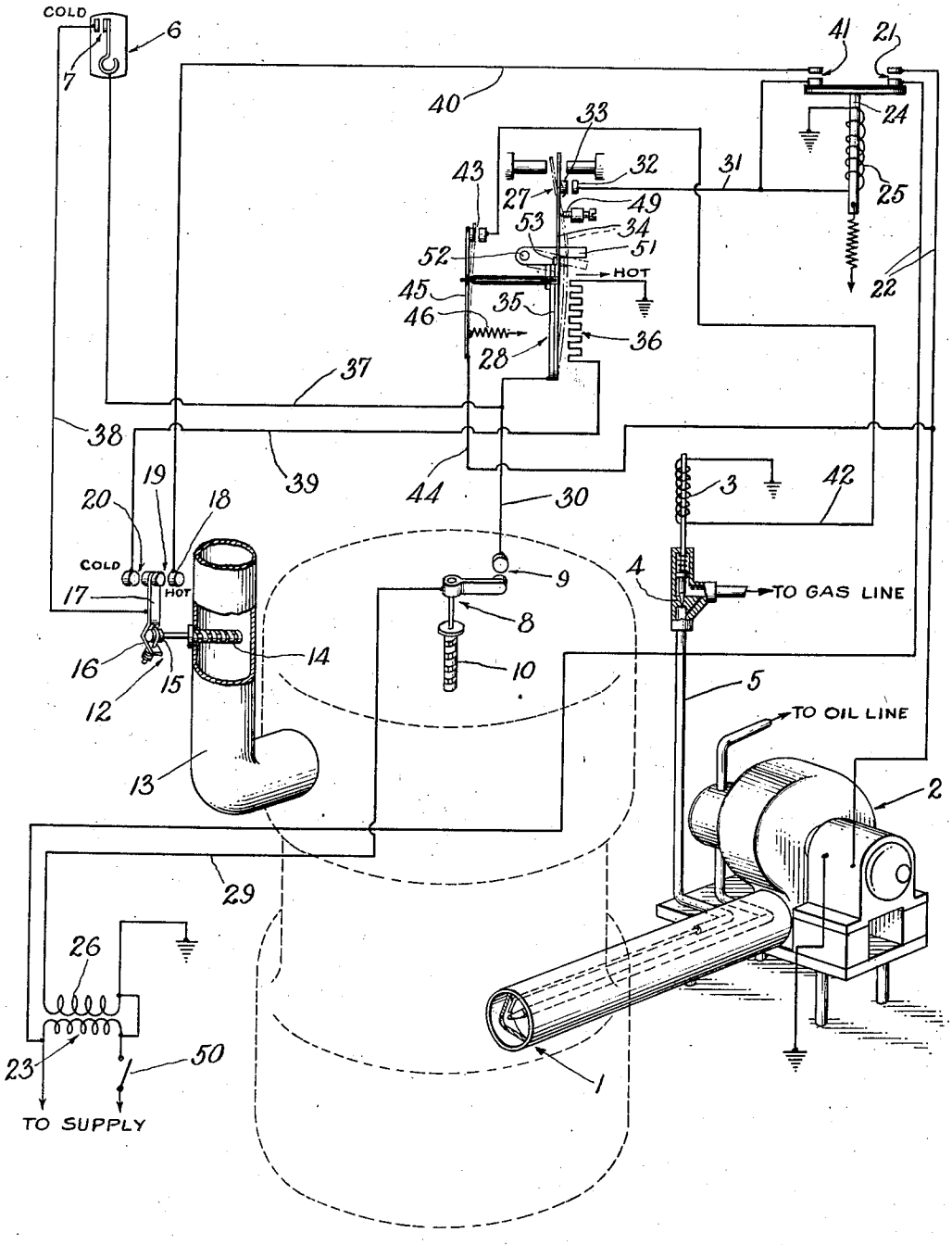
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SYSTEM OF CONTROL FOR LIQUID FUEL BURNERS

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SYSTEM OF CONTROL FOR LIQUID FUEL BURNERS

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This invention relates generally to the automatic control of liquid fuel burners and more particularly to an electric system such as is commonly employed in the control of oil burners used in domestic heating systems.

