

Dec. 30, 1941.

T. A. WETZEL

2,267,775

THERMOCOUPLE-OPERATED ELECTROMAGNET

Filed June 16, 1937

5 Sheets-Sheet 1

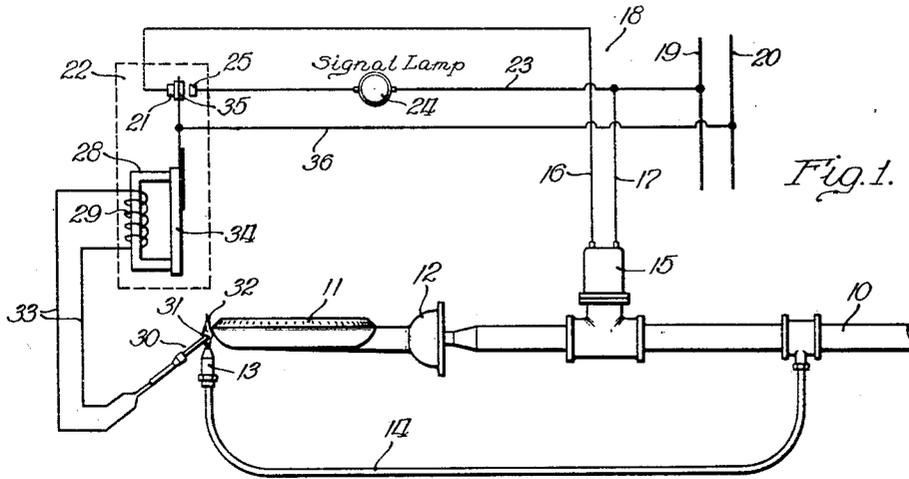


Fig. 1.

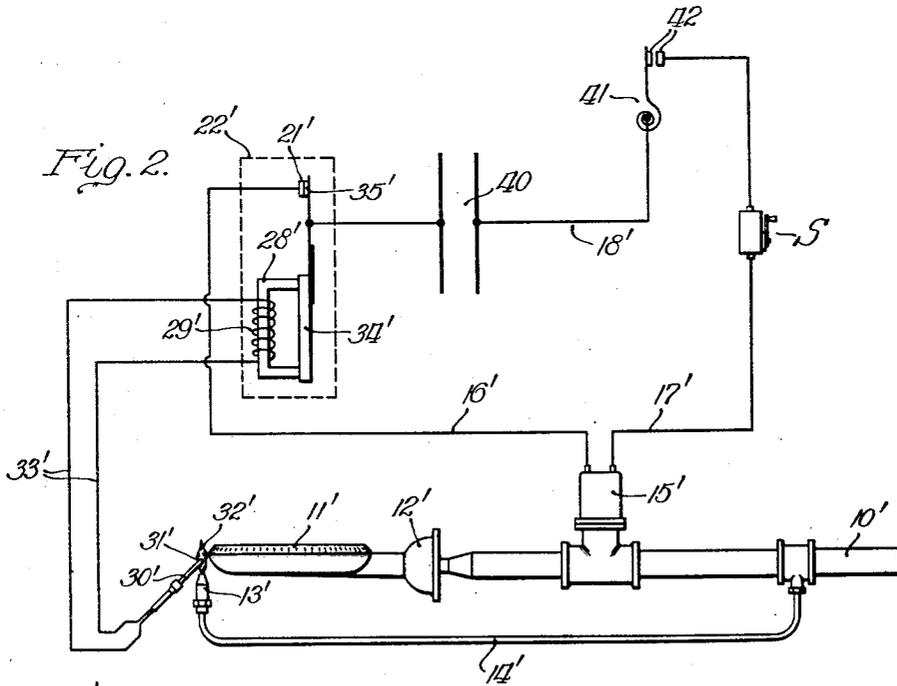


Fig. 2.

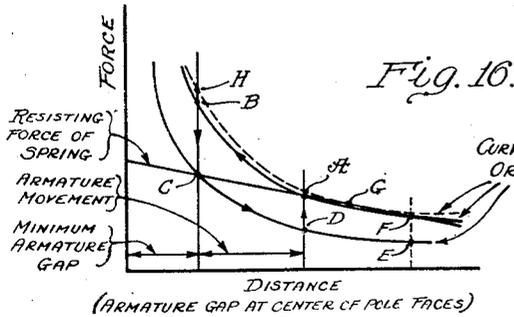


Fig. 16.

CURVES OF CONSTANT MAGNETIZING FORCE OR AMPERE TURNS.

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Fig. 3.

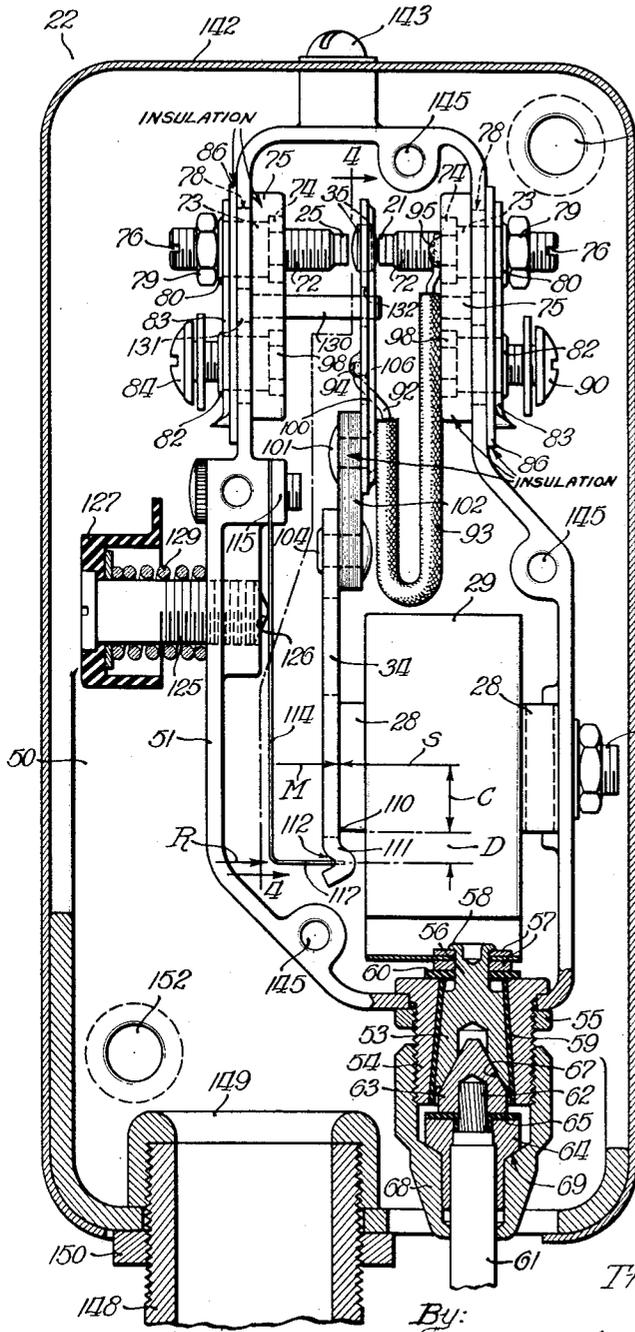


Fig. 4.

