CHAPTER 18

Burner Automatic Control

Were it not for automatic control there would be no domestic oil burners or very few as one might as well shovel coal as to spend considerable time in the cellar adjusting the output of the burner to synchronize with the changes in heating load.

Ques. What is automatic control?

Ans. An automatic system which starts the burner and stops the burner as governed by changes in temperature in the room or rooms to be heated.

Basic Principles of Automatic Control.—In order to understand the principles upon which the automatic control equipment is based, the following is given, relating to a very simple system which is *basic* of most of the systems now in use.

The system here presented is progressively built up, illustrated with diagrams that anybody can understand.

Ques. How many circuits are required for a simple control system?

Ans. Three.

Ques. What names may be given to them based upon their function?

Ans. Circuit No. 1.—Motor circuit; **Circuit No. 2.**—thermostatic time switch circuit; **Circuit No. 3**—stack switch or primary control, also called combustion safety control and what not.

Ques. Describe the power motor circuit No. 1.

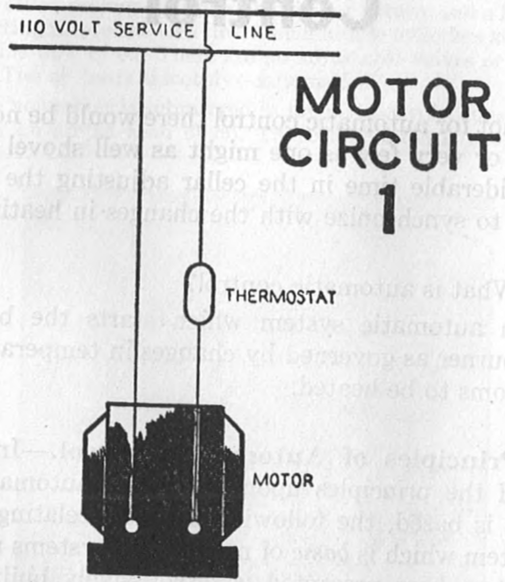


Fig. 1—Automatic control power motor circuit No. 1. The **motor circuit.**

Ans. Current for operating the motor is taken from the house power lines. One terminal of the motor is connected direct to one of the power wires. In the other wire to motor is placed a thermostat as in fig. 1.

Ques. What is a thermostat?

Ans. An instrument which responds to changes of temperature and which directly or indirectly controls the source of heat.

Ques. What happens when the temperature of the room where the thermostat is located becomes too cold?

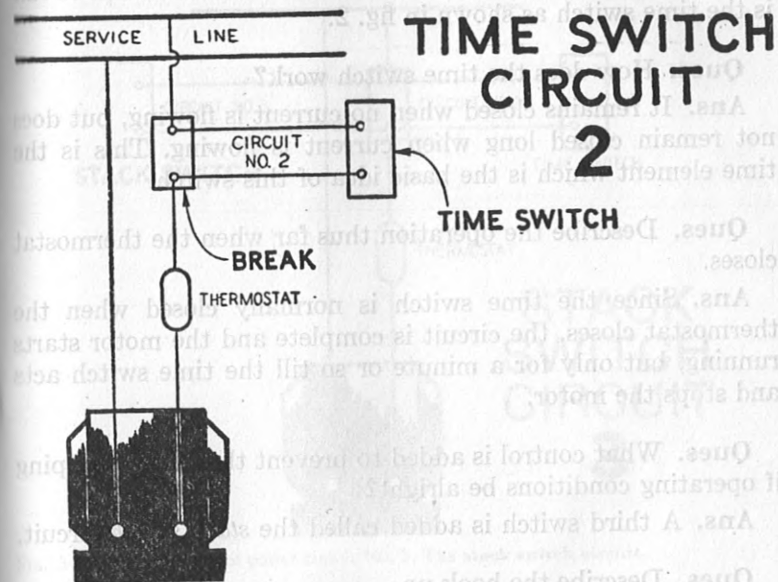


Fig. 2—Automatic control power circuit No. 2. The **time switch circuit.**

Ans. The thermostat closes the circuit which starts the motor, which in turn operates the fan and fuel pump.

Ques. What is lacking in this one circuit hook up?

Ans. No means is provided for igniting the fuel, and no control to act in case of faulty operation.

Ques. What is the next circuit to be connected?

Ans. No. 2. Circuit, that is, the thermostatic time switch circuit.

Ques. Describe the hook up.

