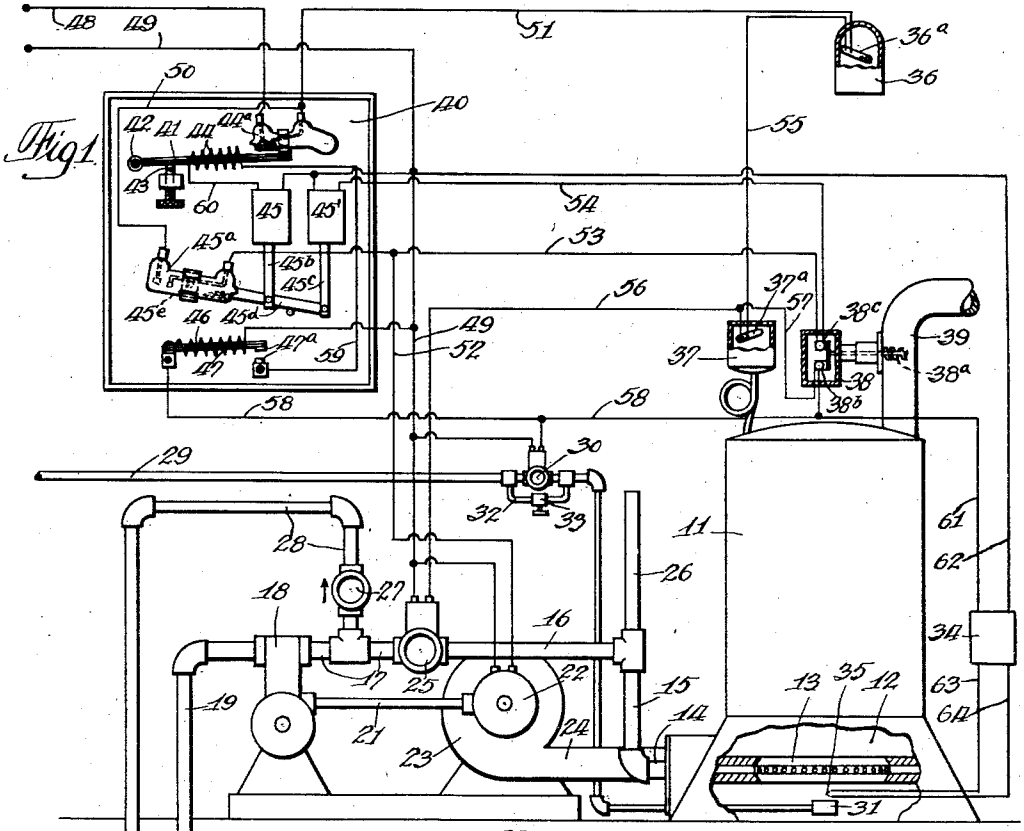
Oct. 18, 1932. J. C. BOGLE 1,883,242

OIL BURNER CONTROL SYSTEM

Filed Jan. 21, 1929

Fig 1.



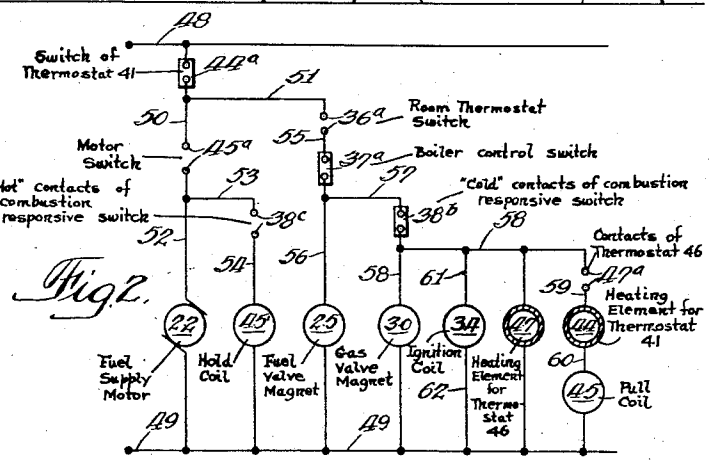


Fig 2.

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UNITED STATES PATENT OFFICE

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OIL BURNER CONTROL SYSTEM

Application filed January 21, 1929. Serial No. 333,951.

This invention relates to an oil burner control system and has particular relation to circuits and apparatus for effecting desired predetermined operation of such systems.

The primary object of this invention is to provide means for effecting the occurrence of predetermined steps or operations in the cycle of operation of an oil burner control system in desired sequence.

Other objects and advantages of the invention will appear from a consideration of the following detailed description in connection with the accompanying drawing, in which:

Figure 1 is a diagrammatic representation of apparatus and circuits embodying the invention, only those parts essential to a full and clear understanding of the invention being shown; and,

Fig. 2 is a schematic representation of the electrical circuits shown in Fig. 1.