The general object is to provide a novel oil burner control system which is inexpensive to manufacture by reason of simplification and reduction in the number of parts required to effect all of the desired control functions; which provides for utmost safety in operation under all conditions of initial failure of ignition or failure of combustion after ignition; which is reliable and durable owing to the advantageous manner in which the control instrumentalities operate, and which requires a minimum of attention by virtue of provisions made for automatic recycling upon failure of combustion after initial ignition.

Another object is to provide an oil burner control system having an electro-thermal switching mechanism acting in a novel manner to perform numerous functions in addition to those performed in present day systems.

A more detailed object is to provide an oil burner control system in which the burner is started under the control of thermostatic means in the space to be heated acting through the medium of an electro-thermal switching mechanism and maintained in operation by the thermostatic means after the establishment of combustion and independently of the relay.

A further object is to provide an oil burning control system in which the safety device ordinarily used to detect the presence and absence of combustion is employed in a novel manner to perform new functions.

The invention also resides in the novel character of the means for controlling the device by which ignition of the fuel discharged from the burner is produced.

Other objects and advantages of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawing which shows the improved control system applied to a liquid fuel burner 1 of a conventional type adapted upon operation of an electric motor 2 to discharge atomized fuel into the combustion chamber of a furnace shown in dotted outline.

While electric spark or glow bar ignition may be employed for igniting the fuel sprayed into the fire-box, a gas pilot is shown herein for the sake of simplicity and adapted to be controlled electrically so that the system may be used interchangeably with gas flame or electric spark igniters. For this purpose, an electromagnet 3 is adapted when energized to open a valve 4 in the gas feed line 5 and thereby expand the flame normally burning at the end of the pipe.

The thermostatic means for controlling the system in acordance with heating requirements in the space to be heated may respond to temperature changes at a plurality of points in the space or, as in the present instance, at a single point. Herein a conventional thermostat 6 is illustrated having a switch 7 which is closed and opened respectively when the room temperature falls below or rises above that for which the thermostat is set. To limit the temperature to which the heating medium may be heated, a limit controller or boiler safety 8 is preferably used. In the form shown, this safety device comprises a switch 9 arranged to be opened and closed respectively when the temperature of the heating medium rises above and falls below a predetermined value determined by a thermostatic element 10 influenced by the temperature of the heating fluid.

The invention contemplates the use of a device for detecting different combustion conditions and in the form shown comprises a thermostat 12 arranged to detect the presence or absence of combustion as evidenced by a rise or fall in the temperature of the products of combustion passing through the furnace stack 13. The thermostat comprises a thermo-sensitive element 14 within the stack arranged to impart movements in opposite directions to a member 15 having a slip or friction connection with a member 16 rigid with a contact carrier 17 outside of the stack. When the temperature rises, the carrier moves in a direction to engage a contact 18 and thereby close a switch 19 after which a further rise in temperature causes slippage at the friction coupling. Conversely, a fall in temperature causes a switch 20 to be closed. It will be observed that the carrier 17 responds immediately to a rise or fall in temperature but that any desired delay in the closing of either switch upon a change in the stack temperature may be imposed by varying the spacing of the stationary contacts of the switches 19 and 20.

Operation of the burner motor 2 to produce a fuel spray in the combustion chamber is controlled by a switch 21 interposed in a conductor 22 leading to the motor from a high voltage source 23 of current. The switch 21 is controlled by the movement of the armature 24 of an electromagnet 25, being closed when the magnet is energized but held open normally, that is, when the burner is idle.

In order to minimize the burden on the sensitive switches by which the magnet is controlled, the latter is intended to be operated from a low voltage current source 26 formed by a transformer which may be of relatively low capacity. One terminal of the transformer secondary is connected to a terminal of the magnet winding as indicated by grounding on the drawing. Completion of the circuit through the magnet to initiate operation of the burner is governed in the present instance by the combined closure of the boiler safety switch 9 and a normally open switch 27 arranged to be actuated by an electro-thermal mechanism 28. The circuit extends from the current source 26 through a conductor 29, the switch 9, a conductor 30, the switch 27 and a conductor 31 to the magnet winding 25.

Preferably the switch 27 is of the single contact type having a stationary contact 32 and a movable contact 33, which, for a purpose to appear later, is carried on the end of a flexible arm 34 secured at its opposite end to an elongated bimetallic strip 35 constituting the actuating element of the thermal relay. Under the heat produced by an electric heating element 36 wound around or disposed in close proximity to the strip 35, the latter bends to the right as viewed in the drawing and shortly after the initial application of heat closes the switch 27. When the strip 35 is cool, the switch 27 is maintained open.