Ans. One line of the motor circuit is cut, forming a break or gap; across this gap Circuit No. 2 is connected. In this circuit is the time switch as shown in fig. 2.

Ques. How does the time switch work?

Ans. It remains closed when no current is flowing, but does not remain closed long when current is flowing. This is the time element which is the basic idea of this switch.

Ques. Describe the operation thus far when the thermostat closes.

Ans. Since the time switch is normally closed when the thermostat closes, the circuit is complete and the motor starts running, but only for a minute or so till the time switch acts and stops the motor.

Ques. What control is added to prevent the motor stopping if operating conditions be alright?

Ans. A third switch is added called the *stack switch* circuit.

Ques. Describe the hook up.

Ans. As shown in fig. 3, the third circuit which includes the stack switch, is connected to the two terminals of the break.

Ques. How does it work?

Ans. The primary purpose of the stack switch is to shut off the oil supply to the burner if it fail to ignite. Evidently if, during the interval the time switch allows the motor to run,

the fuel will be ignited, the stack will become warm which will cause the stack switch to close and maintain operation even after the time switch opens. Again if the fuel do not ignite, the stack will be cold and the stack switch will remain open with result that as soon as the time switch opens, the motor will stop.

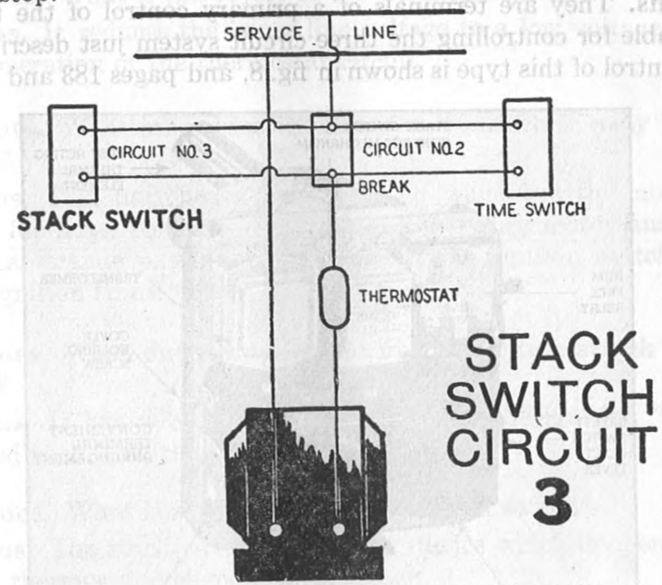


FIG. 3—Automatic control power circuit No. 3. The **stack switch circuit.**

The Primary Control

1. 2. 3. 4. W. R. B

By definition, the primary control is: *The instrument or assembly of electrical devices which actually starts the burner and stops it in response to signals from the room thermostat.*

Ques. Of what does the primary control consist?

Ans. It consists of several electrical switches connected together in such a way that each part of the burner operates at the right moment.

Ques. What are the figures and letters **1.2.3.4. W.R.B.?**

Ans. They are terminals of a primary control of the type suitable for controlling the three circuit system just described. A control of this type is shown in fig. 8, and pages 183 and 184.

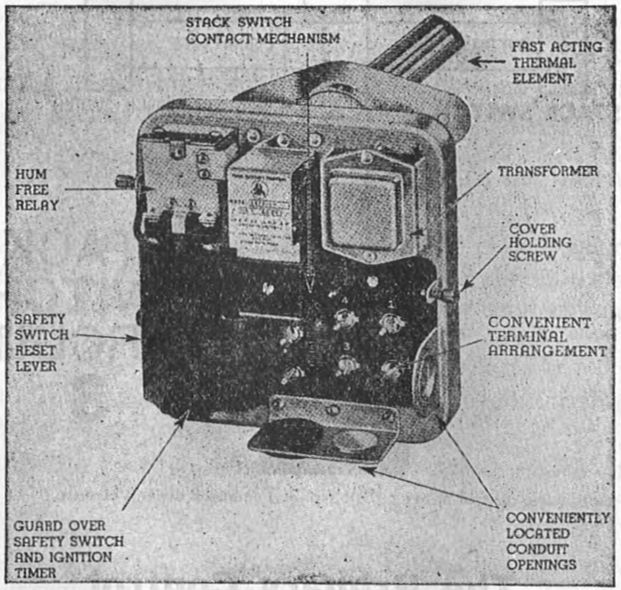


Fig. 4—Series 5540 intermittent ignition primary control. View with cover removed showing parts.

