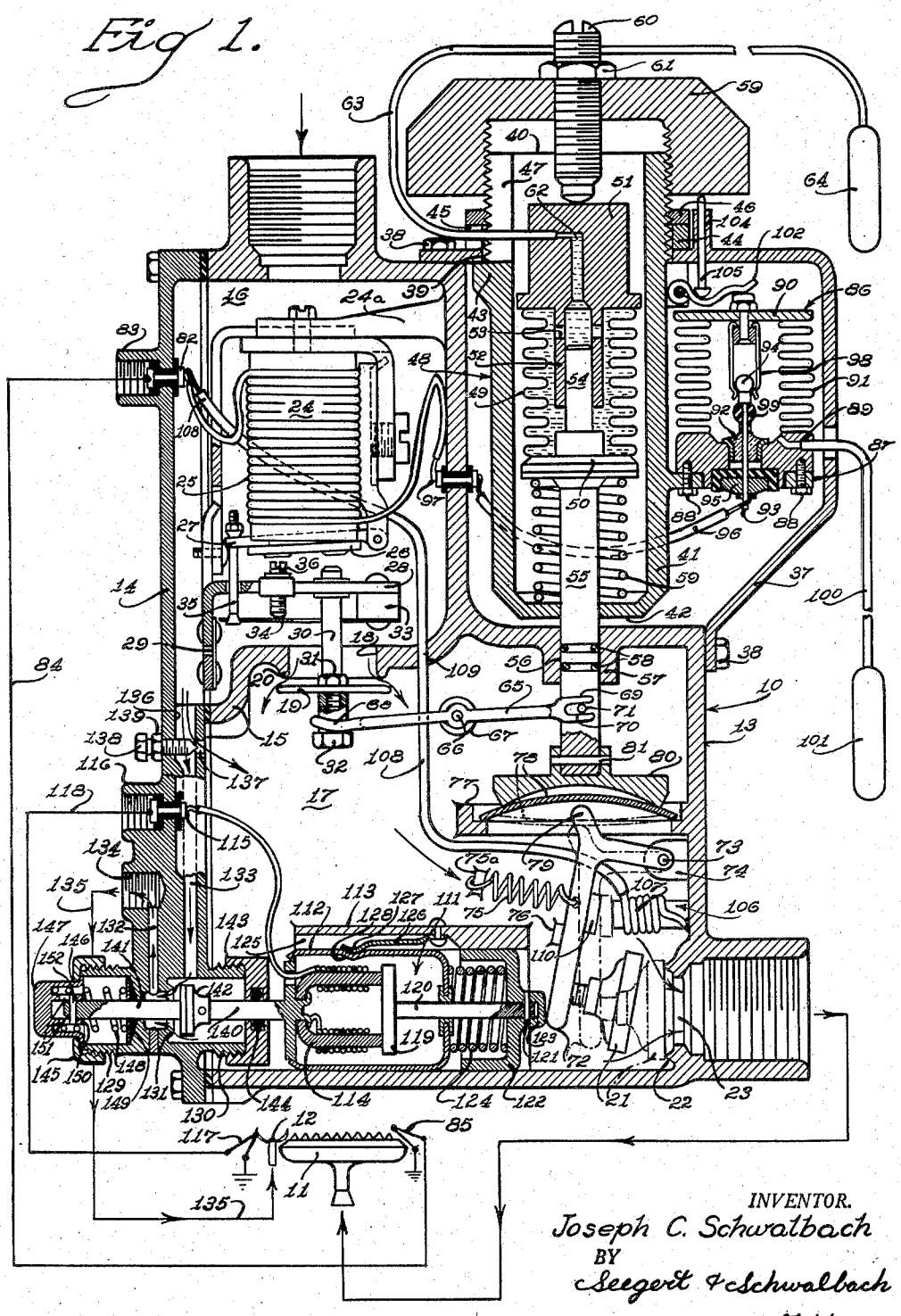
Feb. 24, 1959 J. C. SCHWALBACH 2,874,904

MODULATING FUEL CONTROL APPARATUS

Filed Dec. 28, 1954 2 Sheets-Sheet 1

Fig 1.



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MODULATING FUEL CONTROL APPARATUS

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Fig. 2.

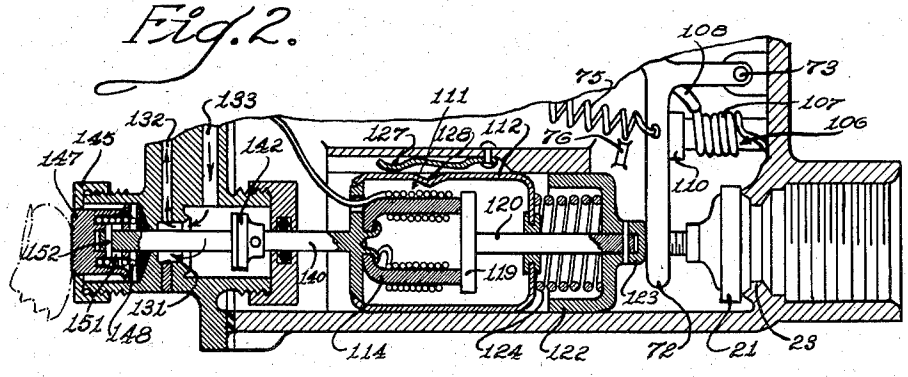
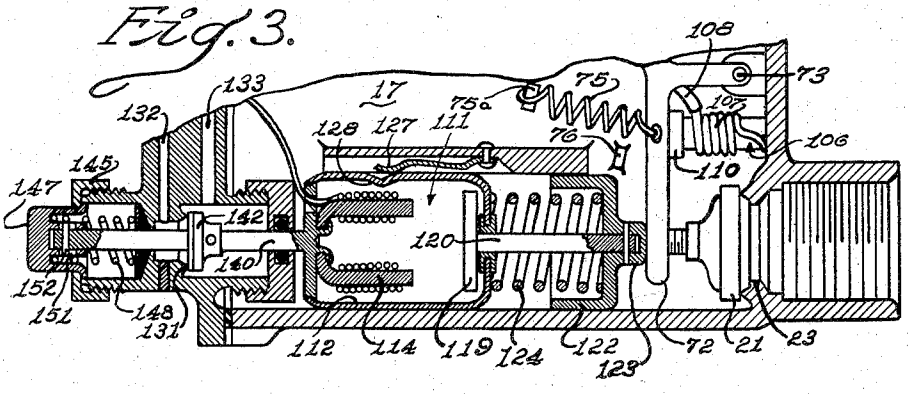


Fig. 3.



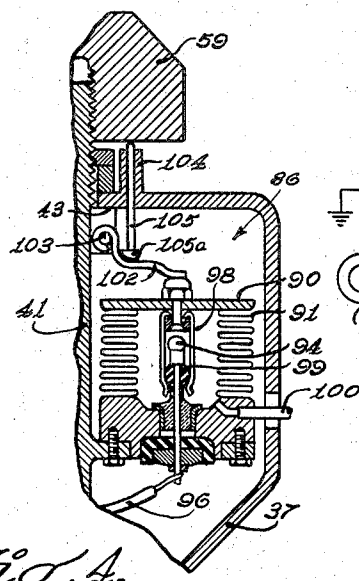


Fig. 4.

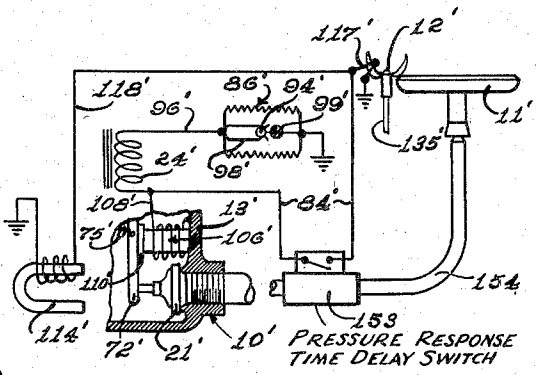


Fig. 5.

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MODULATING FUEL CONTROL APPARATUS

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Application December 28, 1954, Serial No. 478,144

29 Claims. (Cl. 236—1)

This invention relates to improvements in modulating fuel control apparatus and more particularly to apparatus affording modulating control of the flow of gaseous fuel.

Modulation of the fuel flow to the burner of a heater in accordance with the heat loss from the space heated is not only an efficient method of heating, but it also provides the greatest comfort for the occupants of the space by maintaining a substantially constant temperature. The provision of a modulating control for gaseous fuel burning apparatus is complicated by the fact that for every burner there is a safe minimum amount of fuel which is required for the maintenance of a stable flame and below which the fuel flow cannot safely be modulated. On the other hand, fuel in amounts substantially greater than the aforementioned safe minimum must be supplied to the burner for safe initial ignition of the fuel at said burner.