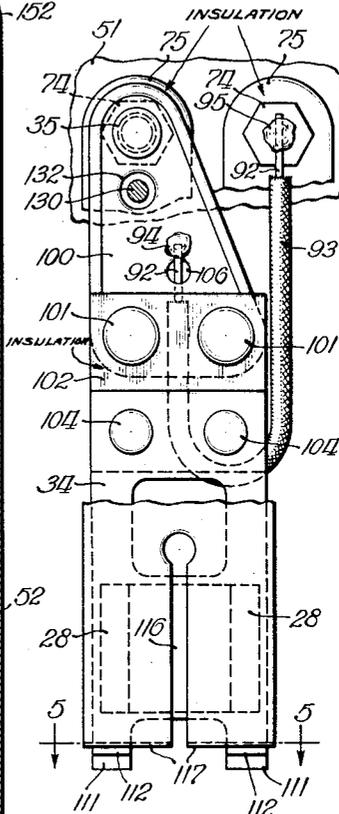
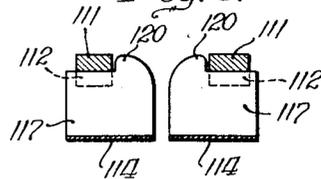


Fig. 5.



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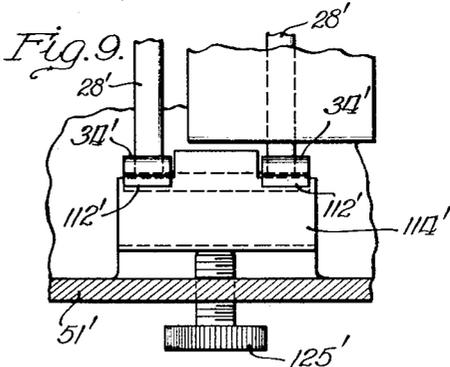
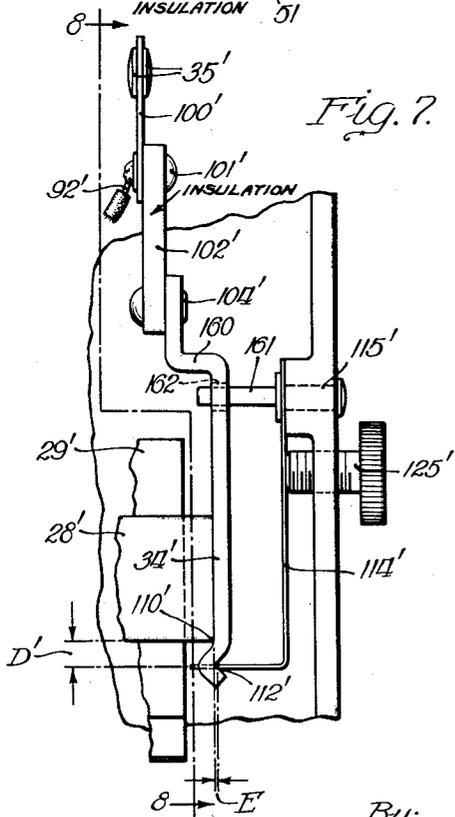
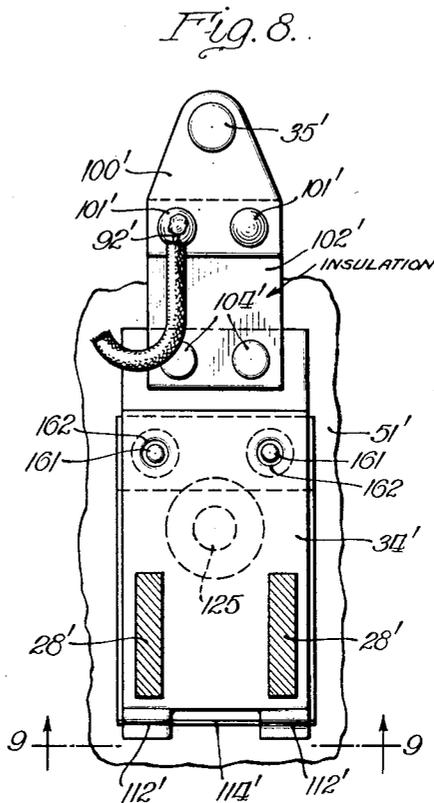
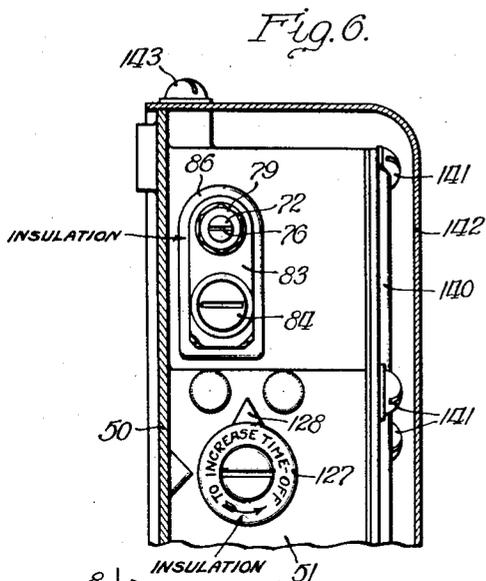
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THERMOCOUPLE-OPERATED ELECTROMAGNET