Primary Control Elements.—The various electrical devices which make up the type master control shown in fig. 4 consist of:

1. Transformer relay.
2. Ignition switch.
3. Stack switch.
4. Safety warp switch.

Ques. What is the object of the transformer relay?

Ans. It reduces the house line voltage to a low voltage for the operation of the thermostat circuit.

Ques. What other function does the transformer relay perform?

Ans. This unit has a switch which when the thermostat calls for heat, passes current to the oil burner motor and at the same time passes current through the ignition switch to the ignition transformer.

Ques. What duty is performed by the ignition switch and why?

Ans. It has a heating coil which *limits* the ignition "on" period each time the burner starts.

Ques. What is accomplished by the stack switch?

Ans. The stack switch is a safety device which is operated by a thermostatic element in the stack.

Ques. How does the stack switch work?

Ans. If the temperature in the stack fail to rise within a few seconds after the burner starts, the contacts remain closed, or if the temperature drop after the burner has started, the stack switch closes. This permits operation of the safety warp switch.

Ques. What is the safety warp switch and what does it do?

Ans. This is a heating coil with a contact attached to a

PRIMARY CONTROL CIRCUITS

Heavy Lines, 110 Volts. Light Lines, Low Voltage.

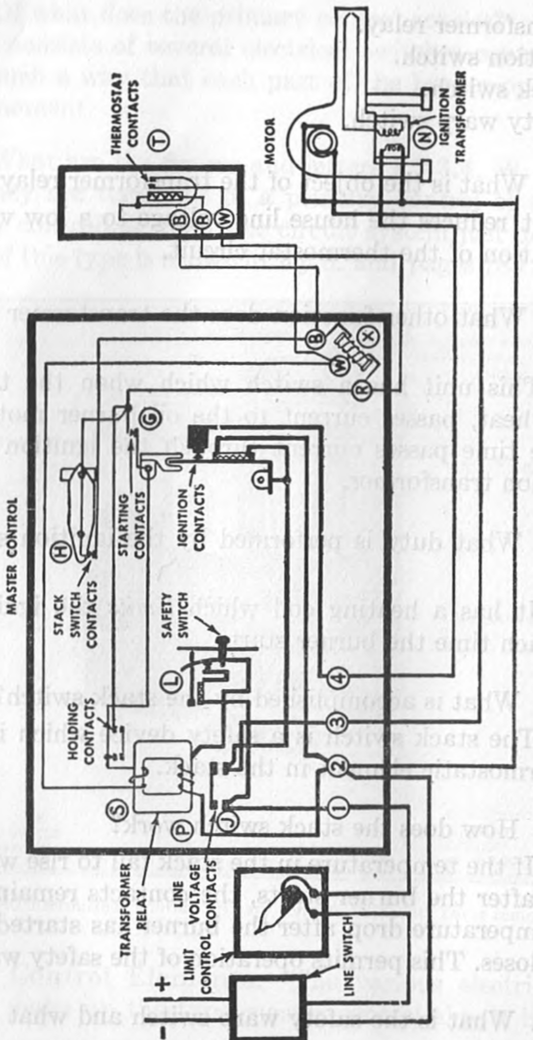


FIG. 5—Circuit diagrams for master control shown on page 183; R, W, B, red, white and blue terminals; 1, line voltage hot; 2, line voltage ground; 3, line voltage hot to burner motor; 4, line voltage hot to ignition transformer; G, starting contacts; H, stack switch; J, line voltage contacts; L, safety warp switch; N, ignition transformer; P, primary winding of relay transformer; S, secondary winding of relay transformer; T, thermostat; X, resistor.

thermostatic bi-metal strip which receives heat from the coil and opens a circuit, locking the burner in "off" position in the event of flame failure or no fire at the start of the burner period.

Ques. What do they call this locking of the burner in the off position?

Ans. They call it "warped out".

Primary Control Sequence of Operation.—The various operations performed by the primary control may be described under these headings:

1. When the thermostat calls for heat.
2. After the burner starts.
3. The burner during normal operation.
4. After the burner stops.
5. Recycling.
6. Flame failure.

When the Thermostat Calls for Heat.—When the room thermostat calls for heat and closes its contacts **T** as shown in the diagram fig. 5.