Referring first to Fig. 1, a boiler or furnace 11 comprises a combustion chamber 12 within which a burner 13 for oil or other liquid fuel is properly disposed. The burner 13 is connected through pipe or conduit sections 14, 15, 16, and 17 to the discharge side of a pump 18, the intake side of which is connected through a pipe or conduit 19 to a tank 20 or other suitable source of liquid fuel supply. The pump 18 is diagrammatically illustrated as being of the reciprocating type, but it will be understood that any other suitable form of pump may be utilized if desired.

The pump 18 is driven through a shaft 21 and suitable gears or other mechanical means (not shown) from an electric motor 22, which also drives a blower 23. The blower 23 is provided with a conduit 24 for supplying air to the burner 13 for combustion purposes.

An electromagnetically operated valve 25 is disposed between the pipe or conduit sections 16 and 17 in the fuel supply line extending from the discharge side of the pump 18 to the burner 13. This valve is normally closed and is adapted to be opened and held in its open position in response to the energization of its electromagnet. The valve 25 may be of the type disclosed in co-pending application Serial No. 226,730, filed October 17, 1927, by Lawrence E. Koch and Harris C. Roth, for magnetically operated valves, or it may be of any other suitable type operating in a similar manner.

A vertically extending pipe or conduit 26 is connected to the fuel supply line for the burner 13 between the pipe or conduit sections 15 and 16. The upper extremity of the pipe or conduit 26 is open to permit this conduit to function as a stand pipe to maintain uniform pressure upon the fuel line extending to the burner 13. The provision of this stand pipe equalizes irregularities of pressure due to the operation of the pump 18 or other causes, and thereby improves the operation of the burner 13.

A pressure relief valve 27 is disposed in a pipe or conduit line 28 which is connected to the section 17 of the fuel supply line for the burner 13, between the discharge side of the pump 18 and the electromagnetically operable valve 25. The valve 27 may be of any well-known type of pressure relief valve and is provided to relieve the pressure created in the fuel supply line by the pump 18 while this pump is running and the electromagnetically operable valve 25 is closed. The manner in which these conditions are caused to exist will be explained more fully hereinafter. The pipe or conduit 28 extends from the pressure relief valve 27 back to the source of fuel supply 20 and is thus adapted to return the liquid fuel delivered by the pump 18 to the source 20 when the valve 25 is closed. It will be understood that the valve 27 is closed at all times except when the pump 18 is operating and the valve 25 is closed, and that it is adapted to be opened only in response to the occurrence of an excessive fluid pressure in the section 17 of the fuel supply line.

A pipe or conduit 29 is connected to a suitable source of combustible gas and extends through an electromagnetically operable valve 30 to auxiliary burner 31 disposed within the combustion chamber 12 of the boiler 11. The valve 30 may be of a type similar to the valve 25, but adapted for the control of a flow of gas instead of liquid. The valve 30

may also be of considerably smaller size or capacity than the valve 25. The operation of the valve 30 is identical with that of the valve 25, it being normally closed and provided with an electromagnet, which, when energized, opens the valve and maintains it in open position as long as the energization of the electromagnet is maintained.

The valve 30 is preferably shunted by a by-pass 32 in which a manually adjustable valve 33 may be disposed. The by-pass 32 is regulated by means of the manually adjustable valve 33, or by a fixed initial adjustment when such a valve is not utilized, to permit a relatively slight constant flow of combustible gas to the auxiliary burner 31, at which point this gas is ignited to maintain a pilot flame in the combustion chamber while the valve 30 is closed.

When the valve 30 is open, the rate of supply of gas to the burner 31 is accordingly increased to expand the pilot flame within the combustion chamber 12 for purposes hereinafter set forth.

It may also be noted at this point that the by-pass 32 may be supplemented, if desired, by electrical ignition means such as a spark coil 34 and a spark gap 35 disposed in proximity to the auxiliary burner 31. In the event that such electrical ignition means are provided, they will be energized, as hereinafter set forth, concurrently with the opening of the valve 30, to ignite a relatively large gas flame in the combustion chamber 12 as soon as the combustible gas is supplied thereto. Under such circumstances it will be obvious that it is not necessary to maintain a pilot flame at the burner 31 while the valve 30 is closed, and hence, if desired, the by-pass 32 may be dispensed with. The question of using a pilot flame or a spark gap and electrical ignition means for the ignition of the gas at the burner 31 is one which may be determined by practical considerations and has no effect upon the operation of the present invention.