While continuous modulation of the fuel flow to a heater ordinarily affords the results desired as long as the temperature of the space being heated is within the modulating range of the fuel modulating apparatus, the operation of controls heretofore available is not entirely satisfactory under all conditions, for example in heating up of cold rooms after a low temperature night setting. In the latter instance prior modulating controls effectively derate the heater by reducing its output as the temperature within the space rises, and a relatively long warm-up period is therefore required to bring the temperature of the space up to the desired level.

Still another undesirable feature of certain prior modulating controls is the fact that once the fuel flow has been shut-off, for example in response to a rise in the temperature within the space beyond the modulating range, said temperature must drop substantially through the entire modulating range to the point where the demand for heat is such that the control can supply sufficient fuel to the burner for safe ignition before such fuel is supplied to the burner. This, of course, subjects the space and its occupants to undesirably large and uncomfortable temperature variations.

With the foregoing in mind, a general objective of the present invention is the provision of an improved modulating fuel control apparatus which, after shut off of the fuel, affords sufficient fuel flow for safe ignition at any time that the modulating apparatus calls for heat, said apparatus, after the establishment of a stable flame at the burner, modulating the flow of said fuel in accordance with the temperature of the space being heated. Thus, safe ignition is insured regardless of what the temperature of the space may be when fuel flow is initiated, and the temperature of the space is not required to cool to the lower end of the modulating range before safe ignition can be effected.

Another object of the invention is to provide an improved modulating fuel control apparatus of the character described which is provided with means affording quick warm-up after a low temperature night setting by

permitting full burner capacity fuel flow during said warm-up period.

Another object of the invention is to provide an improved modulating fuel control apparatus of the class described wherein there is a modulator valve and an on-off valve, there being electroresponsive actuating means for said modulator valve biasing said valve toward a minimum flow-permitting position when said actuating means is energized and biasing said valve to a full flow or ignition position when said actuating means is deenergized, said actuating means being connected in circuit with electrical source means effecting deenergization of said actuating means on closure of said on-off valve and continuing said deenergization for a predetermined period after said on-off valve has been opened, said period being sufficient to afford safe ignition of the fuel at the burner with a full or ignition flow of said fuel.

A more specific object of the invention is to provide an improved modulating fuel control apparatus of the character described wherein the actuating means for the modulator valve is connected in circuit with a source of electrical energy responsive to the heat of burning fuel at the burner, whereby on outage of said burner, said actuating means is deenergized and the modulator valve is moved to full flow or ignition position, said valve remaining in said position until subsequent establishment of a stable flame at said burner effects reenergization of said actuating means and biasing of said valve toward said minimum flow-permitting position.

Another specific object of the invention is to provide an improved control apparatus of the class described wherein the delay in reenergization of the actuating means for the modulator valve after opening of the on-off valve is afforded by a time delay switch in circuit with an electrical energy source means and said actuating means, said switch being responsive to opening of the on-off valve, and more specifically to the pressure of the fluid fuel flowing to the burner through said valve.

Another object of the invention is to provide an improved modulating control apparatus of the class described wherein there is condition responsive, for example temperature responsive modulating mechanism operatively associated with the modulator valve and with the on-off valve, said mechanism restraining movement of the modulator valve toward its minimum flow-permitting position under the bias of its electro-responsive actuating mechanism in accordance with fluctuations in the condition within the modulating range, thereby affording modulation of the fuel flow in accordance with said fluctuations, said mechanism being operable to effect closure of the on-off valve and stoppage of all fuel flow to the burner on occurrence of an extreme in said condition, for example a temperature above the modulating temperature range.

Another specific object of the invention is to provide, in control apparatus of the aforementioned character, electro-responsive latching means in circuit with the actuating means for the modulator valve for preventing movement of the on-off valve from closed to open position at any time that said actuating means is energized. This avoids any danger from downward adjustment of the control point of the modulating mechanism effecting closure of the on-off valve, followed immediately by upward readjustment of said control point tending to effect opening of said on-off valve before the modulator valve has been moved to its ignition position.

Still another object of the invention is to provide an improved modulating fuel control apparatus of the character described having safety shut-off means operatively associated with the on-off valve for overcalling the modulating mechanism and effecting closure of said valve on

outage of a pilot burner disposed in coacting relationship with the main burner, said safety shut-off means being manually resettable and affording interruption of the fuel flow to said main burner during a resetting operation to permit safe ignition of the fuel at the pilot burner.

Another object of the invention is to provide an improved modulating fuel control apparatus of the aforementioned character wherein fast warm-up after a low temperature night setting is afforded by a condition responsive circuit controlling device having latchable contacts in circuit with the electro-responsive actuating means for the modulator valve, said contacts when latched preventing energization of said actuating means, there being reset means operatively associated wth the condition responsive modulating mechanism and said circuit controlling device, said reset means effecting movement of said contacts to latched position when the control point adjustment means of the modulating mechanism is turned to a low temperature night setting, there being releasable latching means for retaining said contacts in said latched position after readjustment of the control point of the modulating mechanism to a normal operating temperature setting and until said contacts are released by response of said circuit controlling device to a predetermined normal temperature setting, said contacts thereafter remaining unlatched until subsequently latched by readjustment of the control point of the modulating mechanism to a low temperature night setting.

Still another object of the invention is to provide an improved modulating fuel control apparatus of the class described which may be entirely self-powered and therefore independent of any electrical utility in its operation.

Other objects and advantages of the invention will appear as the description proceeds, reference being had to the drawings accompanying and forming a part of this specification. In the drawings, which illustrate two forms of the invention, like characters of reference therein indicating the same parts in all of the views:

Figure 1 is a sectional view of an improved modulating fuel control device constructed in accordance with the invention, the associated fuel burning apparatus and electrical control circuit making up the remainder of the improved fuel control apparatus being shown semi-diagrammatically;

Figure 2 is a fragmentary sectional view of the control device of Figure 1 illustrating the disposition of certain parts thereof during resetting of the safety shut-off mechanism;

Figure 3 is a fragmentary sectional view similar to Figure 2 and illustrating the disposition of the parts of the control device when the safety shut-off mechanism is in shut-off position;

Figure 4 is a fragmentary sectional view of the control device of Figure 1 and illustrates the resetting of the latchable contacts of the circuit controlling device on adjustment of the control point of the modulating mechanism to a low-temperature night setting; and

Figure 5 is a fragmentary semi-diagrammatic illustration of another form of the improved modulating fuel control apparatus.

Referring more particularly to Figure 1 of the drawing, the numeral **10** indicates a modulating fuel flow controlling device for controlling the flow of gaseous fuel to a main burner **11** and to a pilot burner **12**. The control device **10** comprises a sealed casing **13** having a removable cover **14** and having a transverse partition **15** separating said casing into a fuel inlet chamber **16** and a fuel outlet chamber **17**. The partition **15** is provided with an aperture **18**, and fuel flow through said aperture is controlled by a modulator valve **19** which coacts with an annular seat **20** in the chamber **17** surrounding the margin of the aperture **18**. Fuel flow from the chamber **17** to the burner **11** is permitted or prevented by an on-off valve **21** which coacts with an annular seat **22** surrounding a fuel outlet passage **23** leading from the chamber **17**.

The modulator valve **19** is provided with electroresponsive actuating means which may take the form of an electromagnetic operator **24** carried by a lug **24***a* projecting into the chamber **16** from a side wall of the casing **13** as shown. The operator **24** comprises an electromagnet **25** having an armature **26** movable to attracted and retracted positions wtih respect thereto and fixed to a pivotal armature arm **27**. The operator **25** also comprises a generally L-shaped valve arm **28** fixed at one end to a resilient metal band hinge member **29**, said arm carrying a valve stem **30**, the outer end of which is threaded to receive a back-up nut **31**, the modulator valve **19** and an internally threaded retaining sleeve **32** having an enlarged head at its outer end as shown. The position of the modulator valve **19** with respect to the stem **30** may be readily adjusted by adjustment of the position of the nut **31** and sleeve **32** on said stem. The hinge member **29** normally biases the modulator valve **19** away from the seat **20** toward a full flow-permitting or ignition position (not shown). Fixed to the valve arm **28** through a spaced member **33** is an energy storing leaf spring **34**, and the free end of said leaf spring is connected to the armature arm **27** by a link **35**. The arm **28** also carries an adjustable screw **36** having an end positioned for engagement by the leaf spring **34** during attractive movement of the armature **26**. In Figure 1 the armature is disposed intermediate its attracted and retracted positions, and the modulator valve is correspondingly disposed intermediate its minimum flow-permitting and full flow-permitting or ignition positions.