This completes the low voltage circuit and current flows from the secondary winding **S**, of the combination transformer relay, through the white thermostat contact **W**, to the blue contact **B**, and stack switch contacts **H**, and starting switch contacts **G**, back to the other side of the transformer secondary **S**.

Ques. What happens when the thermostat closes its contacts **T**?

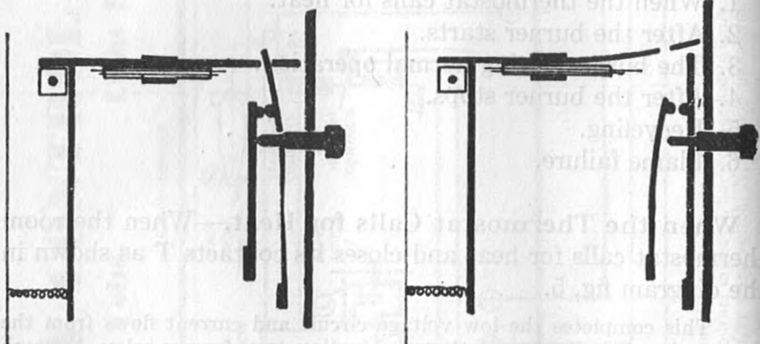
Ans. This action draws more current through the primary winding **P**, of the transformer relay which operates and closes the line voltage contacts **J**.

Line current at 110 volts then flows from the high or "hot" side of the line, through the limit control terminal 1, contacts **J**, terminal 3, oil burner motor, and back to terminal 2, where it is connected to the low or ground side of the incoming line.

Ques. What happens when the line voltage contacts J, close?

Ans. Current immediately flows through the ignition switch contacts, terminal 4, the primary (110 volt) side of the ignition transformer N, and back to the ground side of the line.

Ques. What does the ignition transformer now do?



FIGS. 6 and 7.—Diagrams of safety switch in *running* position and "warped out."

Ans. It steps up the 110 volts to approximately 10,000 volts and this is fed directly to the electrodes of the burner.

Hence, as soon as the oil burner motor starts to deliver oil to the nozzle, a spark is available at the electrodes to ignite this oil.

After the Burner Starts.— As the hot gases from the burning flame rise in the stack, they heat the bi-metallic ele-

ment in the stack switch and cause a small drive shaft to open contacts H.

This generally takes about 30 to 35 seconds. When H, opens, the low voltage circuit is shunted through a resistance X, which reduces the low voltage secondary current. This in turn reduces the line voltage current sufficiently in the transformer primary P, to prevent the safety switch L, warping out, but the current is still strong enough to hold the transformer relay closed.

Ques. What is the result, if for any reason, combustion does not take place?

Ans. The stack switch will not be opened and the current drawn by the transformer secondary will not be reduced by the resistor X.

Heat will be generated in the element of the safety switch L, and in about 90 seconds this will warp out and remain locked out. This interrupts the 110 volt circuit, causes the transformer relay to release and stops the motor and ignition.

Ques. What do they call this position of the master control?

Ans. The master control is said to be on "safety" or "*warped out.*"

Ques. What must be done to restore the master control to the normal starting position?

Ans. The reset button must be pushed in by hand.

Ques. What is the object of this feature?

Ans. It prevents automatic and repeated attempts to start until the trouble has been rectified.

The Burner During Normal Operation.—As the burner continues to operate, the ignition switch opens due to the influence of its heating coil and this cuts off the ignition. Then the fork shaped bakelite arm opens contacts G, and breaks the low voltage starting circuit.

This puts the burner in its normal operating condition and will continue to operate until the room thermostat is satisfied, or until it is turned off by the limit control.

After the Burner Stops.—When the room temperature reaches the desired temperature (corresponding to the setting) the thermostat contacts open and break the low voltage control circuit.

This immediately causes the transformer relay to open, which in turn opens the motor circuit. The motor stops, the flame receives no more fuel and goes out. The stack element cools and closes the stack switch H. The heated warp element on the ignition switch cools and closes the ignition contacts and then the starting contacts G. The burner is now ready to start again when the thermostat contacts are again closed by a drop in the room temperature.