A temperature responsive device 36 is preferably disposed in the room, building, or other space to be heated by the boiler 11, and essentially comprises a switch 36^a that is adapted to be closed in response to a demand for heat in such space. In other words, the switch 36^a is closed in response to the existance of a predetermined temperature in the space to be heated, and is opened in response to the existance of a predetermined higher temperature in such space. The device 36 may be of any well-known type, such, for example, as that illustrated in Fig. 4 of the drawings of co-pending application Serial No. 151,704, filed November 30, 1926, by John C. Bogle, for electrically controlled heating systems. Hence, the structural details of the device 36 do not require illustration herein. The switch 36^a is diagrammatically illustrated as being of the mercury contactor type, according to approved modern practice, but any desired type of switch which will operate in the manner above set forth may be utilized.

A so-called "boiler control" device 37 is associated with the boiler 11 and comprises a switch 37^a that is adapted to remain in closed position as long as the boiler 11 is in normal operating condition. This switch is adapted to be opened, however, upon the occurrence of abnormal conditions in the boiler 11, such as excessive pressure or temperature. The device 37 may be of any well-known type, such, for example, as that illustrated in detail in Fig. 5 of the drawings of the above-mentioned co-pending application Serial No. 151,704, and hence the structural details of this device are not illustrated herein. As in the case of the temperature responsive device 36, the switch 37^a of the device 37 is illustrated as being of the mercury contactor type.

A combustion responsive device 38 comprises a bi-metallic or other thermostatic element 38^a that is suitably disposed within a stack 39 that is provided for conducting the gaseous products of combustion away from the combustion chamber 12. These gases are still at a relatively high temperature as they pass through the stack 39 past the thermostatic element 38^a, and therefore this thermostatic element is actuated in accordance with the conditions of combustion obtaining in the combustion chamber 12. If the burner 13 is in operation and normal combustion conditions are obtaining in the combustion chamber 12, the thermostatic element 38^a is actuated to open a switch 38^b, after first closing a switch 38^c, and to maintain these switches in these respective conditions as long as the normal conditions of combustion exist in the combustion chamber 12. When these normal combustion conditions are non-existent, the thermostatic element 38^a effects the closing of the switch 38^b and the opening of the switch 38^c for purposes hereinafter set forth. It is to be understood that the term "normal combustion conditions" as used herein, refers to combustion of liquid fuel in the burner 13, as the combustion of gas from the auxiliary burner 31 does not yield products of combustion in sufficient volume or at a high enough temperature to affect the thermostatic element 38^a.

The two switches 38^b and 38^c are embodied in the combustion responsive device 38 and are diagrammatically illustrated as being of the mercury contactor type. The details of construction of the device 38 do not constitute an essential part of the present invention, as any desired type of device which will operate in the manner described may be utilized. By way of example, however, reference may be had to Figs. 7, 8, and 9 of the

above-mentioned co-pending application Serial No. 151,704, in which a combustion-responsive device of a suitable type is illustrated in detail. In the said co-pending application, the device referred to is illustrated as comprising a single mercury contactor, or the like, having four electrodes therein, two of which are provided with a common electrical connection. In the present invention, two separate contactors, each comprising only two electrodes having no common electrical connection, are utilized, but the mechanical details of construction of the device may be the same as those of the device disclosed in the said co-pending application if desired. The switches 38^b and 38^c are so mounted that the actuation thereof in response to the heating of the thermostatic element 38^a causes the switch 38^c to be closed before the switch 38^b is opened. This so-called "overlapping" action is utilized for a purpose hereinafter set forth, and is in accordance with the invention of co-pending application Serial No. 234,340, filed November 19, 1927, by John C. Bogle, for electrical switch and control circuit therefor.

The remaining control apparatus of the present invention is shown herein as being mounted upon a common panel 40 for convenience in manufacture and installation, it being understood, however, that the mounting of the remaining devices about to be described may be varied as desired without affecting the present invention. One of the devices mounted on the panel 40 is an electrically-heated thermostatic device, which preferably comprises a bi-metallic strip 41 pivotally mounted at 42 and supported at a point displaced from the pivotal mounting 42 by an adjustable screw 43. An electrical heating element 44 is suitably associated with the bimetallic strip 41 to cause the right-hand extremity of said strip to be deflected downwardly in response to a predetermined electrical energization and resultant heating of the element 44. The said right-hand extremity of the strip 41 carries a switch 44^a of the mercury contactor type, this contactor being normally so tilted that the two contact members thereof are electrically connected by the body of mercury or other conducting fluid within the container of the switch.