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5 Sheets-Sheet 3



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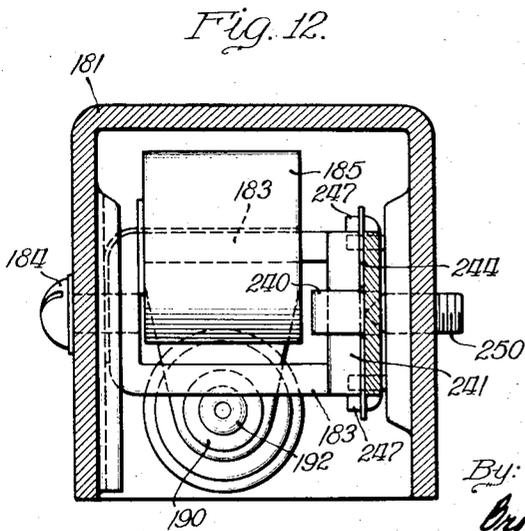
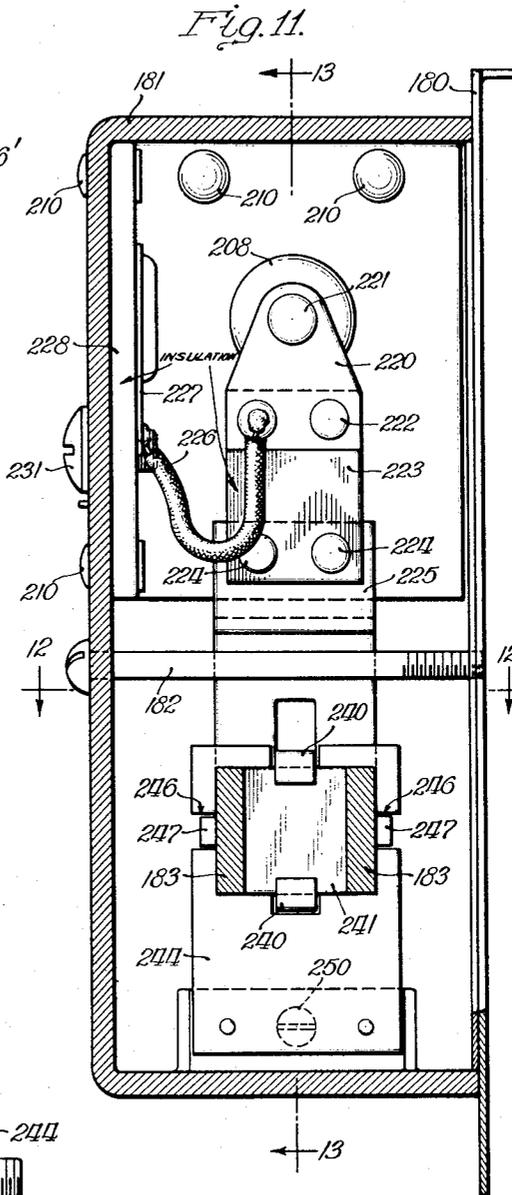
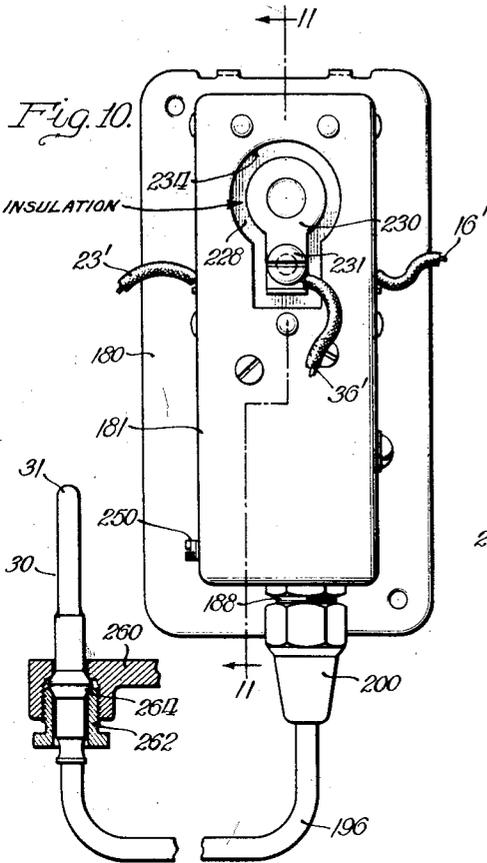
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THERMOCOUPLE-OPERATED ELECTROMAGNET

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5 Sheets-Sheet 4



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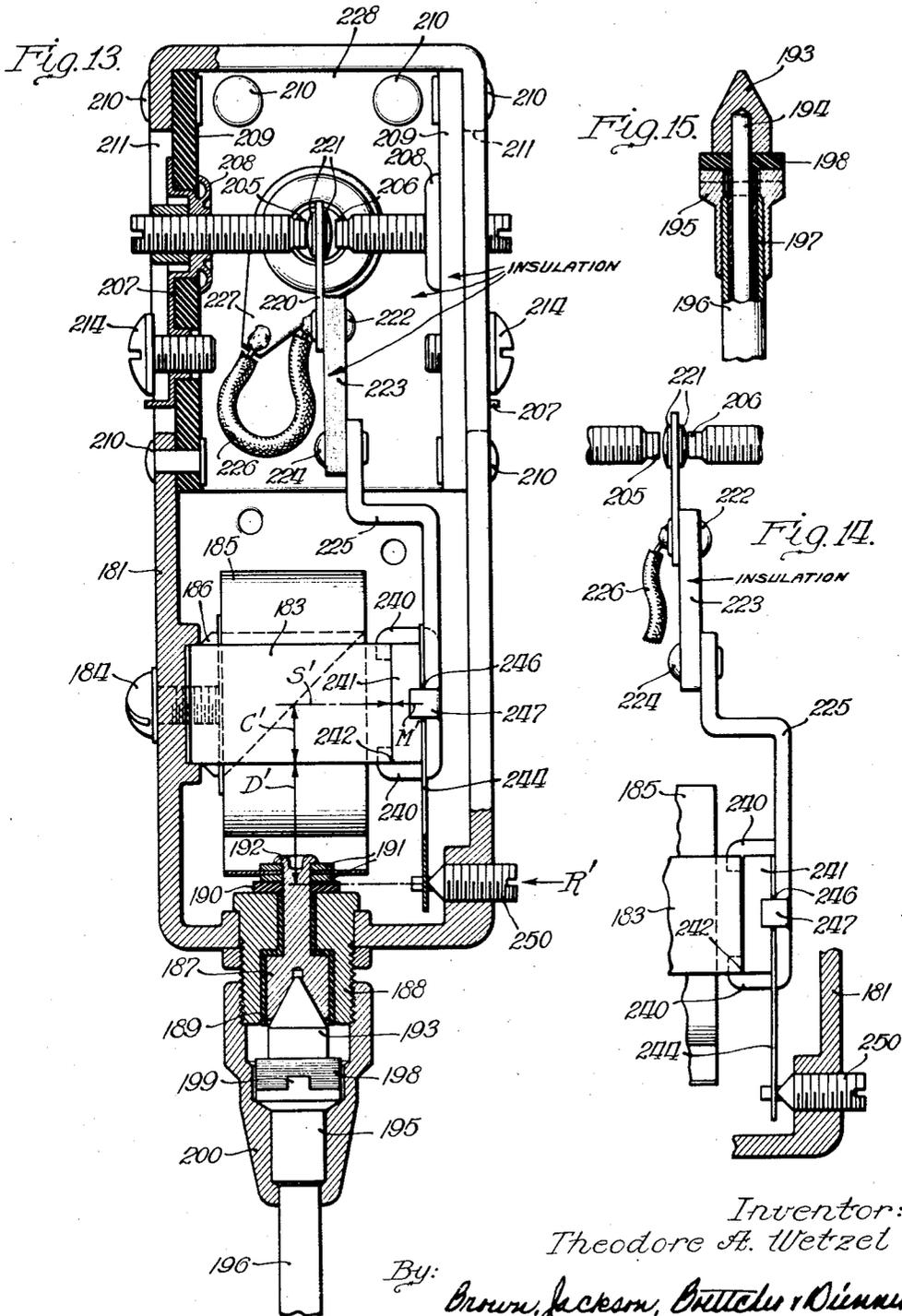
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THERMOCOUPLE-OPERATED ELECTROMAGNET

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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,267,775

THERMOCOUPLE-OPERATED ELECTRO- MAGNET

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Application June 16, 1937, Serial No. 148,495

4 Claims. (Cl. 175—336)

This invention relates to improvements in thermocouple-operated electromagnets, and has particular reference to improvements in thermocouple-operated electromagnets for controlling the supply of gaseous fuel to gas burners and the like.