The application of current to the heater in the present system is dependent upon the coexistence of three conditions, namely, closure of the room thermostat switch 7, closure of the boiler safety switch 9 and the absence of combustion and cooling of the combustion chamber as evidenced by closure of the closed-when-cold switch 20 of the combustion safety. The circuit for the heater extends from the current source 26 through the conductor 29, switch 9, conductor 30, a conductor 37, room thermostat switch 7, a conductor 38, switch 20, a conductor 39 to the ungrounded side of the heater.

Means controlled by the combustion safety 12 is provided for maintaining energization of the magnet 25 independently of the position of the thermal element 35 after combustion has taken place properly. While it is contemplated that this means may be purely mechanical in its action, the means herein illustrated is in the form of an electrical conductor 40 interposed in parallel with the switch 27 between the conductors 30 and 31 and including in series relation a locking switch 41, the closed-when-hot switch 19 of the combustion safety, and the room thermostat switch 7. The switch 41 is arranged to be actuated by the armature of the magnet 25, being closed and open when the magnet is energized and deenergized respectively. With this arrangement, it will be observed that as an incident to the occurrence of proper combustion, the control of the system by the thermostat 6 will be withdrawn from the heater circuit by opening of the closed-when-cold stack switch 20 and transferred to the magnet circuit by closing of the closed-when-hot switch 19 whereby to maintain operation of the burner so long as the room thermostat and boiler safety continue to call for heat.

Another function of the electro-thermal mechanism 28 in the present system is to control the ignition means so as to render the latter active at least simultaneously with the starting of the burner motor and inactive after combustion has occurred. To this end, the winding 3 which controls the expansion gas pilot flame is included in a circuit leading through a conductor 42, a switch 43, a conductor 44, a conductor 22, and a motor switch 21 to one side of the high voltage current source 23. The movable contact of the switch 43 is carried upon an arm 45 urged by a light spring 46 into switch-closing position. The bimetallic strip 35, when cool, acts through the medium of a connection such as an insulating rod 47 to hold the switch 43 open. As the strip is heated, it moves away from a shoulder on the rod 47 and allows the switch 43 to close under the action of the spring 46 without placing any mechanical burden on the strip or interfering with the timing of its warping movement. While the switches 21 and 43 are arranged to act jointly in rendering the ignition device active, they act individually in rendering the same inactive so that the pilot flame may be contracted by cooling of the warp element 35, as is done in normal operation, or as an incident to stopping of the burner under abnormal conditions as will appear later.

It will be observed that the ignition control circuit above described operates on high voltage. This is particularly desirable where electric spark ignition is employed as the arrangement avoids the use of the relatively high capacity supply transformer which would be necessary if the spark ignition were operated from a low voltage circuit.

In addition to its functions of controlling the starting of the burner and the ignition circuit, the electro-thermal mechanism 28 serves as a slow-acting device to time the interruption of the initial energizing circuit for the magnet and thereby renders the burner ineffectual automatically after the lapse of a predetermined interval in the event that the quick-acting safety device, that is, the thermostat 12 does not detect the presence of combustion within such interval. For this purpose, the thermal relay is constructed to open the switch 27 upon continued heating of the strip 35 beyond the time normally required for combustion to occur, and the combustion safety to respond. A simple way of effecting this result is through the use of a stop 49 positioned to be engaged by the flexible arm 34 between the end of the strip 35 and the contact 33. Upon prolonged heating of the strip, the arm 34 strikes the stop 49 which forms a fulcrum about which the arm continues to swing as a lever finally assuming the position shown in dotted outline thereby opening the switch 27. This causes the magnet 25 to be deenergized for at this time the other branch of the magnet circuit is held open by the then open switch 19.

Normal operation

Assuming that the burner has been idle for a substantial length of time allowing the electro-thermal switch to cool and its parts to assume the positions shown in full lines on the drawing, the switch 20 of the combustion safety and the boiler safety switch 9 will be closed. All of the other switches will be open. Now when the room thermostat calls for heat and thereby closes the switch 7, a low voltage circuit for the resistance element 36 is completed through the boiler safety switch 9, the thermostat switch 7 and the closed-when-cold combustion safety switch 20. The flow of current in the element 36 produces heat which causes the strip 35 to warp to the right eventually causing the ignition control switch 43 to be closed and thereafter closing the switch 27. Closure of the latter completes the starting circuit for the magnet 25

which latter circuit also includes the then closed boiler safety switch 9. The resulting movement of the magnet armature closes the locking circuit switch 41 and the motor switch 21 which latter starts the motor and also completes the ignition control circuit thereby causing the ignition device to be rendered active and fuel to be sprayed into the fire-box.