The device is so adjusted that when the heating element 44 has been electrically energized for a predetermined interval of time, the bimetallic strip 41 is so deflected as to tilt the switch 44^a a sufficient distance to cause the body of mercury or other conducting fluid in said switch to move to the right-hand extremity of the container therefor. This extremity is extended downwardly to form a well into which the conducting fluid flows under these conditions. When the conducting fluid has flowed into this well, it will remain therein until the right-hand extremity of the strip 41 has been manually lifted a substantial distance above the normal position of this member corresponding to the de-energized condition of the heater 44. During such manual actuation of the strip 41 the same pivots about its mounting 42 and moves away from the adjusting screw 43 a slight distance. Upon manual release of the strip 41, it returns to the position illustrated in the drawing, the conducting fluid in the switch 44^a then having been returned to circuit-making engagement with the contact members of the switch 44^a. It will be understood that the panel 40 may be provided with a casing and cover and that the manipulation of the strip 41 to reclose the switch 44^a may be facilitated by the provision of a resetting handle or the like extending through a wall of the box or cover for the panel 40.

The details of construction of the switch 44^a and the actuating mechanism therefor are shown more or less diagrammatically, as such details do not form an essential part of the present invention. For a more detailed understanding of the structure of a suitable device of this character, reference may be had to Fig. 6 of the drawings of the above-mentioned co-pending application Serial No. 151,704, or to Figs. 1, 2, and 4 of the drawings of co-pending application Serial No. 235,147, filed November 23, 1927, by John C. Bogle, for electrical switches. The thermostatically-operated switch shown diagrammatically herein may be of the type disclosed in either of these co-pending aplications or of any other suitable type.

The panel 40 also carries a switching device comprising two solenoids 45 and 45′ which are adapted to control the operation of a switch 45^a. This switch is also shown as being of the mercury contactor type and comprising two contact members which are disengaged by a cooperating body of mercury or other conducting fluid when the solenoids 45 and 45′ are de-energized. These two solenoids are respectively provided with core members 45^b and 45^c, each of which is pivotally connected at its lower extremity to an armature member 45^d that is pivotally supported at 45^e on the panel 10. The electromagnet winding of the solenoid 45 has sufficient ampere turns and the core member 45^b is so disposed with respect thereto that energization of the solenoid 45 will result in the actuation of the armature member 45^d from the position shown in the drawing to a position in which the switch 45^a is so tilted that the mercury or other conducting fluid therein flows into circuit-making engagement with the contact members of this switch. The solenoid 45′, however, has an insufficient number of ampere turns to effect such actuation, but is adapted to maintain the armature member 45^d and switch 45^a in actuated position after they have been thus actuated by the so-

lenoid 45. Therefore, the solenoid 45 is designated as a "pull coil" and the solenoid 45' is designated as a "hold coil."

The switching device comprising the solenoids 45 and 45' and the switch 45ª are also shown in diagrammatic form herein as the structural details of this device do not form an essential part of the present invention. For an accurate understanding of the structural details of a suitable device of this character, reference may be had to Fig. 12 of the drawings of the above-mentioned co-pending application Serial No. 151,704. The above-mentioned co-pending application Serial No. 235,147 also shows a device which functions in the same manner as that described herein, although the structural details of the device are of a different design. The device shown in the last-mentioned copending application may likewise be utilized in the system of the present invention if desired, or any other suitable device capable of operating in the same manner may be so used, regardless of the type of switch and details of construction of the actuating means therefor.

A time delay device preferably comprising a bimetallic strip 46 is also mounted upon the panel 40 and is provided with an electrical heating element 47 and contact members 47ª. When the heating element 47 is deenergized, the strip 46 occupies the position illustrated in the drawing, in which the contact members 47ª are separated. When the heating element 47 has been energized for a predetermined interval of time, the right-hand extremity of the strip 46 is deflected downwardly a sufficient distance to effect engagement between the contact members 47ª for a purpose hereinafter set forth. It will be readily understood that the air break contact members of this device may be replaced with a mercury contactor or other suitable form of switch, the selection of the type of switch to be utilized depending upon the type of installation or other practical considerations.

Electrical energy for operating the system of the present invention may be derived from any suitable source to which supply conductors 48 and 49 are properly connected. The supply conductor 48 extends to one terminal of the switch 44ª, the other terminal of which is connected through a conductor 50 to one terminal of the switch 45ª and through a conductor 51 to one terminal of the switch 36ª. The other terminal of the switch 45ª is connected through a conductor 52 to one terminal of the motor 22 and through a conductor 53 to one terminal of the switch 38ᶜ. The other terminal of the motor 22 is connected to the supply conductor 49, thus completing the circuit of said motor. The other terminal of the switch 38ᶜ is connected through a conductor 54 to one terminal of the hold coil 45', the other terminal of which is connected to the supply conductor 49 to complete the circuit of the said coil.