On energization of the operator **24** the armature **26** is attracted to the electromagnet **25**, thereby pivoting the armature arm **27** and, through the link **35**, deflecting the energy storing spring **34** to store energy therein. This pulls the leaf **34** into engagement with the screw **36** to shorten the effective length of said leaf and increase the spring rate thereof so that increasing amounts of energy are stored in the leaf **34** by further attractive movement of the armature in the event that the energy stored in the leaf **34** plus the attractive force on the armature **26** at that point is insufficient to overcome the resistance of the modulator valve **19** to flow restricting movement. In any event, however, except when prevented from so moving by mechanism to be hereinafter described, the modulator valve **19** is moved toward the seat **20** by energization of the operator **24**. On deenergization of the operator **24**, of course, the modulator valve **19** moves away from the seat **20** to a full flow-permitting or ignition position under the bias of the hinge spring **29**.

A modulating mechanism indicated generally by the numeral **48** is provided for effecting modulation of the modulator valve **19** in accordance with fluctuations in a condition, for example temperature, within a predetermined range. The aforementioned mechanism comprises a bracket **37** fixed to the casing **13**, as by screws **38**, said bracket being formed with a circular aperture **39** to receive the externally threaded open end portion **40** of a tubular fitting **41**. The fitting **41** has a centrally apertured end wall **42**, and has an external annular shoulder **43** in abutment with the inner surface of the bracket **37** at the margin of the aperture **39**. An annular spacer **44** surrounds the threaded portion **40** of the fitting **41** and abuts the outer surface of the bracket **37**, said spacer having a radial slot **45** as shown. The fitting **41** is held in position by a nut **46** which is threaded on the portion **40** and engages the spacer **44**, clamping said spacer and the bracket **37** between said nut and the shoulder **43**. The threaded end portion **40** is provided with a longitudinal slot **47**, with which the slot **45** of the spacer **44** is in registry.

A condition responsive, for example temperature responsive, expansible and contractible bellows assembly is positioned coaxially within the fitting **41** and comprises a

bellows 49 having end fittings 50 and 51 closing the opposite ends thereof in hermetically sealed relation. The end fitting 51 is provided with a guide sleeve 52 which projects coaxially within the bellows 49 and has a cross bore 53. The end fitting 50 has a stem portion 54 telescopically slidable within the sleeve 52 and also has an external stem portion 55 which slidably projects through the aperture in the end wall 42 and through a bore 56 formed in the adjacent wall portion of the casing 13, terminating in the chamber 17 of said casing. As shown, the bore 56 extends through a bearing sleeve 57 formed integral with the casing 13. The stem 55 is preferably formed with peripheral grooves to receive sealing rings 58 of rubber like material for preventing leakage of fuel from the chamber 17 along the stem 55. A coiled compression spring 59 surrounds the stem 55 within the fitting 41 and biases the bellows end fitting 50 toward the end fitting 51.

Means are provided for adjusting the position of the bellows assembly 48 within the fitting 41 to thereby provide adjustment of the temperature control point of said assembly. More specifically, a manually engageable knob 59 is internally threaded on the portion 40 of the fitting 41, and a set screw 60 is coaxially threaded through the knob 59 and engages the bellows end fitting 51 as shown. The screw 60 may be locked in place relative to the knob 59 by a locking or jam nut 61.

A passage 62 in the end fitting 51 communicates with the bore of the guide sleeve 52, and a tube 63 affords communication between the passage 62 and a temperature sensing bulb 64. The inner end of the tube 63 is sealed within the passage 62 and extends radially outwardly through the slots 47 and 45 as shown. The bulb 64 is preferably located at the comfort level in the space being heated, for example at the normal location for a room thermostat. With suitable adjustment, however, the bulb 64 may be mounted in other locations, for example in the cold air return of the heating system. The bellows assembly 48 is commonly known as the "solid-liquid" fill type, and said bellows, tube 63 and bulb 64 are filled with a liquid having a high coefficient of expansion and having a boiling point at working pressure which is above the highest ambient temperature to which said fill might be exposed. The fill exists substantially entirely in the liquid phase, as differentiated from fills which exist in the vapor phase as well as the liquid phase. A "solid-liquid" fill bellows provides actuating forces which result from thermal expansion of the liquid fill only, as distinguished from bellows utilizing a fill existing in both the liquid and vapor phases, the latter providing actuating forces produced by vapor pressure. Chloroform is illustrative of a type of liquid well adapted for use as a fill in the bellows assembly 48.

Means is provided for effecting control of the modulator valve 19 and of the on-off valve 21 by the modulating mechanism 48 in accordance with the temperature sensed by the bulb 64. For control of the modulator valve a lever 65 is pivoted intermediate its length, as on a pivot pin 66 carried by a boss 67 formed on the wall of the casing 13 within the chamber 17. The lever 65 has a bifurcated end 68 embracing the sleeve 32, preferably in spaced relation, and engageable with the enlarged head of said sleeve as shown. The opposite end 69 of the lever 65 is also bifurcated to embrace the stem 55, the bifurcated end portions thereof being slotted, as at 70, to receive a pin which extends diametrically through the stem 55.

Since the operator 24 has insufficient power to overcome the force of the spring 59, the coaction of the end 68 of the lever 65 with the head of the sleeve 32 operates to limit movement of the modulator valve 19 toward the seat 20 under the bias of the operator 24 when the latter is energized. It will be noted, however, that the end 68 of the lever 65 cannot limit movement of the modulator valve 19 away from the seat 20, and therefore at any time that the operator 24 is deenergized, the modulator valve 19 is free to move under the bias of the hinge member 29 to its full flow-permitting or ignition position regardless of the position in which the lever 65 is disposed by response of the modulating mechanism 48 to the ambient temperature sensed by the bulb 64. Whenever the operator 24 is energized, and the temperature sensed by the bulb 64 is within the modulating range, the modulating mechanism 48, by its action in restraining or limiting movement of the modulator valve 19 toward its seat under the bias of said operator, continually modulates said modulator valve in accordance with the temperature, between a minimum flow-permitting position wherein said valve is seated on the seat 20 and a full flow-permitting or ignition position.

The on-off valve 21 is carried by an L-shaped arm 72 pivotally mounted, as on a pin 73 carried by a boss 74 on the interior of the casing 13. A coiled tension spring 75 has one end anchored to a lug 75*a* formed on the interior of the casing 13 and has its opposite end anchored to the arm 72 to bias the latter toward a stop lug 76 also formed on the interior of the casing 13 and defining the open or "on" position of the on-off valve.

The interior of the casing 13 is formed with annular shoulder means 77 affording support for a snap disc 78 having the normal unstressed configuration shown. The lever 72 is provided with a projection 79 positioned adjacent the concave surface of the snap disc 78 as shown. A circular dished member 80 is fixed to the end of the stem 55, as by a pin 81, and is positioned for engagement with the convex surface of the snap disc 78 as shown. As long as the temperature sensed by the bulb 64 is within the modulating range for which the modulating mechanism 48 is set, the dished member 80 moves axially with the stem 55 in accordance with fluctuations in the temperature without actuating the snap disc 78. However, when the temperature sensed by the bulb 64 goes beyond the modulating range for which the modulating mechanism is set, expansion of the bellows fill forces the member 80 against the snap disc 78 with sufficient force to snap said disc to the dot and dash line overcenter position shown in Figure 1. As the snap disc snaps to the overcenter position it engages the projection 79 on the arm 72 and pivots said arm and the valve 21 to the dot and dash line closed or "off" position shown in Figure 1, thereby shutting off all fuel flow to the burner 11.

In order to provide for energization of the operator 24 one end of the energizing coil of the electromagnet 25 is connected in circuit with a terminal member 82 insulatably extending through the cover 14 and exposed within an internally threaded external socket 83 formed on said cover. Suitable means, for example, the conductor 84 connects the terminal member 82 with one terminal of an electrical energy source responsive to the heat of fuel burned at the main burner 11. In the embodiment of the invention illustrated in Figure 1, said source takes the form of a thermoelectric generator 85 positioned to be subject to the heat of fuel burned at said main burner. The other terminal of the generator 85 is preferably grounded as shown.

Means is provided for affording quick warm-up of the space being heated after the control knob 59 is adjusted from a low temperature night setting to a higher temperature normal daytime operating setting, said means avoiding derating of the heating system characteristic of modulating controls. To this end a condition responsive, for example temperature responsive, circuit controlling device 86 is provided, said device comprising a hermetically sealed bellows 91 having a movable wall 90 and a wall 89 fixed, as by screws 88, to a flange 87 formed on the fitting 41. The fixed wall 89 is apertured to receive the glass seal 92 through which a contact stem 93 sealingly and insulatably extends, the inner end of said stem terminating in a portion of enlarged diameter

and a spherical contact tip 94. At its outer end the contact stem 93 is provided with an insulatably mounted terminal member 95 for connection with an electrical conductor 96. Mounted on the contact stem 93 between the contact tip 94 and the glass seal 92 is a generally spherical insulating member 99 having a diameter larger than the diameter of the contact tip 94 as shown.