If combustion occurs properly, the temperature in the stack 13 will rise and in response thereto the movable contact of the combustion safety will move in a direction to open the switch 20 and close the switch 19 thereby withdrawing the room thermostat from the control of the heater circuit and transferring the thermostat control to the maintaining circuit for the magnet. The latter circuit becomes completed upon closure of the closed-when-hot switch 19 and is thereafter maintained by the thermostat independently of the thermal relay so long as heat is required in the space to be heated. The interval between opening of the switch 20 and closing of the switch 19 is so short that the maintaining circuit will become closed before the element 35 has cooled sufficiently to open the switch 27. As the strip 35 continues to cool, the switch 27 eventually opens and the switch 43 is opened against the action of the spring 46 thereby rendering the ignition device inactive.

Operation of the burner then continues until the temperature requirements in the room are satisfied or the heating medium becomes overheated. Opening of the boiler safety or room thermostat switches interrupts the maintaining circuit of the magnet and upon deenergization of the latter, the burner motor switch 21 and the locking switch 41 are opened terminating the burner operation and preventing reenergization of the magnet 25 except in the regular way above described.

Operation in case of initial failure of combustion

Assume now that the burner motor has been started and the ignition device rendered active under the control of the room thermostat as above described but that the oil spray does not ignite. In such a case, the temperature in the stack 13 does not rise and the quick-acting device, that is, the stack thermostat 12 does not open its switch 20 within the time during which combustion normally occurs. Thus, the slow-acting device, that is, the warp element 35 continues to bend due to the prolonged application of current to the resistance 36 and eventually the arm 34 strikes the stop 49. Continued warping of the element bends the arm around the stop carrying the movable contact 33 away from the contact 32. The switch 27 is thereby opened breaking the circuit of the magnet 25 and deenergization of the latter interrupts the operation of the burner motor and the ignition device by opening the switch 21. In the present embodiment, current continues to flow through the heater 36 after the burner has been stopped, thereby maintaining the strip 35 in warped condition.

To restore the burner, manual restoration of normal conditions in the system is required. This is accomplished by remedying the cause of the ignition failure and then opening the line switch 50 and thereby interrupting the current supply to the heater 36 for an interval sufficiently long to enable the warp element 36 to cool off. Then when the switch 51 is again closed, the burner will start in the normal way above described.

In the event that there is a prolonged voltage failure after the system has been rendered inoperative by ignition failure as above described, it will be observed that the warp element 35 would become cool and the system would attempt to recycle automatically upon restoration of the voltage without the cause of ignition failure having been removed. To prevent such recycling, a latch 51 pivoted at 52 normally resting upon the end of the warp element is provided. In the event that the element bends far enough to open the switch 27 as above described, the latch falls and a shoulder 53 drops in behind the strip 35 thereby preventing return of the strip to normal position in the event of a voltage failure. To effect normal recycling as above described, it will be apparent that the latch 51 must be raised while the line switch 50 is held open. If desired, this may be effected by a common operating member for the latch and switch arranged to lift the latch whenever the switch 51 is opened.

Operation upon failure of combustion after ignition

After combustion has once taken place in the normal way above described, the flame may become extinguished by momentary or prolonged current failure, by a slug of foreign material in the oil feed drive, or for various other causes. Ordinarily these conditions are remedied automatically and thereafter it is desirable to recycle the control apparatus automatically, but not until all vapors that may accumulate in the combustion chamber as a result of flame failure have been cleared out by the natural draft in the furnace.

First considering failure of the current supply in which event the magnet 25 becomes deenergized and the motor 2 stopped. If the current interruption is of sufficient duration to enable the combustion thermostat 12 to cool and close the switch 20, restarting of the burner will take place in the normal way upon restoration of the current supply. But if the voltage failure has been only momentary, closure of the heater circuit to effect automatic recycling will be delayed until a predetermined degree of cooling has taken place in the combustion chamber as indicated by closure of the switch 20. Thus, in the case of either momentary or prolonged current failure, recycling must take place and the burner started in the normal way.