As above stated, the supply conductor 48 is connected through the switch 44ª and the conductor 51 to one terminal of the switch 36ª of the temperature responsive device 36. The other terminal of this switch 36ª is connected through a conductor 55 to one terminal of the switch 37ª of the boiler device 37. The other terminal of the switch 37ª is connected through a conductor 56 to one terminal of the electromagnet of the valve 25, the other terminal of which electromagnet is connected to the supply conductor 49. The last-mentioned terminal of the switch 37ª is also connected, through a conductor 57, to one terminal of the switch 38ᵇ, the other terminal of which is connected through a conductor 58 to one terminal of the electromagnet of the valve 30, the other terminal of this electromagnet being connected to the supply conductor 49. The conductor 58 is also extended to make connection with the bimetallic strip 46 and to one terminal of the heating element 47 for said bimetallic strip, the other terminal of the heating element 47 being connected to the supply conductor 49.

Since one of the contact members 47ª is mounted on the right-hand extremity of the bimetallic strip 46, this contact member is in electrical connection with the conductor 58 which is connected to the opposite extremity of said bimetallic strip. The other one of the contact members 47ª, which is a fixed contact member, is connected through a conductor 59 to one terminal of the heating element 44 for the bimetallic strip 41. The other terminal of heating element 44 is connected through a conductor 60 to one terminal of the pull coil 45, the other terminal of which is connected to the supply conductor 49, thus completing the energizing circuit for the heating element 44 and the pull coil 45.

When electrical ignition is to be utilized, one of the primary terminals of the ignition device 34 will be connected through a conductor 61 to the terminal of the switch 38ᵇ to which the conductor 58 is connected. The other primary terminal of the device 34 will be connected through a conductor 62 to the supply conductor 49, and the secondary terminals of the device 34 will be connected through conductors 63 and 64 to the opposite sides of the spark gap 35, to establish an igniting arc across this gap when the primary circuit of the ignition device 34 is energized.

The circuit connections of the system embodying the present invention and the operation of the apparatus embodied in said system will be better understood by reference to Fig. 2 of the drawing, in which like reference characters are applied to the schematic representations of the corresponding devices

shown in Fig. 1. Upon reference to Fig. 2, it will be seen that the motor 22 is connected between the supply conductors 48 and 49 in series with the switches 44^a and 45^a. The hold coil 45′ for the switch 45^a is connected in series with the switch 38^c and in a circuit paralleling the motor 22. One terminal of the electromagnet of the valve 25 is connected to the supply conductor 48 through the switches 44^a, 36^a and 37^a, and the other terminal of this electromagnet is connected directly to the supply conductor 49. A branch circuit paralleling the electromagnet of the valve 25 is derived through the conductor 57 and the switch 38^b and supplies energy to the electromagnet of the valve 30, the primary side of the ignition device 34 (when this device is used), and the heating element 47, which controls the contact members 47^a through the bimetallic strip 46. These three devices 30, 34, and 47 are directly connected in parallel relation to each other in this branch circuit, one terminal of each of these devices being connected to the supply conductor 49. A circuit comprising the switch 47^a, the conductor 59, the heating element 44, the conductor 60, and the pull coil 45, all connected in series relation to each other, is also connected in parallel relation to the devices 30, 34, and 47.

It will be seen that all of the electrical apparatus of the system derives energy through the switch 44^a, which is normally closed. The operation of the system is initiated by closure of the switch 36^a in response to a demand for heat in the space to be heated, it being understood, however, that this switch 36^a may be replaced, if desired, with a manually operable switch or other desired type of switch. When this switch 36^a is closed, the electromagnet of the valve 25 is energized, since the switch 37^a, which is connected in series with the switch 36^a, is closed except under abnormal boiler conditions, as heretofore explained. The devices 30, 34 (when used), and 47 are also immediately energized upon closure of the switch 36^a, since the switch 38^b is closed because the thermostatic member 38^a is cold during the period of inactivity of the burner 13.

Upon the energization of the electromagnet of the fuel supply valve 25, this valve is opened preparatory to the starting of the motor 22 and fuel pump 18 to supply fuel to the burner 13. This supply of fuel is not immediately initiated, however, as will presently appear. The energization of the electromagnet of the gas valve 30 increases the rate of supply of combustible gas to the auxiliary burner 31 in the combustion chamber and results in the expansion of the gas pilot flame normally burning in this auxiliary burner by reason of the opening in the by-pass 32 when said by-pass is utilized. If the electrical ignition device 34 and spark gap 35 are utilized in place of the by-pass 32, the supply of gas to the auxiliary burner 31 is ignited by the spark at the gap 35, which is created immediately upon the energization of the ignition device 34, concurrently with the opening of the gas valve 30 in response to the energization of the electro-magnet thereof.

