuating said valve, condition responsive means operable on said liquid motion transmitting means to variably position said valve, means responsive to outlet pressure and operable on said liquid motion transmitting means to regulate said pressure in accordance with the demand of said condition responsive means, said pressure responsive means having a first spring that is operative to regulate outlet pressure when said valve is in a "minimum-flow" position and a second spring which is inactive when said valve is in said "minimum flow" position but becomes active by being operably engaged by said pressure responsive means when said condition responsive means operates on said liquid motion transmitting means to open said valve wider and to compress said first spring an additional amount.

7. In a control valve, the combination comprising a valve body having an inlet and an outlet and a valve seat therebetween, a valve in said body for engaging said seat, motion transmitting means for actuating said valve, condition responsive means including an on-off actuator and a modulating actuator operable on said motion transmitting means to variably position said valve, means responsive to outlet pressure and operable on said motion transmitting means to regulate said pressure in accordance with the demand of said condition responsive means, said pressure responsive means having a first spring that is operative to regulate outlet pressure when said valve is in a "minimum-flow" position and a second spring which is inactive when said valve is in said "minimum flow" position but becomes active by being operably engaged by said pressure responsive means when said condition responsive means operates on said motion transmitting means to open said valve wider and to compress said first spring an additional amount.

8. The combination of claim 7 wherein the operation of said on-off actuator is controlled by the operation of said modulating actuator.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,478,040 | Campbell et al. | Aug. 2, 1949 |
| 2,635,637 | Karrer | Apr. 21, 1953 |
| 2,827,076 | Obermaier | Mar. 18, 1958 |
| 2,899,972 | Matthews | Aug. 18, 1959 |
| 2,925,986 | Woods | Feb. 23, 1960 |
| 2,980,133 | Cooper | Apr. 18, 1961 |
| 2,982,300 | Jackson et al. | May 2, 1961 |