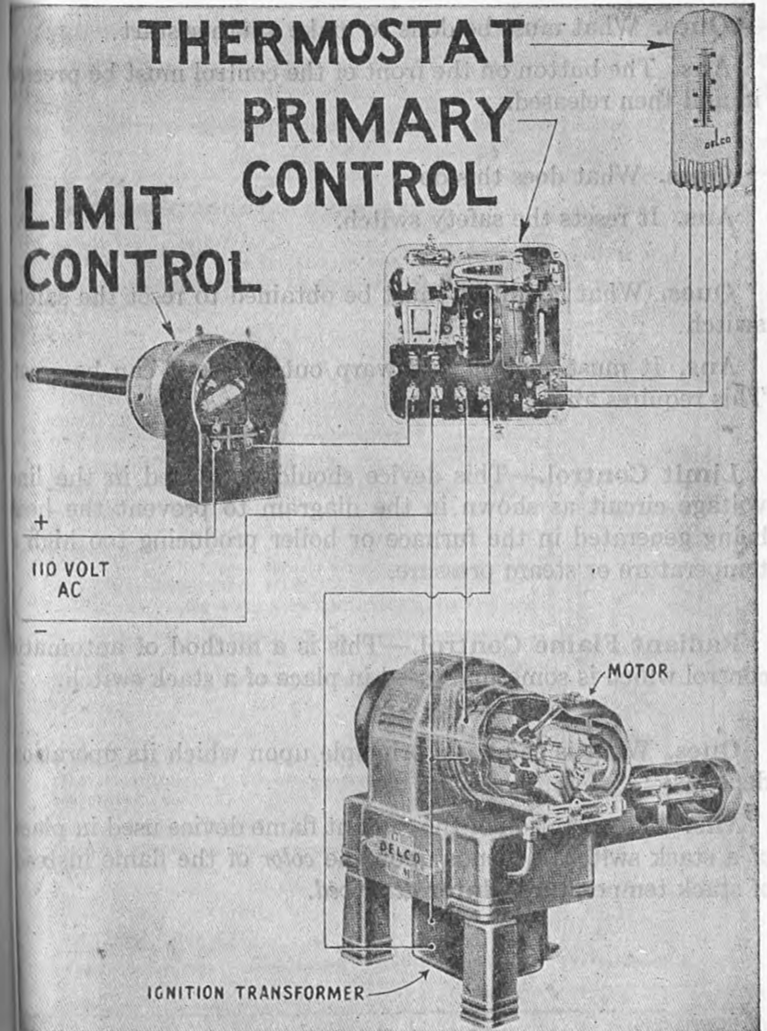
Recycling.—The burner cannot start immediately after it has just shut off.

Ques. Why?

Ans. The heated warp element on the ignition switch must first cool so as to close the ignition contacts and then the starting contacts G.

When the thermostat contacts close by drop of room temperature the burner will start. This fact is of no consequence in normal operation, but it can be misleading when one is testing or working on the burner. Always remember that a cool down period of several minutes is necessary when the master control is warm before it will respond to an increased thermostat setting or other call for heat.

Flame Failure.—When this happens the drop in stack temperature will close the stack switch contacts causing increased current to pass through the safety switch, warping it out, and stopping the burner.



. 8.—Simple electrical system for burner automatic control. The diagram shows the three essential elements and how they are wired.

Ques. What must be done to make another start.

Ans. The button on the front of the control must be pressed in and then released.

Ques. What does this do.

Ans. It resets the safety switch.

Ques. What condition must be obtained to reset the safety switch.

Ans. It must cool off and warp out before it can be reset. This requires about 5 minutes.

Limit Control.—This device should be placed in the line voltage circuit as shown in the diagram to prevent the heat being generated in the furnace or boiler producing too high a temperature or steam pressure.

Radiant Flame Control.—This is a method of automatic control which is sometimes used in place of a stack switch.

Ques. What is the basic principle upon which its operation depends.

Ans. The operation of the radiant flame device used in place of a stack switch, depends upon the *color* of the flame instead of stack temperature—**later** *described.*

General Electric Inverted Oil Burner and Control.—The various controls necessary for proper operation must be brought into action according to a properly timed cycle and this is accomplished by the master or primary control.