In its preferred embodiment, the thermocouple-operated electromagnet of the present invention comprises an electromagnet having a magnet frame and a coil. The main burner is provided with a pilot burner for lighting the same, and a thermocouple provided with a hot junction responsive to the heat of the pilot flame is connected to the coil of the electromagnet. The heat of the pilot flame generates a thermo-electric current in the thermocouple, and this thermo-electric current energizes the electromagnet. The electromagnet has an armature which acts to close and hold closed a circuit for an electrically operated valve in the gas supply pipe for the main burner when the electromagnet is energized by the thermo-electric current generated by the heat of the pilot flame.

Closing of the circuit for the electrically operated valve opens this valve to set up and maintain the desired supply of gaseous fuel to the main burner so long as the pilot burner is lighted. If the pilot burner is extinguished, the thermo-electric current ceases, and the electrically operated valve operates to closed position to shut off the supply of gaseous fuel to the main burner.

A thermo-electric current generated by the heat of a pilot flame has heretofore been used to control an electrically operated valve in the gaseous fuel supply line for the main burner independently of an auxiliary source of current such as house current or battery, but heretofore the thermo-electric switches have been operable only to hold the circuit for the electrically operated valve closed and have been incapable of operating the switch to close said circuit by means of the relatively weak thermo-electric current produced by the heat of the pilot flame. As a result, resetting devices have been required for resetting the thermo-electric switch to closed position.

These resetting devices usually move the armature into contact with the magnet frame of the electromagnet, and, simultaneously, the switch contact means to closed position. If the resetting device is operated to close the thermo-electric switch and thereby the circuit for the electrically operated valve in the fuel supply line, the electrically operated valve will open, and if the pilot burner is not lighted gaseous fuel will

flow to the main burner and escape and collect unburned. This unburned gas presents the danger of possible explosion when a flame is applied to light the pilot burner, and also the possibility of asphyxiation.

One of the main objects of the present invention is to provide a thermo-electric switch which not only is adapted to be held closed by a relatively weak thermo-electric current, but is also adapted to be actuated to closed position by such a current without resetting devices or other auxiliary means for closing the switch.

It is also an object of the invention to provide an improved reaction spring and armature assembly for securing in a thermo-electric switch operated by a relatively weak thermo-electric current not only the desired operation as above set forth, but also a mechanical snap action which will produce a sharp clean interruption of the current in the circuit controlled by the thermo-electric switch.

It is to be understood, however, that the thermo-electric switch of the present invention is not limited to use with circuits requiring a snap action or sharp clean interruption of the current, but may be employed with the so-called "locking" circuits which incorporate auxiliary contacts to relieve the switch contacts of their initial load.

Another object of the invention is to provide means for adjusting the spring reaction member for the purpose of adjusting the action of the armature and contact member carried thereby in order to vary the time "off" after the pilot flame is extinguished.

Another object is to provide means for preventing the armature assembly from disengaging the contacts of the thermo-electric switch if the switch is jolted or dropped, for example, in shipment, and a spring reaction member which will realign and maintain the contact and armature assembly in alignment.

Another object is to provide an improved arrangement of the fulcrum for the armature, and an improved relation of the spring reaction point relative to the fulcrum for the purpose of allowing relatively heavy pressure to keep the armature in position and to permit a low spring rate, i. e., small pressure change per unit of movement, and for the further purpose of eliminating sliding movement of the armature relative to the spring reaction member and magnet frame, and sliding friction therebetween.

Another object is to provide an improved quick detachable terminal connection between the leads

of the thermocouple and the coil of the electro-magnet of the thermo-electric switch.

Another object is to provide an improved thermo-electric switch base and an improved arrangement of the parts of the thermo-electric switch.

Further objects and advantages of the invention will be apparent from the following detailed description taken in connection with the accompanying drawings, in which.

Figure 1 is a fragmentary and more or less diagrammatic view showing an embodiment of the present invention in a main burner and pilot burner gas supply system;

Figure 2 is a view similar to Figure 1, showing a modification;

Figure 3 is a front view of the thermo-electric switch on an enlarged scale, with the cover for the switch and some of the other parts in vertical section;

Figure 4 is a view taken on the line 4—4 of Figure 3;

Figure 5 is a horizontal detail section, taken on the line 5—5 of Figure 4;

Figure 6 is a fragmentary side view of the thermo-electric switch, with the cover and switch base in section;

Figure 7 is a fragmentary view showing a modified form of reaction spring member and armature assembly embodying the present invention;

Figure 8 is a view taken on the line 8—8 of Figure 7;

Figure 9 is a horizontal detail section taken on the line 9—9 of Figure 8;

Figure 10 is a front elevational view of a further modified form of thermo-electric switch embodying the present invention;

Figure 11 is a vertical section taken on the line 11—11 of Figure 10;

Figure 12 is a horizontal section taken on the line 12—12 of Figure 11;

Figure 13 is a vertical section taken on the line 13—13 of Figure 11;

Figure 14 is a fragmentary view showing the reaction spring member and armature system employed in the embodiment of the invention shown in Figures 10 to 13, inclusive;

Figure 15 is a fragmentary sectional view through the terminal member for the leads of the thermocouple; and

Figure 16 is a diagram showing the cycle of operation of the thermo-electric switch of the present invention.

Referring first to Figure 1, the pipe 10 is the gas supply pipe or manifold for supplying gas to the main burner 11. The burner 11 is fed from the pipe 10 by a mixing tube 12, to the outer end of which air is admitted, as well understood in the art.

Associated with the main burner 11 is a pilot burner 13 which is intended to remain lighted and serves to light the main burner 11 when the valve therefor is opened. The pilot burner 13 is supplied with gaseous fuel by a tube 14 shown in the drawings as connected to the pipe 10 ahead of the electrically operated valve 15 provided in said pipe 10. The pilot burner supply line may, however, be connected to the pipe 10 between the valve 15 and the burner 11, or otherwise as desired.