The gas flame from the auxiliary burner 31, which is expanded by opening the valve 30 when the by-pass 32 is utilized and initiated by opening the valve 30 when electrical ignition is utilized, is of sufficient size and intensity to heat the combustion chamber 12 and the burner 13 to a relatively high temperature in a relatively short interval of time, without, however, materially affecting the thermostatic element 38^a. This heating of the combustion chamber and fuel burner prior to the supplying of liquid fuel thereto places the burner in condition for immediate operation upon the supply of liquid fuel thereto and eliminates the danger of failure of ignition which would be likely to result from the supplying of liquid fuel to a cold burner and combustion chamber. Such a failure of ignition in systems of the prior art frequently results in the fouling of the burner nozzles and in the accumulation of liquid fuel in the bottom of the combustion chamber. The danger of explosions and inoperativeness of the burner by reason of these conditions is entirely eliminated in the system of the present invention by the preliminary heating of the burner and combustion chamber by the gas flame.

During the period while the combustion chamber 12 and the fuel burner 13 are being heated by the gas flame from the auxiliary burner 31, the electrical heating element 47 is continuously energized. After this energization has continued for a certain interval of time, which may be determined by calibration and adjustment of the bimetallic strip 46 and contact members 47^a, the strip 46 is deflected sufficiently by the heat created by the electrical heating element 47 to effect circuit-making contact between the contact members 47^a. When such contact is made, a series circuit comprising the heating element 44 and the pull coil 45 is connected in parallel relation to the devices 30, 34, and 47 to be energized in similar manner. The energization of the pull coil 45 in this manner results in the actuation of the switch 45^a to closed position, thereby establishing the energizing circuit for the motor 22. The motor thereupon starts to operate to cause the pump 18 to supply liquid fuel from the source 20 to the burner 13 and to cause the blower 23 to supply air to the burner for the combustion of the liquid fuel. As the liquid fuel and air are supplied to the burner, combustion is immediately established by the gas flame from the auxiliary burner 31, and the normal operation of the heating system is thus initiated.

As soon as combustion is thus established, the hot gases resulting therefrom are conducted away through the stack 39 past the thermostatic member 38ª of the combustion responsive device 38. The thermostatic member 38ª thereupon actuates the switches 38ᵇ and 38ᶜ to close the latter and then to open the former. The opening of the switch 38ᵇ interrupts the energizing circuits for the devices 30, 34, 47, 44, and 45, the energization of these devices not being required after the normal operation of the heating system is initiated.

The closing of the switch 38ᶜ, which, as above described, precedes the opening of the switch 38ᵇ, connects the hold coil 45′ in parallel relation to the motor 22 and thus establishes the energizing circuit for the hold coil, which circuit is maintained as long as the burner 13 is operating. The energization of the hold coil 45′ causes the switch 45ª to be maintained closed, thereby maintaining energization of the motor 22 and of the hold coil 45′. It will be observed that the overlapping action of the device 38, inclosing the switch 38ᶜ before opening the switch 38ᵇ, is necessary in order that the hold coil 45′ will be energized before the pull coil 45 is de-energized, thus insuring that the switch 45ª is continuously maintained in its closed position.

In the event that combustion is not properly established in the combustion chamber 12 within a reasonable interval of time after the pump 18 starts to supply fuel to the burner 13, the switch 38ᵇ remains in its closed position for an abnormal length of time, during which time the heating element 44 is continuously energized. After a predetermined period of such energization the bimetallic strip 41 is sufficiently deflected to effect opening of the switch 44ª, which can be reclosed only by manual operation, as hereinbefore described. The opening of the switch 44ª de-energizes all of the electrical apparatus of the control system, as will be readily apparent upon referring to Fig. 2 of the drawing.

Since manual reclosing of the switch 44ª is prerequisite to the restoring of the control system to operative condition, it is necessary that someone attend to this matter personally, at which time a proper inspection may be made to determine the cause of the failure of combustion. The fact that the system failed to establish combustion within the proper interval of time will be shown by the fact that the body of mercury or other conducting fluid in the switch 44ª will have flowed into the well at the right-hand extremity of the container of this switch, where it is visible through the glass walls of the container.

In the normal operation of the system, however, and particularly in view of the fact that the combustion chamber is thoroughly heated by the gas flame from the auxiliary burner 31 before fuel is supplied to the burner 13, the proper combustion conditions will be established in much less time than that required for the described operation of the switch 44ª, and this switch will always remain in its closed position. The provision of this additional safety feature, however, is desirable in view of modern standards of safety in systems of this character.

After the heating system has been in operation for a sufficient length of time to raise the temperature of the space to be heated to the desired degree, the temperature-responsive device 36 causes the switch 36ª thereof to be opened, thereby interrupting the energizing circuit for the electromagnet of the fuel supply valve 25. This valve is thereupon closed to terminate the flow of fuel from the pump 18 to the burner 13.