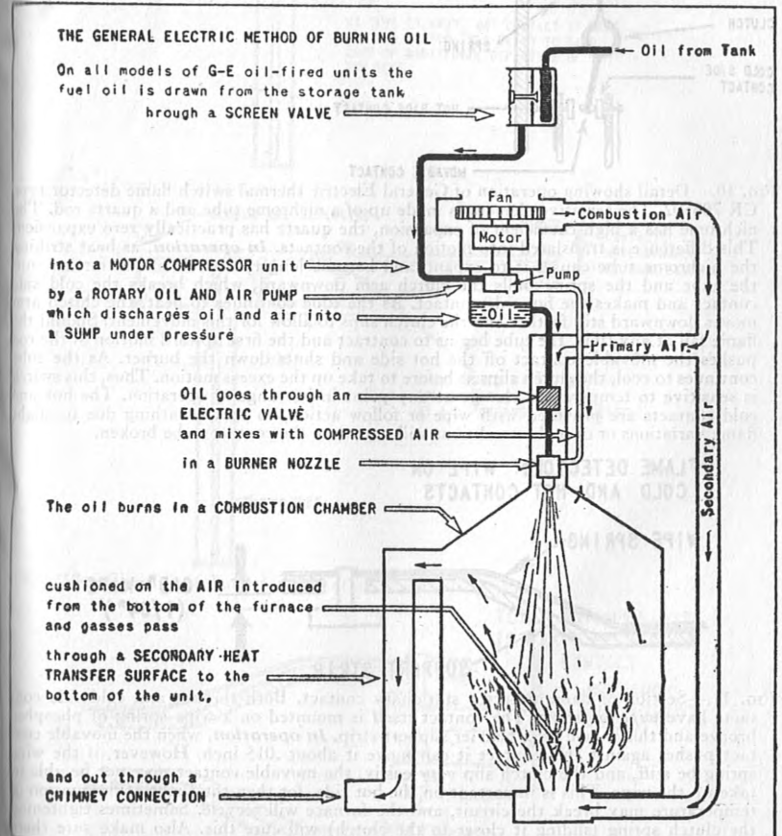


FIG. 9—Diagram showing essential parts of General Electric inverted oil burner of the automatic heating equipment shown in the accompanying illustrations.

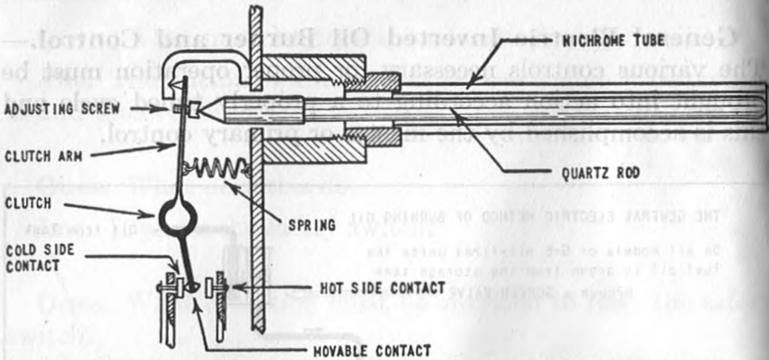


FIG. 10.—Detail showing operation of General Electric thermal switch flame detector type CR 786502. The sensitive element is made up of a nichrome tube and a quartz rod. The nichrome has a high coefficient of expansion, the quartz has practically zero expansion. This difference is translated into motion of the contacts. ***In operation,*** as heat striking the nichrome tube causes it to expand and become longer, the rod moves farther into the tube and the spring pulls the clutch arm downward, which breaks the cold side contact and makes the hot side contact. As the tube continues to heat, the clutch arm moves downward still farther and the clutch slips to allow for this movement. Should the flame fail at any time, the tube begins to contract and the first upward motion of the rod pushes the movable contact off the hot side and shuts down the burner. As the tube continues to cool, the clutch slips as before to take up the excess motion. Thus, this switch is sensitive to temperature change at any point in its range of operation. The hot and cold contacts are provided with wipe or follow action, so that breathing due to slight flame variations or draught conditions will not cause the contact to be broken.

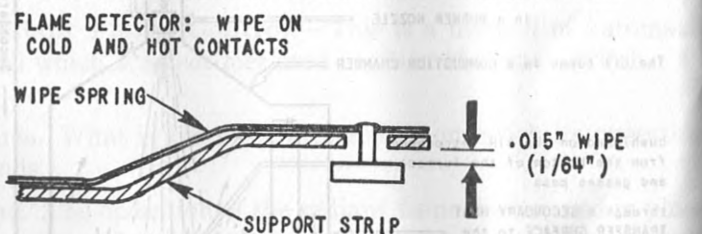


FIG. 11.—Section of flame detector stationary contact. Both the hot and cold side contacts have *wipe* or *follow*. The contact itself is mounted on a wipe spring of phosphor bronze and this is held by a heavier support strip. ***In operation,*** when the movable contact pushes against this contact it can move it about .015 inch. However, if the wipe spring be stiff, and the clutch slip very easily, the movable contact may not be able to take up the wipe. This is important on the hot side, for then the slightest fluctuation in temperature may break the circuit, and the furnace will recycle. Sometimes tightening the clutch spring (sliding it closer to the clutch) will cure this. Also make sure there is no grease on the clutch. Dirt or corrosion behind the contact may also cause insufficient wipe by limiting the movement. Wipe is also lost if the wipe spring become bent so that the contact stays back against the support strip and therefore has no movement.