The electrically operated valve 15 may be a motor valve, solenoid valve, or any other electrically operated valve well known in the art. It is normally closed to shut off the supply of gaseous fuel to the main burner 11, and has elec-

trically controlled mechanism connected across conductors 16 and 17 of an electric circuit 18. The conductors 19 and 20 constitute the conductors of a controlled supply circuit connected to a suitable source of electricity for energizing the electrically controlled mechanism of the valve 15 to open said valve when the circuit 18 is closed.

One conductor 16 is connected to a stationary contact 21 at the thermo-electric switch designated in its entirety at 22, and the other conductor 17 is connected to a conductor 23, which conductor 23 is connected to one of the supply conductors 19 and through a signal lamp 24 or other suitable indicator to a second stationary contact 25 at the thermo-electric switch 22.

The thermo-electric switch 22 has an electromagnet comprising a magnet frame 28 and a coil 29. A thermocouple 30, having a hot junction 31 responsive to the heat of the pilot flame 32, is connected through thermocouple leads 33 to the coil 29. The heat of the pilot flame 32 generates a thermo-electric current in the thermocouple, and this thermo-electric current energizes the electromagnet. The electromagnet has an armature 34 which is fulcrumed for swinging movement, as will hereinafter appear, and carries a contact member 35 which moves with the armature 34 for engagement with the contact 21 when the electromagnet is energized and the armature attracted to the magnet frame 28, and for engagement with the other contact 25 when the armature moves away from the magnet frame.

Engagement of contact 35 with contact 21 completes a circuit from conductor 20 of the supply circuit through conductor 36, contacts 35 and 21, conductor 16, the electrically operated mechanism of valve 15, conductor 17, and conductor 23, to the other side 19 of the supply circuit. The completion of this circuit energizes the electrically operated mechanism of the valve 15 which, by such energization, opens and holds this valve open so long as the pilot flame 32 is burning.

Upon cessation of the pilot flame 32 the thermo-electric current generated thereby ceases, and the armature 34 moves away from the magnet frame 28 and engages the contact 35 with the contact 25. This opens the circuit for the electrically operated mechanism of the valve 15, which valve thereupon closes to shut off the supply of fuel to the main burner. At the same time, engagement of contact 35 with contact 25 completes a circuit from the conductor 20 of the supply circuit through conductor 36, contacts 35 and 25, conductor 23, and signal lamp 24, to the other side 19 of the supply circuit. The completion of this circuit lights the lamp 24 to indicate that the valve 15 is closed and the pilot flame 32 extinguished.

In the modification shown in Figure 2, the main burner 11' is fed with gaseous fuel from pipe 10' by a mixing tube 12'. The pilot burner 13' for the main burner 11' is supplied with gaseous fuel by tube 14' connected to pipe 10' ahead of the electrically operated valve 15' provided in the pipe 10'.

The valve 15', like the valve 15 of the preceding embodiment of the invention, is normally closed and has electrically controlled mechanism connected across conductors 16' and 17' of an electric circuit 18'. The circuit 18' has a suitable source of current therein, as indicated at 40, and may be provided with a thermostat 41 for open-

ing and closing the circuit 18' in accordance with the temperature of the room, oven, or other space heated by the main burner.

One conductor 16' is connected to a stationary contact 21' at the thermo-electric switch 22', and the other conductor 17' is connected through contacts 42 of thermostat 41 when these contacts are closed, and through the source of current 40 to the contact 35' carried by the armature 34' of the thermo-electric switch. The thermocouple 30' has a hot junction 31' responsive to the heat of the pilot flame 32', and the thermocouple leads 33' are connected to the coil 29' of the electromagnet at the thermo-electric switch. This electromagnet includes the coil 29' and a magnet frame 28'.

When the pilot burner is burning, the heat of the flame 32' thereof produces a thermo-electric current in the thermo-electric circuit. This energizes the coil 29', and the armature 34', which is fulcrumed for swinging movement as will presently appear, is attracted to the magnet frame 28'. This engages the contact 35' with the contact 21', closing the circuit 18' and energizing the electrically operated mechanism of the valve 15' to open and hold this valve 15' open so long as the pilot flame is burning, and the temperature to which the thermostat 41 is subject does not reach the temperature at which the thermostat operates to open the circuit 18' at the contacts 42. An auxiliary boiler or furnace switch is shown at S in Figure 2.

Upon cessation of the pilot flame 32', the thermo-electric current generated thereby ceases and armature 34' moves away from the magnet frame 28', thereby separating the contact 35' from the contact 21'. This opens the circuit 18' for the valve 15', which valve thereupon closes to shut off the supply of fuel to the burner 11'. When the pilot burner 13' is lighted, it sets up a thermo-electric current which energizes the coil 29', and the armature 34' is attracted to the magnet frame to close the circuit 18' and thereby open the valve 15' so that gaseous fuel may be fed to the burner 11'. Between valve 15' and the source of fuel supply, a manually operated or other suitable control valve (not shown) may be placed, for controlling the flow of fuel through the pipe 10'.

The thermocouple-operated electromagnet which is shown in detail in Figures 3 to 6, inclusive, comprises a switch base 50 having an outstanding frame 51 formed integral therewith. The magnet frame 28 is of U-shaped form, secured at its base to one side of the frame 51 by bolt or screw means at 52. The coil 29, which is in the form of a spirally wound flat ribbon-like conductor, surrounds one of the legs of the magnet frame 28, which legs extend laterally (Figure 3) from the side of the frame 51 to which the magnet is secured.

One end of the coil 29 is electrically connected to the frame 51, and the opposite end of the coil is electrically connected to a terminal plug 53. The outer periphery of plug 53 is of conical form to seat upwardly in a corresponding conical bore in a sleeve member 54. The upper end of this member 54 is headed to seat against the upper side of the bottom of the frame 51, and a nut 55, threaded upon the member 54 and into engagement with the bottom side of the lower wall of the frame 51, binds the member 54 in place. The plug 53 has an upwardly extending reduced stem 56 which passes up through reinforcing washers 57 on opposite sides of the

adjacent end of the ribbon-like member forming the coil 29, and is riveted over at 58. Insulation at 59 and 60 insulates the terminal plug 53 and the connected end of the coil 29 from the sleeve member 54.

The thermocouple leads shown diagrammatically at 33 in Figure 1 are in the form of an outer lead tube 61 and an inner lead wire 62 which extends through the lead tube 61 and is suitably insulated therefrom. The bared end of the wire 62 has a terminal member 63 fixed thereon in good electrical contact therewith, and a terminal sleeve 64 surrounds and makes good electrical contact with the tube 61. Insulation at 65 insulates the terminal member 64 from the wire 62 and from the terminal member 63. This latter terminal member 63 has a conical tip which seats at 67 against a conical seat in the plug 53. A union or coupling member 68, provided with a tapered surface which seats at 69 against the terminal member 64, has threaded engagement with the sleeve member 54 and binds the parts firmly together with the terminal member 63 in good contact with the plug 53 and the lead tube 61 electrically connected through terminal member 64, union member 68, sleeve member 54, and frame 51, to one end of the coil 29. The contact between terminal member 63 and plug 53 connects the lead wire 62 to the other end of the coil 29.