The conductor 96 is connected in circuit with a terminal member 97 insulatably extending through a wall portion of the casing 13 and in turn connected in circuit with the other end of the energizing coil of the electromagnet 24 within the chamber 16. The movable wall 90 of the bellows 91 carries a movable contact member 98 of generally U-shaped conformation and having a pair of resilient jaws for frictionally engaging the contact tip 94 as shown, to effect a low resistance electrical connection therewith. The contact 98 is, of course, grounded to the casing 13 through the bellows 91, fitting 41 and bracket 37.

The fixed wall 89 of the bellows 91 is bored to sealingly receive a capillary tube 100 affording communication between the interior of said bellows and a bulb 101 which may be mounted adjacent the bulb 64. The bellows 91, tube 100 and bulb 101 all contain a common sub-atmospheric volatile fluid fill whose vapor pressure increases and decreases in response to increases and decreases in temperature. The fill is also of a type which will not react with the contacts 94 and 98 to form films thereon or in any way increase the contact resistance. While the fills used in different applications may vary in accordance with the temperature encountered in said application, satisfactory fills for space heating applications are ether and isopentane, both of which provide a sub-atmospheric fill at operating temperatures. Thus, in the event of a leak anywhere in the fluid system, i. e., in either the bellows, tube 100 or bulb 101, atmospheric pressure enters this system and tends to expand the bellows to separate the contacts therein.

Means is provided for compressing the bellows 91 to move the frictional contact 98 into clamping engagement with the insulating ball 99 as shown in Figure 4 and to thereby interrupt the circuit between the contacts 94 and 98. For convenience, the disposition of the contacts shown in Figure 4 will be termed a reset position, and the operation of moving the parts of the device 86 from the position of Figure 1 to the position of Figure 4 will be termed a resetting operation. The aforementioned resetting operation is accomplished by mechanism including a lever 102 mounted for pivotal movement on a pivot pin 103 carried by the annular shoulder 43 within a radial slot formed therein, as shown most clearly in Figure 4. The bracket 37 is formed with an integral bearing sleeve 104 on which a pin 105 is axially slidable. The pin 105 has a rounded head 105*a* for coaction with the lever 102, and the opposite end of said pin projects from the sleeve 104 for coaction with the inner surface of the knob 59 as shown.

When the parts are disposed as shown in Figure 1, the knob 59 is set so that the temperature control point of the modulating mechanism 48 is at a normal daytime operating temperature setting, and the inherent bias of the bellows 91, and the vapor pressure of the fill therein, act through the lever 102 to bias the stem 105 into engagement with the inner surface of the knob 59, while at the same time biasing the jaws of the contact 98 into engagement with the contact tip 94. When, however, the knob 59 is turned inwardly to adjust the temperature control point of the modulating mechanism 48 to a low temperature night setting, said inward movement is imparted to the slidable pin 105 to effect pivoting of the lever 102 to the position of Figure 4 and cause the latter to compress the bellows 91, thereby sliding the jaws of the contact 98 into clamping engagement with the insulating ball 99 and out of electrical contact with the contact tip 94. This interrupts the power circuit to the electromagnet, preventing energization of the latter and thereby effecting disposition of the modulator valve 19 in full flow or ignition position.

When the knob 59 is subsequently turned outwardly to adjust the temperature control point of the modulating mechanism to a normal daytime operating temperature setting, the sliding pin 105 and lever 102 do not follow such outward movement, since as long as the room temperature is below a predetermined control point or release value to which the device 86 is responsive, for example 70° F., the clamping engagement of the jaws of the contact 98 with the insulating ball 99 is sufficient to overcome the inherent bias of the bellows 91 and the vapor pressure of the fill within the bellows tending to expand the latter. As a result, the electrical circuit to the operator 24 remains interrupted, after upward readjustment of the knob 59 from a night turndown setting, and therefore the modulator valve 19 remains in full open or ignition position, affording maximum output of the heater continuously until the temperature of the space as sensed by the bulb 101 is raised to the predetermined control point of the circuit controlling device 86, for example the 70° F. value mentioned hereinbefore. When this predetermined temperature is reached, the inherent bias of the bellows and the vapor pressure within said bellows overcome resistance to bellows expansion afforded by the clamping engagement of the jaws of the contact 98 with the ball 99, and the bellows expands to the position of Figure 1. In this position the contact 99 effects a low resistance electrical connection with the contact tip 94 to complete the low resistance power circuit for the electromagnet 25 for energization thereof by current from the source 85. It is apparent, therefore, that the circuit controlling device 86 provides fast warm-up after night turndown by preventing modulation of the fuel flow by the modulator valve until the space has been heated to near the temperature control point for which the modulating mechanism has been set.

Interlock means is provided for insuring against the unsafe condition which would result if the on-off valve 21 were closed to shut off all main burner fuel flow, and then allowed to reopen before the generator 85 has had time to cool and deenergize the operator 24 for movement of the modulator valve 19 to its full open or ignition position. In the absence of the aforementioned interlock means, such a situation could be brought about by turning the knob 59 inwardly sufficiently to effect snapping of the disc 78 and closure of the on-off valve 21, and then immediately turning said knob outwardly to permit the snap disc to return to its normal position. Without the means to be described hereinafter, the on-off valve member 21 would move to open position as the snap disc 78 returns to its normal position. Since the generator 85 has not had time to cool sufficiently to deenergize the operator 24, said operator continues to hold the modulator valve 19 in a reduced flow-permitting position thus creating a dangerous situation by supplying insufficient fuel to the burner 11 for safe ignition.

To avoid the aforementioned dangerous condition, an electromagnet 106 is fixedly mounted within the chamber 17 adjacent the valve arm 72 and has an energizing coil 107, one end of which is grounded to the casing 13, and the other end of which is connected in circuit with the terminal member 82 by a conductor 108 which extends through an aperture 109 in the partition 15 as shown. The valve arm 72 carries a magnetically permeable armature 110 for coaction with the electromagnet 106. The electromagnet 106 is thereby connected in parallel circuit relation with respect to the operator 24 and is energized by electrical energy from the source 85 at any time that the operator 24 is energized. Thus, at any time that the operator 24 is energized to hold the modulator valve in a reduced flow-permitting position and the on-off valve 21 is moved to closed position, the simultaneously energized electromagnet 106 magnetically

latches the armature **110** thereto and prevents opening of the on-off valve member **21**. The on-off valve cannot be opened under the bias of the spring **75** until the electromagnet **106** is deenergized, and such deenergization can occur only simultaneously with deenergization of the operator **24**, so that when the on-off valve is opened, the modulator valve **19** is certain to be in its full flow or ignition position. Safe ignition of the fuel at the burner **11** is thereby insured at any time that the on-off valve **21** is moved from closed to open position.

Means is provided for overcalling the modulating mechanism and for providing 100 percent shut-off of the fuel to the main and pilot burners in the event of outage of the flame of the pilot burner **12**. The aforementioned means comprises a manually resettable electromagnetic safety shut-off mechanism indicated generally by the numeral **111** and includes a generally cylindrical hood or casing **112** which is axially slidable within a cylindrical guide-way **113** formed in the chamber **17** of the casing **13**. Fixed within the hood **112** is an electromagnet **114** having an energizing coil, one end of which is grounded to said hood, and the other end of which is provided with a suitable flexible lead which extends to a terminal member **115** insulatably extending through the cover **14** and exposed within an internally threaded external socket **116** formed on said cover.

An armature **119** is cooperable with the electromagnet **114** and is carried by an axially slidable stem **120** which projects through a suitable bearing in an end wall of the hood **112** and is fixed, as by a pin **121**, to a generally cup-shaped member **122** having a nose **123** engageable with the valve arm **72**. A coiled compression spring **124** surrounds the stem **120** between the hood **112** and the member **122** and biases the armature **119** away from the electromagnet **114**, simultaneously biasing the member **122** away from the hood **112**. The guideway **113** is formed with a longitudinal groove **125** in which a leaf type positioning spring **126** is mounted as shown, said spring having a curved end portion **127** for coaction with an indentation **128** formed in the adjacent wall portion of the hood **112**, for a purpose to be hereinafter set forth. Electrical source means, for example a thermoelectric generator, responsive to the heat of fuel burned at the pilot burner **12** is connected in circuit with the electromagnet **114** by having one terminal thereof connected in circuit with the terminal member **115**, as by the conductor **118** shown diagrammatically. The other terminal of the generator is grounded in the usual manner.