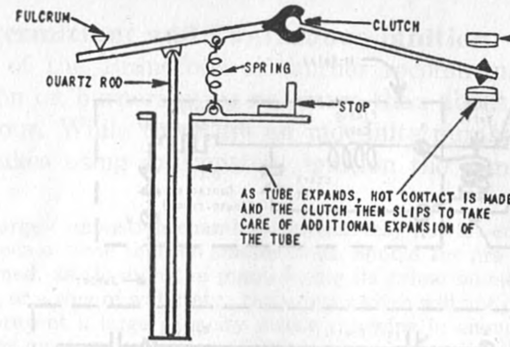


FIG. 12.—Normal flame detector action.

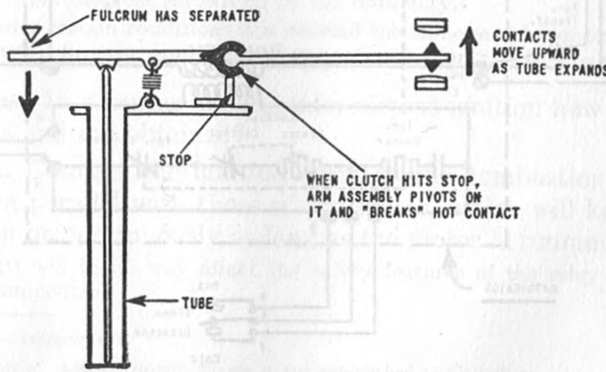


FIG. 13.—Pivoting of flame detector after clutch strikes stop.

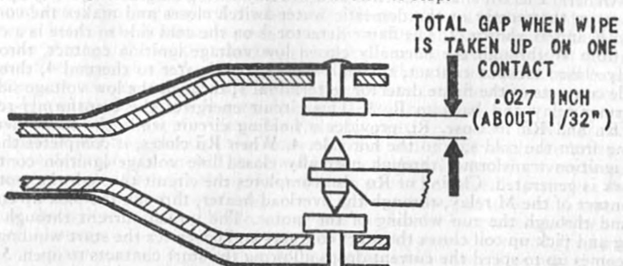


FIG. 14.—Flame detector contact adjustment.