A quick detachable connection is thus provided between the leads of the thermocouple and the coil 29 of the electromagnet. The thermocouple leads are disconnected from the coil 29 by unthreading the union member 68 from the sleeve 54, and connection is made by placing the tip of the terminal member 63 in the lower end of plug 53 and screwing the union member 68 upwardly upon the sleeve 54 to bind the parts together with the wire 62 connected to one end of the coil 29 and the lead tube 61 connected to the other end of the coil through the frame 51.

The contacts 21 and 25 have threaded shanks 72 which have threaded engagement with thimbles 73. The thimbles 73 are held against turning movement by polygonal or other non-circular heads 74 which fit in corresponding depressions in terminal blocks 75. The terminal blocks 75 may be formed of molded "Bakelite" or other suitable insulating material. The outer ends of the threaded shanks 72 have kerfs 76 for engagement by a screw driver or other suitable tool to adjust the positions of the contacts 21 and 25. The terminal blocks 75 fit at 78 in openings in the opposite sides of the frame 51. Nut members 79 serve to lock the contacts 21 and 25 in adjusted position, and the outer ends of the thimbles 73 are riveted over at 80 to secure the terminal blocks 75 to the opposite sides of the frame 51.

The single terminal block 75 at one side of the frame 51 for the contact 25 is additionally secured to the frame by a second thimble 82 corresponding with the thimble 73 and positioned below the same. This second thimble 82 is electrically connected with the shank of the contact 25 by a connector piece 83, and a terminal screw 84, having threaded engagement with the thimble 82, serves to connect the conductor shown at 23 in Figure 1 to this thimble 82. Insulation at 86 insulates the connector piece 83 from the frame 51.

Two of the insulating blocks 75 are provided at the opposite side of the frame, one rearwardly disposed for the contact 21 and the other dis-

posed forwardly thereof, for connecting the conductor shown at 36 in Figure 1 to the contact member 35 carried by the armature 34. The rearwardly disposed block 75 has a lower thimble corresponding with the thimble 82 and connected to the upper thimble 73 by a connector piece corresponding with the connector piece 83, and a terminal screw corresponding with the terminal screw 84 has threaded engagement with the lower thimble for connecting the conductor shown at 16 in Figure 1 to the contact 21. The forwardly disposed terminal block 75 on the right hand side of the frame 51 (Figure 3) has upper and lower thimbles corresponding with the thimbles 73 and 82. A terminal screw 90, having threaded engagement with the lower thimble 82 of the forwardly disposed insulating block 75, connects the conductor shown at 36 in Figure 1 to the thimble 82 which, in turn, is connected to the other thimble by the connector piece 83 insulated from the frame 51 by insulation at 86.

A flexible conductor 92, which may be insulated at 93, is soldered or otherwise suitably connected at one end at 94 to the contact member 35 carried by the armature 34. The opposite end of this conductor 92 is soldered or otherwise suitably connected at 95 to the upper and forwardly disposed thimble 73 at the right hand side of the frame 51, as shown in Figure 3. The lower thimbles 82 are all held against turning movement by polygonal or other non-circular heads 98, and are riveted over to bind the lower ends of the insulating blocks 75 in place as described in connection with the upper thimbles 73.

The contact 35 is carried on the upper end of a generally triangular contact arm 100 secured at its lower end at 101 to an insulating piece 102. This insulating piece 102 is, in turn, secured at 104 to the armature 34, and serves to insulate the contact means from the armature. The conductor 92 preferably passes from the right hand side (Figure 3) of the contact arm 100 through an opening 106 in the contact arm, and is soldered or otherwise connected to this arm on the opposite side thereof.

The armature 34 is fulcrumed at 110 on the lower edges of the outer ends of the legs of the magnet 28. The lower end of the armature is bifurcated, and the two short depending forks 111 have V-shaped notches 112 disposed in close proximity to the fulcrum 110. A generally L-shaped spring member 114 has the upper end of its vertical arm secured at 115 to the adjacent side of the frame 51. The spring member 114 is bifurcated at 116, and the inturned forks at the lower end of the vertical arm engage the forks 111 of the armature 34 in the V-shaped notches 112 for swinging the armature counterclockwise (Figure 3) about the fulcrum 110 to separate the contact 35 from the contact 21 and engage the same with the contact 25 upon cessation of the thermo-electric current in the coil 29.

The inner ends of the inturned forks 117 have ears 120 (Figure 5) which fit between and engage the respective forks 111 of the armature to hold the forks 111 against lateral displacement.

With the spring member and armature assembly shown, not only is the armature 34 held against the pole faces at the ends of the legs of the magnet 28 when the coil 29 is energized by the relatively weak thermo-electric current set up therein by the action of the pilot flame on the hot junction of the thermocouple, but the armature is actuated to position against the magnet to engage the contact 35 with the contact 21 by

the relatively weak thermo-electric current without resetting devices or other auxiliary means.

In Figure 3, let

X=movement of armature at center of magnet,
 R=force of spring tending to rotate armature about fulcrum,
 S=force at center of magnet opposing magnetic pull on armature=

$$\text{armature} = \frac{DR}{C}$$

M=magnetic pull at center of magnet on armature when coil is energized.

Now→for a given magnet pull in equilibrium

M=S.

And, since

$$S = \frac{DR}{C}$$

it will be apparent that the force R exerted by the spring 114 may be relatively great by virtue of the relatively close proximity of the spring reaction point on the armature to the fulcrum 110.

Thus the spring may exert a relatively great force and flex a relatively slight amount for a given magnet pull and armature movement.

The spring rate is defined as the ratio

$$\frac{\text{force change}}{\text{unit deflection}} = \frac{\text{lbs.}}{\text{inch}} \text{ or } \frac{\text{ounces}}{\text{inch}} = \text{rate}$$

It should be further noted that the reaction point of the spring member 114 in the generally V-shaped notches 112 in the armature is in substantially the same vertical plane as the fulcrum 110. The advantages of this will hereinafter appear.

When the magnet pull M drops below that of the opposing force S, the armature will move away from the pole faces the amount X by virtue of the force S. As the armature moves, the force S diminishes (always in excess of the pull M, however) due to the movement relieving the stress on the spring member whose force is exerted at the distance D from the fulcrum.

With the structure shown and described it is possible to secure in a device of this sort and notwithstanding the relatively weak thermo-electric current employed a mechanical snap action which will produce a sharp, clean interruption of the current in the circuit controlled by the thermo-electric switch.