The cover **14** is formed with an outwardly projecting externally threaded socket **129** and with a coaxial inwardly projecting externally threaded socket **130**. The socket **130** is counterbored to afford an annular pilot fuel valve seat **131**, there being a pilot fuel outlet passage **132** affording communication between said bore and an internally threaded socket **134** which is adapted to receive a pilot fuel supply pipe indicated diagrammatically at **135**. A pilot fuel inlet passage **133** affords communication between the counterbore of the socket **130** and an enlarged passage **136** which opens into the fuel inlet chamber **16** as shown. An aperture **137** affording communication between the passage **136** and the chamber **17** provides a by-pass for the flow of fuel around the modulator valve **19**. An adjustment screw **138**, which may have a lock nut **139**, is threaded into the cover **14** as shown and controls the amount of fuel which can flow through the by-pass **137**, said screw being so set that at least sufficient fuel can flow through the by-pass to provide the minimum safe flame at the main burner **11** when the modulator valve **19** is seated on the seat **20**. By having the pilot fuel inlet passage **133** communicate with fuel inlet chamber **16** through the passage **136**, the fuel flow to the pilot burner is not subject to the pressure fluctuations to which it would be subjected if said passage led from the chamber **17**.

To afford control of the fuel flow to the pilot burner **12**, the hood **112** of the safety shut-off mechanism **111** is provided with an integral stem **140** which projects through the bore of the socket **130** and through a coaxial bore **141** in the cover **14**, into the bore of the socket **129**. The stem **140** carries a pilot fuel valve **142** which is cooperable with the annular valve seat **131** to control pilot fuel flow. An internally threaded cup-shaped cap **143** is threaded on the socket **130** and is bored to slidably receive the stem **140**. If desired, the bore of the member **143** may be grooved to receive a resilient sealing ring **144** of rubber-like material.

An internally threaded cup-shaped retaining nut **145** is threaded on the socket **129** and is formed with an aperture **146** having a diameter smaller than the bore of said socket, so that said nut has an annular flange portion projecting radially inwardly of said bore. A generally cup-shaped reset button **147** is slidably positioned within the aperture **146** and has an out-turned annular lip within the bore of the socket **129** cooperable with the nut **145** to limit axial outward movement of said button. The reset button **147** is formed with a coaxial tubular portion **150** in which the outer end of the stem **140** is slidably received. The tubular portion **150** is formed with a pair of diametrically opposed longitudinal slots **151** for receiving the opposite ends of a pin **152** which extends diametrically through the adjacent end portion of the stem **140**. A coiled compression spring **148** surrounds the stem **140**, having one end surrounding the tubular portion **150** and in engagement with the reset button **147**, and the opposite end in engagement with suitable sealing material **149** surrounding the stem **140** at the base of the bore of socket **129**. Thus, the spring **148** biases the reset button **147** outwardly to the position shown in Figure 1, and simultaneously biases the material **149** into sealing engagement with the stem **140**.

Whenever the electromagnet **114** is deenergized, the parts of the safety shut-off mechanism **111** are disposed as shown in Figure 3. When the parts are so disposed, the spring **124** biases the nose **123** of the member **122** into engagement with the valve arm **72** and holds the on-off valve **21** closed against the bias of the spring **75**. At the same time, the spring **124** biases the hood **112** in the opposite direction, and through the stem **140**, biases the pilot fuel valve **142** onto the seat **131**. Since no fuel can flow to either the main burner **11** or the pilot burner **12**, 100 percent shut-off of the fuel is thus provided.

In order to set the improved modulating fuel control apparatus into operation, the safety shut-off mechanism **111** must first be reset and the pilot burner **12** ignited. To reset the safety shut-off mechanism **111** and establish fuel flow to the pilot burner **12**, the reset button **147** is depressed as shown in Figure 2, thereby moving the stem **140**, pilot valve **142** and hood **112** toward the right as viewed in Figure 2. Unseating the pilot valve member **142** establishes fuel flow from the pilot fuel inlet passage **133** through the pilot fuel outlet passage **132**, and thence to the pilot burner **12** through the supply pipe **135**, for ignition at the pilot burner. In addition to the establishment of pilot fuel flow, depression of the reset button **147** and corresponding movement of the hood **112** simultaneously compresses the spring **124** and moves the electromagnet **114** into engagement with the armature **119**. At the same time, the on-off valve is being held closed by coaction of the nose **123** of the member **122** with the valve arm **72**, and flow interruption is thereby provided to prevent flow of any fuel to the main burner during the resetting operation.

The reset button **147** is held depressed for a period sufficient to allow the ignited pilot burner to heat the generator **117** and energize the electromagnet **114** to effect magnetic latching of the armature **119** thereto. On release of the reset button, the spring **148**, which has been compressed by depression of said button, biases the latter to its outermost position shown in Figures 1 and 3. However, because of the lost motion provided by coaction

of the pin 152 with the slots 151 in the tubular portion 150 of the reset button, the stem 140 and hood 112 are not moved outwardly far enough to seat the pilot fuel valve 142, but rather, they are moved only far enough for the curved end portion 127 of the positioning spring 126 to seat in the hood depression 128 and thereby define the operative position of the hood 112 and valve 142 shown in Figure 1. Pilot fuel, therefore, continues to flow to the pilot burner 12.

As the hood 112 is moved outwardly with the stem 140 in the manner described, the magnetic latching of the armature 119 to the electromagnet 114 maintains the spring 124 compressed and moves the member 122 with said hood to the position shown in Figure 1, thereby freeing the on-off valve 21 for movement from its closed position to its full open position shown in Figure 1. The parts of the safety shut-off mechanism 111 remain in the position shown in Figure 1 as long as the generator 117 continues to be heated by the flame of the pilot burner 12. However, on outage of the pilot burner 12, the generator 117 cools, the electromagnet 114 becomes deenergized, and the spring 124 thereupon pulls the armature 119 away from the electromagnet 114 and disposes the parts as shown in Figure 3 to provide 100 percent shut-off of the fuel.

Assume that the bulb 64 is subjected to a temperature above the modulating range and expansion of the fill in bellows 49 has moved the stem 55 toward the snap disc 78 to actuate the latter to its overcenter position and to also rotate the lever 65 clockwise to the position where it permits the modulator valve 19 to be seated on the seat 20 on energization of the electromagnetic operator 24. Closure of the on-off valve 21 on snapping of the disc 78, extinguishes the main burner 11, and the generator 85 cools to deenergize the operator 24 and move the modulator valve 19 to its full flow-permitting or ignition position.

As the room cools below the upper end of the modulating range, contraction of the fill within the bellows 49 withdraws the stem 55 and permits the snap disc 78 to return to its normal position shown in Figure 1, whereupon the valve lever 72 and the on-off valve 21 move under the bias of the spring 75, to their solid line open position shown in Figure 1. This, of course, permits a full flow of fuel to the main burner 11 for safe ignition. This full flow of fuel continues until the burning of fuel at the main burner has heated the generator 85 sufficiently to energize the electromagnetic operator 24, whereupon said energized operator draws the modulator valve 19 toward the seat 20 to whatever modulated position the modulating mechanism, via the lever 65, permits. The flow of fuel to the burner 11 is thereafter modulated in accordance with the temperature sensed by the bulb 64 of the modulating mechanism. As the temperature approaches the upper end of the modulating range the fuel flow may be modulated down to the point where the modulator valve 19 is seated, at which point a minimum safe flow of fuel can still flow to the burner 11 through the by-pass 137.

It will be observed that with the improved modulating fuel control apparatus the temperature of the space being heated does not have to drop through the entire modulating range before the main burner can be reignited, since at any time the on-off valve 21 is moved from closed to open position, the modulator valve 19 is at the same time disposed in full open or ignition position to insure safe ignition of the main burner 11. Whenever the electromagnetic operator 24 is energized, it biases the modulator valve 19 toward its seat 20, but, as described hereinbefore, the actual modulated position of said valve is determined by the response of the modulating mechanism 48 to the temperature sensed by its bulb 64. As the fill in the bellows 49 expands in response to increased temperature sensed by the bulb 64, the stem 55 moves downwardly, as viewed in Figure 1, and the lever 65 rotates clockwise to permit the energized operator 24 to pull the modulator valve 19 closer toward the seat 20, thereby reducing the amount of fuel flowing to the burner 11 and thereby the amount of heat generated thereat. Conversely, contraction of the fill in the modulating mechanism in response to a drop in temperature sensed by the bulb 64, withdraws the stem 55 upwardly, as viewed in Figure 1, and pivots the lever 65 in a counterclockwise direction, thereby pulling the modulator valve 19 away from its seat 20 to an increased flow-permitting position to thereby increase the amount of fuel flowing to the burner 11 and correspondingly increase the heat generated at said burner.

The snap disc 78 operates as a high temperature limit device, since the parts are so arranged that said snap disc is not snapped to overcenter position until after the temperature sensed by the bulb 64 has reached the upper end of the modulating range and the modulator valve 19 has been seated on its seat to thereby throttle the fuel flow to the main burner 11 to the safe minimum amount. Any further rise in temperature sensed by the bulb 64 moves the stem 55 downwardly beyond the position thereof permitting seating of the valve 19, and the snap disc is thereby snapped to its overcenter position, effecting closure of the on-off valve.