The opening of the switch 36ª does not affect the energizing circuit for the motor 22, however, and this motor continues in operation until combustion in the chamber 12 is terminated. During this time the blower 23 is maintained in operation and supplies air for the combustion of the liquid fuel remaining in the pipe or conduit sections 14, 15, 16, and the stand pipe 26, at the time the valve 25 is closed. This fuel remaining in the pipes continues to flow by gravity into the burner and combustion is maintained until this supply is entirely drained off. This feature provides an additional element of safety in the operation of the heating system by preventing the extinguishment of the burner flame before all of the fuel remaining in the pipes has been drained off, which extinguishment would result from the termination of operation of the blower 23 prior to the complete drainage of the fuel supply pipes. It will be seen, therefore, that combustion is terminated in the system of the present invention only by reason of the termination of fuel supply to the burner, which means that there is no fuel remaining in the supply pipes.

When combustion in the chamber 12 is terminated in the manner described, and all of the hot gases resulting therefrom have been conducted away through the stack 39, the thermostatic member 38ª is permitted to cool off, which results in the closing of the switch 38ᵇ and the opening of the switch 38ᶜ. The closing of the switch 38ᵇ establishes the connections for initiating the next cycle of operation of the system and the opening of the switch 38ᶜ interrupts the energizing circuit of the hold coil 45′, resulting in the opening of the switch 45ª by the action of gravity. When the switch 45ª is thus opened, the energizing circuit of the motor 22 is interrupted and the operation of the motor and the blower 23 is terminated.

During the interval between the closing of valve 25 in response to the opening of the temperature responsive switch 36ª and the time when the motor 22 is denergized in response to the opening of the switch 38ᶜ, the fuel supply pump 18 continues to be operated by the motor 22. Since the valve 25 is closed, the fuel suplied by the pump 18 cannot be delivered to the burner 13, and it is for this reason that the pressure relief valve 27 is provided. During the interval of time referred to, therefore, the relief valve 27 is opened by the excessive pressure in the section 17 of the fuel supply line and permits the liquid fuel that is pumped by the pump 18 to be returned to the source 20 through the pipe or conduit line 28.

From the foregoing description it will be seen that the present invention provides additional features of safety in the operation of heating systems of the character described and insures the occurrence of predetermined steps in the cycles of such operation in desired sequence.

It will be apparent to those skilled in the art that various changes and modifications may be made in the details of structure and circuit connections of the apparatus herein described without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed as new and is desired to secure by Letters Patent is:

1. In a heating system, in combination, a fuel burner, a combustion chamber therefor, a source of liquid fuel supply, a pump for supplying liquid fuel from said source to said burner, a blower for supplying air to said burner for combustion purposes, an electric motor for operating said pump and said blower, a normally closed valve for controlling the flow of fuel from said pump to said burner, an electromagnet for opening said normally closed valve, a switch responsive to the temperature of the space to be heated, means responsive to combustion conditions in said combustion chamber, a switch for controlling the energization of said electric motor, means for actuating said motor switch to closed position, and means for maintaining said motor switch in closed position, said space-temperature-responsive switch controlling said means for actuating said motor switch to closed position and also controlling the period of energization of said valve-opening electromagnet, and said combustion-condition-responsive means controlling said means for maintaining said motor switch in closed position.

2. In a heating system, in combination, a fuel burner, a combustion chamber therefor, a source of liquid fuel supply, a pump for supplying liquid fuel from said source to said burner, a blower for supplying air to said burner for combustion purposes, an electric motor for operating said pump and said blower, a normally closed valve for controlling the flow of fuel from said pump to said burner, an electromagnet for opening said normally closed valve, a switch responsive to the temperature of the space to be heated, means responsive to combustion conditions in said combustion chamber, a switch for controlling the energization of said electric motor, means for actuating said motor switch to closed position, and a hold coil for maintaining said motor switch in closed position, said space-temperature-responsive switch controlling said means for actuating said motor switch to closed position and also controlling the period of energization of said valve-opening electromagnet, and said combustion-condition-responsive means controlling said means for maintaining said motor switch in closed position and rendering said maintaining means ineffective only upon the termination of combustion in said combustion chamber.

3. In a heating system, in combination, a fuel burner, a combustion chamber therefor, a source of liquid fuel supply, a pump for supplying liquid fuel from said source to said burner, a blower for supplying air to said burner for combustion purposes, an electric motor for operating said pump and said blower, a normally closed valve for controlling the flow of fuel from said pump to said burner, an electromagnet for opening said normally closed valve, a switch responsive to the temperature of the space to be heated, means responsive to combustion conditions in said combustion chamber, a switch for controlling the energization of said electric motor, a pull coil for actuating said motor switch to closed position, and a hold coil for maintaining said motor switch in closed position, said space-temperature-responsive means controlling the energization of said pull coil and of said valve-opening electromagnet, and said combustion-condition-responsive means controlling the energization of said hold coil.