Referring now to Figure 16, the electrical and magnetic functioning of the various parts take place, and the snap action is secured as follows:

When the instrument is deenergized the armature gap is at a maximum. With lighting of the pilot flame, the electrical energy delivered by the thermocouple increases to a point where the magnetic force attracting the armature overcomes the force of spring resistance shown at A and the armature moves to its minimum gap position. Assuming no increase in magnetizing force, the magnetic pull increases to B along the curved line, and the spring resisting force increases according to Hooke's law along the straight line to C. The difference between the magnetic pull on the armature and the spring resisting force is the resultant force which urges the armature to assume its minimum gap position, and this resultant force increases as the armature moves toward the pole faces. The armature is thus accelerated by an increasing force for each increment moved to give a rapid or snap-like action. The thermo-electric current may rise and the magnetic pull increase much above point B with further change in the armature position since

the entire assembly has come to rest against the opposite switch contact.

Upon cessation of the pilot flame the electrical energy subsides to a point where the magnetizing force produces a magnetic pull slightly less than the spring force at C. The resultant force urges the armature away from its pole faces to snap to its maximum gap position D. Rapid or snap action is facilitated by the fact that the resultant force increases for each increment of armature travel away from the pole faces.

Now let us consider a condition where snap action would not be possible. Let us adjust one of the switch contacts to permit a greater armature movement to the line EF in Figure 16. It will be seen that the spring resisting force exceeds the magnetic pull between the points F and A and that an increasing magnetizing force is necessary to cause the magnetic pull to overcome the spring force and move the armature by small increments to the point G, from where it snaps to the minimum gap position. This stiff arm slow movement from F to G does not permit a sharp clean break of the switch contacts, and welding or sticking of the contacts results.

Reference to Figure 16 shows that the flatter the slope of the spring resisting force line CF the more remote the possibility of encountering the condition just described. In other words, it is most desirable to have a resisting or spring force with very little change in pressure during the armature movement. Gravity would be the ideal force, but does not seem practical. In lieu of gravity, a spring with a very "soft" rate is used.

The limiting factor in a "soft" rate spring is the stress imposed on the spring when exerting the required force. By means of the improved structural arrangement of the present invention it is possible to accomplish the equivalent of a "soft" rate spring with one of heavier proportions, or vice versa, to accomplish a spring with a rate "soft" enough for successful snap operation with spring proportions possible within such a small switch structure.

As already pointed out, it is to be understood that the improvements of the present invention are not limited to use with circuits requiring a snap action or sharp, clean interruption of the current, but may be employed with the so-called "locking" circuits which incorporate auxiliary contacts to relieve the switch contacts of their initial load.

A screw 125, threaded through one side of the frame 51 (Figure 3), abuts the spring reaction member 114 at its inner end at 126, and is provided at its outer end with a finger piece or knob 127. By grasping the finger piece or knob 127 and turning the screw 125, the tension of the reaction spring member may be adjusted to adjust or vary the time "off" after the pilot flame is extinguished. An arrow or pointer 128 on the finger piece or knob 127, as shown in Figure 6, indicates the setting of the adjusting screw 125. The direction in which the screw is turned to increase the time "off" is indicated by the arrow in Figure 6. The finger piece 127, which may be formed of molded or other suitable material, is fixed to the outer end of the screw 125 to turn the same therewith, and a spring 129, interposed between the finger piece and the frame 51, holds the screw against accidental turning, for example if the instrument is jolted or vibrated.

A guide pin 130, anchored at 131 to one side of the frame 51, extends loosely through an opening 132 in the armature assembly, and particularly in

the contact member 100 thereof, to prevent the armature assembly from disengaging the contacts if the switch is jolted or dropped, for example in shipment. The spring pressure is great enough at the V-shaped notches 112 to reline contacts and armature assembly and to maintain same properly aligned.

The front of the frame 51 is provided with a cover plate 140 secured in place by screws 141 as shown in Figure 6, and a switch cover 142 encloses the entire device and is secured to the base 50 by screws 143. The front of the cover 142 may have ribs drawn therein, or may be formed otherwise as suitable or desired. The screws 141 engage in threaded openings 145 (Figure 3) formed in bosses integral with the frame 51.

The conductors shown at 16, 23 and 36 in Figure 1 are led into the switch housing and to the respective contacts through an inlet conduit 148. This conduit 148 threads into an inwardly disposed nipple 149 and is secured in place by a nut 150 threaded thereon. Openings 152 in the base 50 provide for mounting the instrument upon a suitable support.

The outer exposed faces of the insulating pieces 86, one of which is shown in Figure 6, may be differently colored at the respective contacts, i. e., at the screw constituting the contact 25, the screw constituting the contact 21, and at the connection between the terminal screw 90 and the conductor 92, to facilitate proper connection of the respective conductors therewith. In the case of coloring, the outer face of the insulation at one contact may be colored red, the outer face of the corresponding insulating member at another contact may be colored blue, and the outer exposed face of the insulating member at the third contact means may be colored white. Any other different colorings or other suitable markings may, of course, be employed.

The modification shown in Figures 7, 8 and 9 is similar to the embodiment of the invention shown in Figures 3 to 6, except that the armature 34' is offset at 160 and the guide pin 161, which corresponds with the guide pin 130 of the preceding embodiment, passes loosely through an opening 162 in the armature 34' instead of through an opening in the contact member indicated at 100' and provided with the contact 35'. The contact member 100' is secured at 101' to the insulating member 102' which, in turn, is secured at 104' to the armature 34'. The conductor 92' corresponds with the conductor 92 of the preceding embodiment of the invention.

The spring reaction member is indicated at 114'. This member is fixed at 115' to the frame 51', and the reaction point between the lower returned end at the V-shaped notch 112' at the lower end of the armature corresponds with the reaction point of the preceding embodiment of the invention and is in close proximity to the fulcrum at 110' on the lower edges of the outer ends of the legs of the magnet 28'. The coil is indicated at 29'. The distance from the fulcrum 110' to the spring reaction point at 112' is indicated at D' and corresponds with the distance D of the preceding embodiment of the invention. Also as shown at E, the spring reaction point at 112' is approximately in the vertical plane of the fulcrum 110', as in the preceding embodiment of the invention. The screw at 125' corresponds with the screw 125 of the preceding embodiment, and is adapted for adjusting the

spring reaction member to vary the time "off" after the pilot flame is extinguished.

The modified form of instrument shown in Figures 10 to 15, inclusive, comprises a thermo-electric switch base 180 and a metal box 181 secured thereto by bolt means at 182.

The U-shaped magnet 183 is secured at 184 to one side of the box 181. One end of the coil 185 is electrically connected to the box 181 at 186, and the opposite end of the coil is electrically connected to a terminal plug 187 which is like the plug 53 shown in Figure 3, except that its outer periphery is cylindrical instead of conical. The sleeve 188 and insulation at 189 are similar to the sleeve 54 and insulation 59 of the preceding embodiment, except that they are formed to conform with the slightly different formation of the plug 187. The insulation at 190, washers 191, and riveting of the upper end of the shank of the plug 187 at 192 are similar to the corresponding parts in the preceding embodiment of the invention.