Closure of the on-off valve 21, of course, shuts off the flow of fuel to the main burner 11, and the generator 85 thereupon cools to effect deenergization of the operator 24 and of the electromagnet 106. As the operator 24 is deenergized, the modulator valve 19 drops to the full open or ignition position to afford safe ignition of the fuel at the main burner on subsequent opening of the on-off valve as the modulating mechanism 48 responds to a drop in temperature sensed by the bulb 64.

In Figure 5 another form of the invention is illustrated, and all of the parts in Figure 5 indicated by primed reference characters may be identical with the parts in Figure 1 indicated by the same reference characters unprimed. The modulating control device 10' may be identical with the control device 10 illustrated in Figure 1, parts of the device 10' being illustrated diagrammatically only in Figure 5. In the form of the invention shown in Figure 5, the time delay between opening of the on-off valve 21' and movement of the modulator valve of the device 10' to a reduced flow-permitting position is provided by a fluid pressure responsive time delay switch 153 located in the fuel supply line 154 to the main burner 11'. The normally open low resistance contacts of the switch 153 are connected in circuit with heat source means, for example a thermoelectric generator 117', subject to the heat of the pilot burner 12'. The switch 153 controls the flow of energizing current from said generator to the electromagnetic operator 24' and to the electromagnet 106', said operator and magnet being connected in parallel circuit relation, and said operator being connected in series circuit relation with the circuit controlling device 86' corresponding to the circuit controlling device 86 of the modulating control device 10 as shown in Figure 1. It will be noted that the safety shutoff mechanism electromagnet 114' is also connected in circuit with the generator 117', wherefore said generator affords the sole source of electrical energy for the apparatus illustrated in Figure 5.

In the form of the invention illustrated in Figure 5, when the modulator mechanism thereof calls for heat and effects opening of the on-off valve 21' in the manner described in connection with the form of the invention shown in Figure 1, the pressure of the fuel flowing through the supply pipe 154 to the burner 11' actuates the fluid pressure responsive switch 153, which, after a predetermined time delay, closes the contacts thereof and completes the electrical circuit between the generator 117', operator 24' and electromagnet 106'. The time delay afforded by the switch 153 allows a full flow of fuel to flow to the main burner 11' for a period sufficient to insure safe ignition of said fuel at the main burner

before the contacts of the switch **153** are closed to energize the operator **24'** and move the modulator valve to a reduced flow-permitting position. When the on-off valve **21'** is subsequently closed by the modulating mechanism, the contacts of the switch **153** immediately open in response to the pressure drop in the fuel supply line **154**, thereby immediately deenergizing the operator **24'** and causing the modulator valve of the device **10'** to move to full open or ignition position. Where the response of the switch **153** to a pressure drop in the supply line **154** is substantially instantaneous, the interlock afforded by the electromagnet **106'** and armature **110'** may not be required and therefore may be eliminated. Except for the different means for providing the desired time delay, i. e., by the switch **153**, and for the fact that the apparatus in Figure 5 is powered from a single generator **117'** as distinguished from the powering of the apparatus of Figure 1 by the generators **85** and **117**, the operation of the apparatus shown in Figure 5 is substantially identical with that of the apparatus shown in Figure 1.

Having thus described two specific embodiments of the present invention, it is to be understood that these forms have been selected to facilitate the disclosure rather than to limit the number of forms which the invention may assume. Various modifications, adaptations and alterations may be applied to the specific forms shown to meet the requirements of practice, without in any manner departing from the spirit or scope of the present invention, and all of such modifications, adaptations and alterations are contemplated as may come within the scope of the appended claims.

What is claimed as the invention is:

1. Apparatus for controlling the flow of fuel to a fluid fuel burner comprising, a first control member having an ignition position and a lesser flow-permitting position, a second control member having fuel flow-permitting and fuel flow-preventing positions, and electroresponsive actuating means for biasing said first control member toward said lesser flow-permitting position when energized and toward said ignition position when deenergized, and time delay means in circuit with said actuating means for preventing energization of the latter and movement of said first control member toward said lesser flow-permitting position for a predetermined period after movement of said second control member to flow-permitting position, said period being of sufficient duration for safe ignition of the fuel at said burner.

2. Apparatus for controlling the flow of fuel to a fluid fuel burner comprising, a first control member having an ignition position and a lesser flow-permitting position, a second control member having fuel flow-permitting and fuel flow-preventing positions, and electroresponsive actuating means for biasing said first control member toward said lesser flow-permitting position when energized and toward said ignition position when deenergized, time delay means in circuit with said first actuating means for preventing energization of the latter and movement of said first control member toward said lesser flow-permitting position for a predetermined period after movement of said second control member to flow-permitting position, said period being of sufficient duration for safe ignition of the fuel at said burner, said time delay means comprising electric energy source means responsive to the heat of fuel burned at said burner for energizing said first actuating means.

3. Apparatus for controlling the flow of fuel to a fluid fuel burner comprising, a first control member having an ignition position and a lesser flow-permitting position, a second control member having fuel flow-permitting and fuel flow-preventing positions, an electroresponsive actuating means for biasing said first control member toward said lesser flow-permitting position when energized and toward said ignition position when deenergized, and time delay means in circuit with said first actuating means for preventing energization of the latter and movement of said first control member toward said lesser flow-permitting position for a predetermined period after movement of said second control member to flow-permitting position, said period being of sufficient duration for safe ignition of the fuel at said burner, said time delay means comprising means including a thermoelectric generator subject to the heat of fuel burned at said burner for energizing said first actuating means.

4. Apparatus for controlling the flow of fuel to a fluid fuel burner comprising, a first control member having an ignition position and a lesser flow-permitting position, a second control member having fuel flow-permitting and fuel flow-preventing positions, an electroresponsive actuating means for biasing said first control member toward said lesser flow-permitting position when energized and toward said ignition position when deenergized, and time delay means in circuit with said first actuating means for preventing energization of the latter and movement of said first control member toward said lesser flow-permitting position for a predetermined period after movement of said second control member to flow-permitting position, said period being of sufficient duration for safe ignition of the fuel at said burner, said time delay means comprising time delay switch means in circuit with a source of electric energy and with said first actuating means, said switch means being responsive to movement of said second control member toward flow-permitting position.

5. Fuel flow control apparatus, comprising enclosure means having fuel flow passage means therein, first and second flow control members for controlling fuel flow through said passage means and each movable to first and second controlling positions with respect to said passage means, first condition responsive actuating means for said first control member operable to bias the latter toward its first controlling position in response to a first condition, and second actuating means operatively related to said first control member for restraining the movement of the latter toward its first controlling position under the influence of said first actuating means, the restraint afforded by said second actuating means being variable in accordance with normal fluctuations in a second condition, said second actuating means also being operatively related to said second control member for actuation of the latter toward its second controlling position in response to an extreme in said second condition.

6. Fuel control apparatus, comprising enclosure means having fuel flow passage means therein, first and second flow control members for controlling fuel flow through said passage means and each movable to first and second controlling positions with respect to said passage means, first condition responsive actuating means for said first control member operable to bias the latter toward its first controlling position in response to a first condition, second actuating means also operatively related to said first control member for restraining the movement of the latter toward its first controlling position under the influence of said first actuating means, the restraint afforded by said second actuating means being variable in accordance with normal fluctuations in a second condition, said second actuating means also being operatively related to said second control member for actuation of the latter toward its second controlling position in response to an extreme in said second condition, and condition responsive safety shut-off means operatively related to said second control member for insuring disposition of said second control member in its second controlling position in response to a third condition.

7. Fuel control apparatus, comprising enclosure means having fuel flow passage means therein, first and second control members for controlling fuel flow through said passage means and each movable to first and second controlling positions with respect to said passage means, first

condition responsive actuating means for said first control member operable to bias the latter toward its first controlling position in response to a first condition, second actuating means also operatively related to said first control member for restraining the movement of the latter toward its first controlling position under the influence of said first actuating means, the restraint afforded by said second actuating means being variable in accordance with normal fluctuations in a second condition, said second actuating means also being operatively related to said second control member to bias the latter toward its first position during said normal fluctuations in said second condition and to actuate said control member toward its second controlling position in response to an extreme in said second condition, and condition responsive safety shut-off means operatively related to said second control member for overcalling said second actuating means and insuring disposition of said second control member in its second controlling position in response to a third condition irrespective of the response of said second actuating means to said second condition.