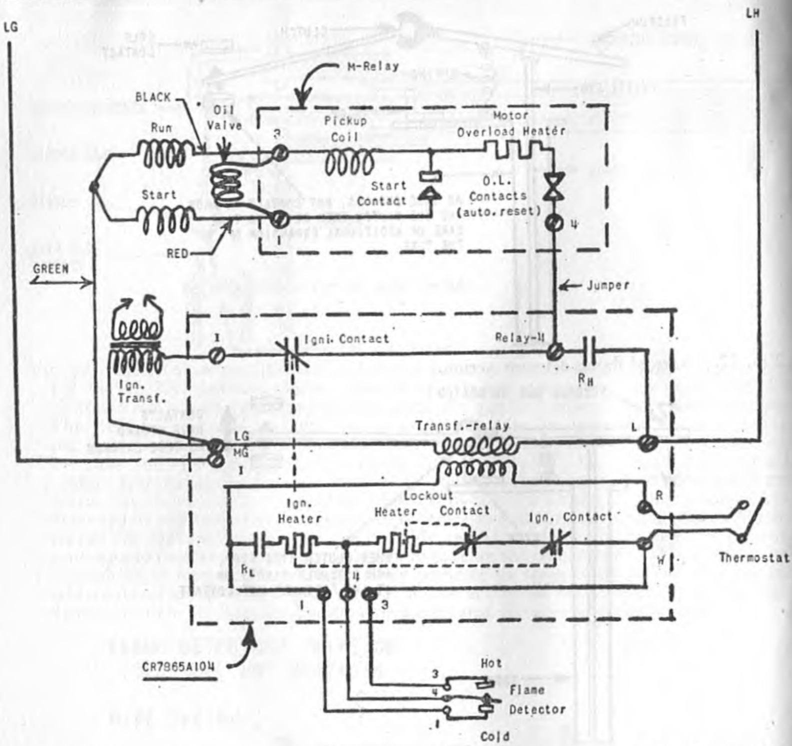


FIG. 15.—General Electric master control and M relay wiring diagram. ***Cycle of operation:*** 1, The room thermostat or the domestic water switch closes and makes the connection between R and W shown. 2, The flame detector is on the cold side so there is a complete circuit from W through the normally closed low voltage ignition contact, through the normally closed lockout contact, through the lockout heater to thermal 4, through the cold side contacts of the flame detector to terminal 1, through the low voltage side of the transformer relay and back to R. 3, This circuit energizes the transformer-relay and causes R_L and R_H to close. R_L provides a holding circuit while the flame detector is traveling from the cold side to the hot side. 4, When R_H closes, it completes the circuit to the ignition transformer through normally closed line voltage ignition contact and the spark is generated. Closing of R_H also completes the circuit through the motor overload contact of the M relay, through the overload heater, through the pick up coil of the relay and through the run winding of the motor. The inrush current through the run winding and pick up coil closes the start contacts and energizes the start winding. As the motor comes up to speed the current drops allowing the start contacts to open. 5, The oil valve coil is connected to 1 and 3 of the M relay. This puts it across the start and run windings of the motor. The oil valve coil is energized and the needle picks up when the

Intermittent and Continuous Ignition.—The manufacturer of the Brandford oil burner recommends intermittent ignition on burners using not more than about 3 gallons of oil per hour. While there are an indefinite number of burners of all makes using intermittent ignition the same manufacturer says:

Large combustion chambers remain very hot for considerably greater periods of time than do smaller ones. Should the fire be suddenly extinguished, as through the pump losing its prime momentarily, air in the line, or a slug of water etc., the safety switch will not operate fast enough to prevent a large capacity nozzle throwing in enough unlighted oil to cause more or less serious damage when it does finally ignite spontaneously from the heat thrown off by the refractory.

Under certain conditions it is claimed the flame may be smoother and make less furnace rumblings when continuous ignition is provided.

Ques. In a burner having intermittent ignition how is continuous ignition obtained?

Ans. Connect the ignition wires at the combustion safety relay in parallel with those of the motor, which will keep the ignition on continuously as long as the motor is running.

This will in no way affect the safety features of the relay or combustion control.

FIG. 15.—*Text continued.*

start circuit is de-energized. Flame is not established until a short instant after the motor compressor starts. 6, When flame is established, the flame detector leaves the cold side and starts moving toward the hot side. When it leaves the cold side, the current in the secondary of the transformer relay must flow through R_L, through the ignition heater and also through the lockout heater, the lockout contacts and ignition contacts. If the current flow through the lockout heater for more than 28 seconds it will cause the lockout contacts to open and stop the burner. These contacts must be reset manually if they open. The flame detector will normally get over to the hot side in 5 to 10 seconds. When it reaches the hot side it provides a low resistance path in parallel with the lockout heater. The current will flow through this low resistance and not through the heater. Assuming the flame detector has reached the hot side in less than 28 seconds, everything is normal. 7, Current started through the ignition heater when the flame detector left the cold side. Sixty seconds later this heater causes both ignition contacts to open. Current continues to flow through the ignition heater as long as the burner is operating. When the thermostat or domestic water switch is satisfied everything shuts down and the ignition heater cools off. Sixty seconds later both ignition contacts will close. This period then is a scavenging period at the end of the heating cycle. The burner cannot start up again until this period is over.

Boiler Control Devices.—These are also known as limit switches.

Ques. Name two kinds of limit controls.

Ans. 1, Temperature control; and 2, water level control.

Ques. What is the reason for temperature limit control?

Ans. It takes time to heat a room and even if all the radiators are filled with steam, the thermostat will keep calling for more heat until the room has become warm. During this interval the limit control will shut down the furnace before the steam pressure or temperature reach an unsafe degree, that is, the pressure or temperature for which the device has been set.

Hot Water Switch.—On some outfits there is a thermostatic device which holds the temperature of the water in the hot water or steam boiler within pre-determined limits—usually between 160° and 180°. Heat is transferred from the boiler to the domestic hot water storage tank by means of an indirect water heater. The location of the domestic hot water switch is shown in fig. 13.