The thermocouple terminal comprises a terminal member 193 fixed on the bared end of the thermocouple lead wire 194 (Figure 15), and a terminal member 195 surrounds and makes contact with the thermocouple lead tube 196. The lead wire 194 and lead tube 196 are insulated from each other at 197, and the terminal member 193 is insulated from the terminal member 195 at 198. The insulation at 198 and terminal member 195 are interlocked at 199, and the union or coupling member 200 binds the parts firmly together with the conical tip of the terminal member 193 in good electrical contact with the corresponding seat in the plug 187 and with the lead wire connected to one end of the coil 185 and the lead tube 196 connected to the other end of the coil through the box 181.

A quick detachable connection is thus provided between the leads of the thermocouple and the coil 185 of the electro-magnet. The thermocouple leads are disconnected from and connected to the coil terminal as described in connection with the preceding embodiment of the invention.

The threaded shanks of contacts 205 and 206, which correspond with the contacts 21 and 25 of the preceding embodiment of the invention, have threaded engagement with metallic connector pieces 207 mounted upon and secured at 208 to insulating terminal blocks 209. These blocks 209 are secured at 210 over openings 211 in the opposite side walls of the box 181. Each connector piece 207 has a terminal screw 214 in threaded engagement therewith for connecting the circuit conductors to the connector pieces, and thereby with the contacts 205 and 206, respectively. Where the circuit is of the type shown in Figure 1, the conductor 16 is connected to the terminal screw 214 for the contact 205, and the conductor 23 is connected to the terminal screw 214 for the opposite contact 206.

The contact arm 220, which carries the contact member 221, corresponds with the contact arm 100 of the preceding embodiment of the invention, and is secured at 222 to the insulating member 223. This insulating member in turn is secured at 224 to the armature arm 225. The contact arm 220 is connected by a conductor 226 to a connector piece 227 mounted on an insulating terminal block 228 at the front of the box 181. The connector piece 227 is electrically connected to an externally disposed connector piece 230 (Figure 10) which is provided with a

terminal screw 231 for connecting conductor 36', corresponding to the conductor 36 in Figure 1, to the contact arm 220. The conductors corresponding to the conductors 16 and 23 are indicated in Figure 10 at 16' and 23', and the opening in the front of the box 181, over which the insulating block 228 is secured, is indicated at 234.

The armature arm 225 is secured by lugs 240 to the armature 241 which is fulcrumed at 242 on the lower edges of the outer ends of the legs of the magnet 183. The spring member 244 tends to force the armature assembly clockwise (Figure 13) about the fulcrum 242 to engage contact 221 with contact 206 when the coil 185 is deenergized. When the coil 185 is energized, the magnet 183 pulls the armature to the minimum gap position toward the pole faces of the magnet, and thereby moves the contact 221 out of engagement with the contact 206 and into engagement with the contact 205, and holds the same in this position so long as the pilot flame is burning.

The sides of the spring member 244 have slots 246 in which lugs 247 on the armature arm 225 engage to interlock the armature arm and spring reaction member against relative longitudinal movement. At its lower end, the spring reaction member 244 bears against the inner pointed end of a screw 250 threaded through the adjacent side wall of the box 181. The screw 250 is adjustable to adjust the tension of the spring member 244 and, thereby, the time "off" after the pilot flame is extinguished. The armature 241 is shown in Figure 13 in minimum gap position relative to the pole faces of the magnet 183 and with the contact 221 in engagement with the contact 205, whereas in Figure 14 the armature is shown separated at maximum gap position from the pole faces of the magnet 183 and with the contact 221 in engagement with the contact 206.

The movement is relatively slight, and the structure described not only holds the armature against the magnet when the coil is energized, but moves the armature from maximum armature gap position to engagement with the magnet by the energization of the coil with the relatively weak thermo-electric current set up by the thermocouple.

The thermocouple 30, which has the hot junction 31 and the usual cold junction, may be mounted as shown in Figure 10 on a bracket or other suitable support 260 by means of a tubular nut 262 having threaded engagement with the bracket or support 260, and cooperating with the tapered surface of an enlargement 264 on the thermocouple element.

The outer exposed surfaces of the insulating terminal blocks 209 in Figure 13 may be differently colored or differently marked as set forth, and for the purpose described in connection with the coloring or marking of the insulating pieces 86 of Figure 3.

I do not intend to be limited to the precise details shown or described.

I claim:

1. In a device of the class described, in combination, an electromagnet comprising an energizing winding, a magnet frame constituting a core for said winding, an armature fulcrumed directly on one edge of the outer end of said magnet frame and adapted to be swung and held in attracted position with respect to said magnet frame by energization of said winding, said arma-

ture having a notch to one side of said magnet frame and in close proximity to the fulcrum, a spring support, and a leaf spring mounted on said support and provided with an angular end having substantially knife-like engagement in the notch in said armature and normally holding said armature in retracted position.

2. In a device of the class described, in combination, an electromagnet comprising an energizing winding, a magnet frame constituting a core for said winding, an armature fulcrumed directly on one edge of the outer end of said magnet frame and adapted to be swung and held in attracted position with respect to said magnet frame by energization of said winding, said armature having a notch to one side of said magnet frame and in close proximity to the fulcrum, a spring support, a leaf spring mounted on said support and provided with an angular end having substantially knife-edge engagement in the notch in said armature and normally holding said armature in retracted position, and means for adjusting the tension of said spring to vary the actuation of said armature by said spring and by energization of said winding.

3. In a device of the class described, in combination, a main frame, an electromagnet disposed within said main frame and comprising an energizing winding and a magnet frame secured to one side of said main frame and constituting a core for said winding, an armature fulcrumed directly on one edge of the outer end of said magnet frame and adapted to be swung and held in attracted position with respect to said magnet frame by energization of said winding, said arma-

ture having a notch to one side of said magnet frame and in close proximity to the fulcrum, and a generally L-shaped leaf spring having one arm thereof secured to the opposite side of said main frame and another arm disposed generally normal to said first arm and having substantially knife-edge engagement in the notch in said armature and normally holding said armature in retracted position.

4. In a device of the class described, in combination, a main frame, an electromagnet disposed within said main frame and comprising an energizing winding and a magnet frame secured to one side of said main frame and constituting a core for said winding, an armature fulcrumed directly on one edge of the outer end of said magnet frame and adapted to be swung and held in attracted position with respect to said magnet frame by energization of said winding, said armature having a notch to one side of said magnet frame and in close proximity to the fulcrum, a generally L-shaped leaf spring having one arm thereof secured to the opposite side of said main frame and another arm disposed generally normal to said first arm and having substantially knife-edge engagement in the notch in said armature and normally holding said armature in retracted position, and means having threaded engagement with said opposite side of said main frame and abutting engagement with the first mentioned arm of said spring for adjusting the tension of said spring to vary the actuation of said armature by said spring and by energization of said winding.

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