8. In combination with a burner, apparatus for controlling the flow of fuel to said burner comprising, enclosure means having flow passage means therein for the flow of fuel therethrough to said burner, first and second flow control members each movable to first and second flow controlling positions with respect to said passage means, first actuating means for said first control member responsive to the heat of fuel burned at said burner for biasing said control member toward its first controlling position on burner outage and biasing said control member toward its second controlling position when fuel is burned at said burner, and second condition responsive actuating means operatively related to said first control member for variably restraining movement of the latter toward its second controlling position under the influence of said first actuating means to thereby variably position said first flow control member in accordance with normal fluctuations in a second condition, said restraint being afforded only when fuel is burned at said burner, said second actuating means also being operatively related to said second control member for actuation of the latter toward its second controlling position in response to an extreme in said second condition.

9. In combination with a burner, apparatus for controlling the flow of fuel to said burner comprising a control body having flow passage means therein for the flow of fuel therethrough to said burner, first and second control members each movable to first and second controlling positions for control of the flow of fuel through said control body, electroresponsive first actuating means for said first control member biasing said control member toward its first controlling position when deenergized and biasing said control member toward its second controlling position when energized, means in circuit with said actuating means for energizing said actuating means in response to burning of said fuel at said burner and for deenergizing said actuating means in response to outage of said burner, whereby said first control member is biased toward its first controlling position on burner outage and is biased toward its second controlling position in response to burning of fuel at said burner, and second condition responsive actuating means operatively related to said first control member to variably restrain movement of said first control member toward its second controlling position under the influence of said first actuating means, the restraint afforded by said second actuating means positioning said first control member in various positions in accordance with normal fluctuations in a second condition, said second actuating means also being operatively related to said second control member for actuation of the latter to its second controlling position in response to an extreme in said second condition irrespective of the position of said first control member.

10. Modulating fuel control apparatus comprising, enclosure means having fuel flow passage means therein, a modulating fuel control valve member in said passage means biased toward a full flow-permitting position and movable toward a reduced flow-permitting position with respect to fuel flow through said passage means, an on-off fuel control valve in said passage means biased to an on position and movable to an off position with respect to fuel flow through said passage means, first condition responsive actuating means operatively related to said modulating valve member and tending to move the latter toward said reduced flow-permitting position against said bias in response to a first condition, and second actuating means operatively related to said modulating valve member for restraining the movement of the latter under the influence of said first actuating means, the restraint afforded by said second actuating means being variable in accordance with normal fluctuations in a second condition to afford modulation of the fuel in accordance with said fluctuations, said second actuating means also being operatively related to said on-off valve for actuation of the latter to said off position in response to an extreme in said condition.

11. In combination with a burner, modulating fuel control apparatus for controlling the flow of fuel to said burner comprising a valve body having flow passage means therein for the flow of fuel therethrough to said burner, a modulating fuel control valve member in said valve body biased toward a full flow-permitting position and movable toward a reduced flow-permitting position with respect to fuel flow through said passage means, an on-off fuel control valve in said passage means biased to an on position and movable to an off position with respect to fuel flow through said passage means, said on-off valve when in said off position preventing all fuel flow through said passage means to said burner, first condition responsive actuating means tending to move said modulating valve member toward said reduced flow-permitting position against said bias in response to the heat of fuel burned at said burner, said bias returning said valve member to full flow-permitting position on burner outage, and second condition responsive actuating means operatively related to said modulating valve member for restraining movement of the latter under the influence of said first actuating means, the restraint afforded by said second actuating means being variable in accordance with normal fluctuations in a second condition to afford modulation of the fuel in accordance with said fluctuations, said second actuating means also being operatively related to said on-off valve for actuation of the latter to its said off position shutting off all fuel flow to said burner in response to an extreme in said second condition, whereupon said modulating valve member moves toward its full flow-permitting position in response to burner outage.

12. Fluid fuel flow control apparatus comprising first and second flow control members movable between first and second controlling positions with respect to the fuel flow, first actuating means for biasing said first control member toward its second controlling position, condition responsive second actuating means operable to actuate said second control member between its controlling positions and including manually operable control point adjustment means, resettable condition responsive control means operatively related to said first actuating means and including a pair of relatively movable latchable members having a released position and movable toward a reset position preventing said first actuating means from positioning said first control member in its second position, means latching said latchable members in said reset position when moved thereto, said latching means being releasable by said control means in response to a predetermined condition, and resetting means operatively associated with said control means and said control point adjustment means for effecting resetting of said latchable members upon an adjustment of said control point setting means to a first predetermined setting, said latching means retaining said latchable members in said reset po-

sition after a readjustment of said control point setting means to a second predetermined setting at which said resetting means is inoperative for resetting purposes for disposition of said first flow control member in its first controlling position until said latchable members are released by response of said control means to said predetermined condition.

13. Fluid fuel flow control apparatus comprising first and second flow control members biased toward first and movable toward second controlling positions with respect to the fuel flow, first electroresponsive actuating means tending when energized to move said first flow control member against its bias toward its second controlling position, condition responsive second actuating means operable to actuate said second flow control member between its controlling positions and including manually operable control point adjustment means, resettable temperature responsive circuit controlling means in circuit with said first actuating means and a source of electric energy, said control means including a pair of relatively movable latchable contacts having a reset position preventing energization of said first actuating means and thus preventing the latter from moving said first control member toward its second position, said contacts having a released position permitting energization of said first actuating means by electric energy from said source, means latching said contacts in said reset position when moved thereto, said latching means being releasable by said circuit controlling means in response to a predetermined temperature, and resetting means operatively associated with said circuit controlling means and said control point adjustment means for effecting resetting of said contacts upon an adjustment of said control point setting means to a first predetermined setting, said latching means retaining said contacts in said reset position after a readjustment of said control point setting means to a second predetermined setting at which said resetting means is inoperative for resetting purposes to maintain said first actuating means deenergized for disposition of said first flow control member in its first controlling position until said contacts are released by response of said circuit controlling means to said predetermined temperature.

14. A control device for controlling the flow of fuel to a fluid fuel burner, comprising a first valve disposed in the path of fluid fuel to said burner and having an ignition and a lesser flow-permitting position, a second valve also disposed in the path of fluid fuel to said burner and having open and closed positions, first means for actuating said first valve to its ignition position in response to a predetermined condition, second actuating means operable to move said second valve from its closed to open position, and interlock means operatively associated with both of said actuating means and operable to overcall said second actuating means and prevent movement of said second valve from its closed to open position except when said predetermined condition prevails, thereby insuring safe ignition of said burner.

15. A control device for controlling the flow of fuel to a fluid fuel burner and tending to insure safe ignition thereof, comprising a modulator valve disposed in the path of fluid fuel to said burner and having an ignition and a lesser flow-permitting position, an on-off valve also disposed in the path of fluid fuel to said burner and having open and closed positions, actuating means normally operable to move said second valve from its closed toward its open position, and latching means for said on-off valve operatively related to said modulator valve in a manner to be rendered operative when said modulator valve is in said lesser flow-permitting position and inoperative when said modulator valve is in said ignition position, said latching means when operative latching said on-off valve in closed position when moved thereto and thereafter retaining said on-off valve in said closed position against any tendency of the actuating means therefor to open said on-off valve until said latching means is rendered inoperative with subsequent movement of said modulator valve to said ignition position, whereupon said on-off valve is released by said latching means.

16. A control device for controlling the flow of fuel to a fluid fuel burner and tending to insure safe ignition thereof comprising a modulator valve disposed in the path of fluid fuel to said burner and having an ignition and a lesser flow-permitting position, an on-off valve also disposed in the path of fluid fuel to said burner and having open and closed positions, first electroresponsive actuating means for biasing said modulator valve toward its ignition position when deenergized and biasing said valve toward said lesser flow-permitting position when energized, second actuating means for said on-off valve, and electroresponsive latching means operatively associated with said on-off valve and operable when energized to prevent movement of said on-off valve from closed to open position, said latching means being connected in circuit with said first actuating means to be energizable and deenergizable simultaneously therewith, wherefore said on-off valve is prevented from moving from closed toward open position whenever said modulator valve is biased toward said lesser flow-permitting position by said first actuating means.

17. A fuel flow control device for main and pilot burners comprising relatively movable first and second flow control members serially arranged in the path of fluid fuel to said main burner and a third control member in the path of fluid fuel to said pilot burner, said first flow control member being biased to an increased flow-permitting position and movable toward a reduced flow-permitting position, said second flow control member being movable between flow-permitting and flow-preventing positions, said third control member being movable between flow-preventing and flow-permitting positions, second operator means operatively related to said second flow control member for moving the latter between its flow-preventing and flow-permitting positions, first operator means responsive to heat of burning fuel at said main burner for moving said first flow control member from increased flow-permitting toward reduced flow-permitting position only after ignition of fuel at said main burner, and condition responsive safety shut-off means operatively related to said second and third flow control members for overcalling said second operator means to position said second flow control member in its flow-preventing position and to simultaneously position said third flow control member in its flow-preventing position in response to a predetermined condition.