If the flame failure, due to some cause other than interruption of the current supply, is only momentary, the magnet may not become deenergized. If, however, the flame interruption is prolonged or the oil spray is not ignited by the heat of the fire-box after a momentary flame failure, the burner will be stopped within a short interval of time by cooling of the combustion chamber sufficiently to open the switch 19. The delay between flame failure and shutting down of the burner is thereby reduced to a minimum. But an interval of substantial length must elapse before actual recycling takes place. Thus, the stack thermostat 12 must cool sufficiently to close its switch 20 whereupon the heater 36 is started, provided the room thermostat and boiler safety are still calling for heat. By the time that the combustion thermostat has cooled and the element 35 heated to the degree required to render the ignition device active, sufficient time will have elapsed to enable any oil vapors that may have accumulated in the fire-box to be cleared out by natural circulation. Any danger of ex-

plosions by ignition of accumulated vapors is thereby effectually eliminated in the present system.

From the foregoing, it will be apparent that the present system performs all of the automatic functions and possesses all of the safeguards which are desired in an oil burner control and yet employs only one magnet and a simple thermal relay in addition to the usual room, combustion and boiler safety thermostats and a small capacity transformer. The cost of manufacture is therefore materially less than with prior systems.

I claim as my invention:

1. In combination with a heating system having a furnace heated by a liquid fuel burner driven by an electric motor, a control circuit including said motor, a switch in said circuit adapted when closed to maintain operation of said motor, an electromagnet arranged to close and open said switch when energized and deenergized respectively, an electro-thermal switch having an electric heater and a thermal element operating a switch to closed and opened positions upon heating and cooling of said heater, a circuit for said magnet including said thermal switch, a room thermostat having a switch which is closed when the temperature in the space to be heated falls below a predetermined value, a circuit for said heater in parallel with said thermal switch and including said thermostat switch, a maintaining circuit for said magnet in parallel with said thermal switch and including in series relation said thermostat switch and a holding switch adapted to be closed when said magnet is energized, a device responsive to combustion conditions in said furnace, a first switch in said heater circuit controlled by said device and arranged to be closed in the absence of and open in the presence of combustion, and a second switch controlled by said device and arranged to be closed in the presence of and open in the absence of combustion, said last mentioned switch being in said maintaining circuit with said holding switch and room thermostat switch.

2. In combination with a heating system having a furnace heated by a liquid fuel burner driven by an electric motor, a control circuit including said motor, an electromagnetic switch adapted when energized to maintain operation of said motor, a thermostatic switch responsive to temperature changes in the space to be heated, a slow-acting device operable when energized to cause energization of said electromagnet and subsequently to deenergize the electromagnet, and switching mechanism responsive to combustion conditions in said furnace and acting jointly with said thermostatic switch in the absence of combustion to control the energization of said slow-acting device and in the event of successful ignition of the fuel to assume control and maintain energization of said electromagnet independently of said slow-acting device.

3. In combination with a fluid fuel burner having an electrically actuated means controlling fuel feed, a control system including in circuit said fuel feed controlling means, an electrical switching mechanism operable when energized to close the circuit to the fuel feed control means, a slow acting switching device operable when energized to cause energization of said electrical switching mechanism and to cause subsequent deenergization of said electrical switching mechanism, a main switch controlling energization of said slow acting device, and switching mechanism responsive to combustion conditions in said furnace and acting jointly with said main switch in the absence of combustion to control the energization of said slow-acting device and in the event of successful ignition of the fuel to assume control and maintain energization of said electrical switching mechanism independently of said slow-acting device.

4. In combination with a fluid fuel burner having an electrically actuated means controlling fuel feed and an igniter, a control system including in circuit said fuel feed controlling means, an electrical switching mechanism operable when energized to close the circuit to the fuel feed control means, a slow acting switching device operable when energized to cause energization of said electrical switching mechanism and to cause subsequent deenergization of said electrical switching mechanism, a main switch controlling energization of said slow acting device, switching mechanism responsive to combustion conditions in said furnace and acting jointly with said main switch in the absence of combustion to control the energization of said slow-acting device and in the event of successful ignition of the fuel to assume control and maintain energization of said electrical switching mechanism independently of said slow-acting device, and means responsive to the energization and deenergization of said slow-acting device to render said igniter operative and inoperative respectively.

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