4. In a heating system, in combination, a fuel burner, a combustion chamber therefor, a source of liquid fuel supply, a pump for supplying liquid fuel from said source to said burner, a blower for supplying air to said burner for combustion purposes, an electric motor for operating said pump and said blower, a normally closed valve for controlling the flow of fuel from said pump to said burner, an electromagnet for opening said normally closed valve, a switch responsive to the temperature of the space to be heated, means responsive to combustion conditions in said combustion chamber, a switch for controlling the energization of said electric motor, a pull coil for actuating said motor switch to closed position, and a hold coil for maintaining said motor switch in closed po-

sition, said space-temperature-responsive means controlling the energization of said pull coil and of said valve-opening electromagnet, and said combustion-condition-responsive means controlling the energization of said hold coil and maintaining said hold coil energized independently of the operation of said space-temperature-responsive means until the termination of combustion in said combustion chamber.

5. In a heating system, in combination, a fuel burner, a combustion chamber therefor, a source of liquid fuel supply, a pump for supplying liquid fuel from said source to said burner, a blower for supplying air to said burner for combustion purposes, an electric motor for operating said pump and said blower, a normally closed valve for controlling the flow of fuel from said pump to said burner, means for relieving the pressure created by said pump while the same is operating and said normally closed valve is closed, an electromagnet for opening said normally closed valve, a switch responsive to the temperature of the space to be heated, means responsive to combustion conditions in said combustion chamber, a switch for controlling the energization of said electric motor, means for actuating said motor switch to closed position, and means for maintaining said motor switch in closed position, said space-temperature-responsive switch controlling said means for actuating said motor switch to closed position and also controlling the period of energization of said valve-opening electromagnet, and said combustion-condition-responsive means controlling said means for maintaining said motor switch in closed position.

6. In a heating system, in combination, a fuel burner, a combustion chamber therefor, a source of liquid fuel supply, a pump for supplying liquid fuel from said source to said burner, a blower for supplying air to said burner for combustion purposes, an electric motor for operating said pump and said blower, a normally closed valve for controlling the flow of fuel from said pump to said burner, means for relieving the pressure created by said pump while the same is operating and said normally closed valve is closed, an electromagnet for opening said normally closed valve, a switch responsive to the temperature of the space to be heated, means responsive to combustion conditions in said combustion chamber, a switch for controlling the energization of said electric motor, means for actuating said motor switch to closed position, and means for maintaining said motor switch in closed position, said space-temperature-responsive switch controlling said means for actuating said motor switch to closed position and also controlling the period of energization of said valve-opening electromagnet, and said combustion-condition-responsive means controlling said means for maintaining said motor switch in closed position and rendering said maintaining means ineffective only upon the termination of combustion in said combustion chamber.

7. In a heating system, in combination, a fuel burner, a combustion chamber therefor, a source of liquid fuel supply, a pump for supplying liquid fuel from said source to said burner, a blower for supplying air to said burner for combustion purposes, an electric motor for operating said pump and said blower, a normally closed valve for controlling the flow of fuel from said pump to said burner, a connection including a relief valve between the discharge side of said pump and said source of fuel supply for relieving the pressure created by said pump and for returning the fuel pumped thereby to said source while said pump is operating and said normally closed valve is closed, an electromagnet for opening said normally closed valve, a switch responsive to the temperature of the space to be heated, means responsive to combustion conditions in said combustion chamber, a switch for controlling the energization of said electric motor, a pull coil for actuating said motor switch to closed position, and a hold coil for maintaining said motor switch in closed position, said space-temperature-responsive means controlling the energization of said pull coil and of said valve-opening electro-magnet, and said combustion-condition-responsive means controlling the energization of said hold coil.

8. In a heating system, in combination, a fuel burner, a combustion chamber therefor, a source of liquid fuel supply, a pump for supplying liquid fuel from said source to said burner, a blower for supplying air to said burner for combustion purposes, an electric motor for operating said pump and said blower, a normally closed valve for controlling the flow of fuel from said pump to said burner, a connection including a relief valve between the discharge side of said pump and said source of fuel supply for relieving the pressure created by said pump and for returning the fuel pumped thereby to said source while said pump is operating and said normally closed valve is closed, an electromagnet for opening said normally closed valve, a switch responsive to the temperature of the space to be heated, means responsive to combustion conditions in said combustion chamber, a switch for controlling the energization of said electric motor, a pull coil for actuating said motor switch to closed position, and a hold coil for maintaining said motor switch in closed position, said space-temperature-responsive means controlling the energization of said pull coil and of said valve-opening electromagnet, and said combustion-condi-

tion-responsive means controlling the energization of said hold coil and maintaining said hold coil energized independently of the operation of said space-temperature-responsive means until the termination of combustion in said combustion chamber.

In witness whereof, I have hereunto subscribed my name.

JOHN C. BOGLE.