18. A control device for controlling the flow of fuel to a fluid fuel burner, comprising condition responsive first fuel control means for said burner having a safe initial ignition flow-permitting position in which it is disposed in response to a predetermined condition and having a lesser than safe initial ignition flow-permitting position, second fuel control means for said burner having first and second controlling positions, and interlock means operatively associated with said first and second fuel control means and operable to prevent movement of said second flow control means from its first toward its second position except when said predetermined condition prevails.

19. A control device for controlling the flow of fuel to a fluid fuel burner, comprising condition responsive first valve means for said burner having a safe initial ignition flow-permitting position in which it is disposed in responsive to a first condition and having a lesser than safe initial ignition flow-permitting position in which it is disposed in response to a second condition induced by the burning of fuel at said burner, second valve means for said burner having first and second controlling positions, actuating means operable to move

said second valve means from its first to second position, and interlock means operatively associated with said actuating means and said first valve means and operable to overcall said actuating means and prevent movement of said second valve means from its first to second position except when said first condition prevails.

20. A control device for controlling the flow of fuel to a fluid fuel burner and tending to insure safe ignition thereof, comprising first flow-control means having an ignition and a lesser than safe initial ignition flow-permitting position, second flow-control means for said burner and having first and second controlling positions, actuating means normally operable to move said second flow-control means from its first toward its second controlling position, and latching means for said second flow-control means operatively related to said first flow-control means in a manner to be rendered operative when said first flow-control means is in said lesser than safe initial ignition flow-permitting position and inoperative when said first flow-control means is in said ignition position, said latching means when operative latching said second flow-control means in said second position when moved thereto and thereafter retaining said second flow-control means in said second position against any tendency of the actuating means therefor to move said second flow-control means toward its first position until said latching means is rendered inoperative with subsequent movement of said first flow-control means to said ignition position, whereupon said second flow-control means is released by said latching means.

21. Fuel control apparatus comprising, a burner, first control means for controlling the flow of fuel to said burner and having a safe ignition position and a lesser than safe ignition flow-permitting position, second control means having fuel flow-permitting and fuel flow-preventing positions with respect to said burner, and actuating means for said first control means operable to actuate said first control means from said ignition position toward said lesser flow-permitting position but only when fuel is burning at said burner, whereby to insure that upon movement of said second control means from flow-preventing to flow-permitting position a safe ignition flow of fuel is supplied to said burner at least until said fuel is ignited at said burner.

22. Fuel control apparatus comprising, a burner, first control means for controlling the flow of fuel to said burner biased toward a safe ignition position and having a lesser than safe ignition flow-permitting position, second control means serially arranged with respect to said first control means and having fuel flow-permitting and fuel flow-preventing positions with respect to said burner, actuating means operable to move said second control means between flow-permitting and flow-preventing positions, and actuating means for said first control means operable to actuate said first control means toward said lesser flow-permitting position against said bias but only when fuel is burning at said burner, whereby to insure that upon movement of said second control means from flow-preventing to flow-permitting position by its actuating means a safe ignition flow of fuel is supplied to said burner at least until said fuel is ignited at said burner.

23. Fuel control apparatus, comprising enclosure means, first and second control means for controlling fuel flow through said enclosure means and each movable to first and second controlling positions with respect to the fuel flow therethrough, first actuating means for said first control means operable to bias the latter toward its first controlling position, and second actuating means operatively related to said first control means for restraining the movement of the latter toward its first controlling position under the influence of said first actuating means, the restraint afforded by said second actuating means being variable in accordance with normal fluctuations in a condition, said second actuating means also being operatively related to said second control means for actuation of the latter toward its second controlling position in response to an extreme in said condition.

24. Fuel control apparatus, comprising enclosure means, first and second control means for controlling fuel flow through said enclosure means and each movable to first and second controlling positions with respect to the fuel flow therethrough, first actuating means for said first control means operable to bias the latter toward its first controlling position, second actuating means also operatively related to said first control means for restraining the movement of the latter toward its first controlling position under the influence of said first actuating means, the restraint afforded by said second actuating means being variable in accordance with normal fluctuations in a condition, said second actuating means also being operatively related to said second control means for actuation of the latter toward its second controlling position in response to an extreme in said condition, and condition responsive safety shut-off means operatively related to said second control means for insuring disposition of said second control means in its second controlling position in response to another condition.

25. A control device for controlling the flow of fuel to a fluid fuel burner and tending to insure safe ignition thereof comprising first control means disposed to control the flow of fluid fuel to said burner and having an ignition and a lesser than safe initial ignition flow-permitting position, second control means also disposed to control the flow of fluid fuel to said burner and having first and second positions with respect to the fuel flow, first electroresponsive actuating means for biasing said first control means toward its ignition position when deenergized and biasing said valve toward said lesser than safe initial ignition flow-permitting position when energized, second actuating means for said second control means, and electroresponsive latching means operatively associated with said second control means and operable when energized to prevent movement of said second control means from its second to its first position, said latching means being connected in circuit with said first actuating means to be energizable and deenergizable simultaneously therewith, wherefore said second control means is prevented from moving from its second toward its first position whenever said first control means is biased toward said lesser than safe initial ignition flow-permitting position by said first actuating means.

26. A fuel flow control device for main and pilot burners comprising relatively movable first and second flow control means disposed to control the flow of fluid fuel to said main burner and a third control means disposed to control the flow of fluid fuel to said pilot burner, said first flow control means having an increased flow-permitting position and being movable toward a reduced flow-permitting position, said second flow control means being movable between first and second controlling positions, said third control member being movable between first and second controlling positions, second operator means operatively related to said second flow control means for moving the latter between its first and second controlling positions, first operator means responsive to a predetermined condition for moving said first flow control means from increased flow-permitting toward reduced flow-permitting position only upon occurrence of said predetermined condition, and condition responsive safety shut-off means operatively related to said second and third flow control means for overcalling said second operator means to position said second flow control means in its second position and to simultaneously position said third flow control member in its second position in response to a different predetermined condition.

27. Modulating condition controlling apparatus, comprising means for varying a condition of a medium operable at a rate variable in accordance with corresponding changes in a condition of a given controlling fluid, flow controlling means for effecting changes in said condition of the controlling fluid, actuating means for said flow controlling means responsive to variations in the condition of said medium and operable to modulate the flow of said controlling fluid in a flow restricting manner and thereby to derate said condition varying means in response to a change in the condition of said medium in one sense and to modulate the flow of said controlling fluid in a flow increasing manner and thereby to increase the rate of said condition varying means in response to a change in the condition of said medium in the opposite sense, control point adjustment means for said actuating means, and means for insuring a rapid change in the condition of said medium in response to a predetermined adjustment of the setting of said control point adjustment means calling for operation of said condition varying means, said insuring means including condition responsive means operatively associated with said control point adjustment means and with said actuating means and operable, following said adjustment, to prevent restriction of flow of said controlling fluid and derating of said condition varying means until the condition of said medium reaches a predetermined value.

28. Modulating condition controlling apparatus, comprising means including a burner for varying a condition of a medium operable at a rate variable in accordance with corresponding changes in the rate of fuel flow to said burner, flow controlling means for effecting changes in the rate of said fuel flow, actuating means for said flow controlling means responsive to variations in the condition of said medium and operable to modulate the fuel flow in a flow restricting manner and thereby to derate said condition varying means in response to a change in the condition of said medium in one sense and to modulate the fuel flow in a flow increasing manner and thereby to increase the rate of said condition varying means in response to a change in the condition of said medium in the opposite sense, control point adjustment means for said actuating means, and means for insuring a rapid change in the condition of said medium in response to a predetermined adjustment of the setting of said control point adjustment means calling for operation of said condition varying means, said insuring means including condition responsive means operatively associated with said control point adjustment means and with said actuating means and operable, following said adjustment, to prevent restriction of said fuel flow and derating of said condition varying means until the condition of said medium reaches a predetermined value.

29. Modulating condition controlling apparatus, comprising a heater including a burner for heating a medium operable at a rate variable in accordance with corresponding changes in the rate of fuel flow to said burner, flow controlling means for effecting changes in the rate of said fuel flow, actuating means for said flow controlling means responsive to variations in the temperature of said medium and operable to modulate said fuel flow in a flow restricting manner and thereby to derate said heater in response to a rise in the temperature of said medium and to modulate said fuel flow in a flow increasing manner and thereby to increase the rate of said heater in response to a drop in the temperature of said medium, control point adjustment means for said actuating means, and means for insuring a rapid rise in the temperature of said medium in response to a predetermined adjustment of the setting of said control point adjustment means calling for operation of said heater, said insuring means including temperature responsive means operatively associated with said control point adjustment means and with said actuating means and operable, following said adjustment, to prevent restriction of said fuel flow and derating of said heater until the temperature of said medium reaches a predetermined value.

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