CHAPTER 22

Automatic Control Devices; Construction

The various devices for automatic control, so far, have been shown simply by elementary sketches or diagrams intended to present basic principles and not actual construction. Having learned how they *work*, next should be learned how they are *made* and what they look like.

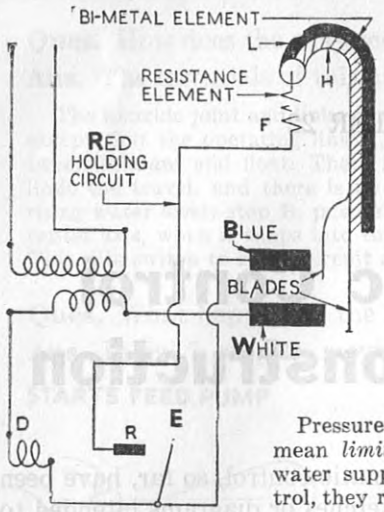
The principle devices to be considered are:

1. Thermostats.
2. Primary controls.
3. Limit controls.
4. So called "operating" controls.

An undue multiplicity of names have been given to these four basic controls by manufacturers and the service man must know: 1. What they are; 2, who made them, 3, how they work, and 4, what they look like.

Practically everybody is familiar with the term *thermostat*, yet so called sensatherms, chronotherm temtrol acratherms and what not are nothing but thermostats as made by different manufacturers. There are too many -stats, -trols, -therms, and other nondescript compounds.

Terms where possible, should be self-defining. For instance, the basic term "operating control" is stupid — all controls are operating controls and if they don't operate, servicing is necessary.



The alleged "operating control" is a hot water control (self defining) and should be called just that.

Referring to the basic controls, when they call them Sensatherm, chronotherm, acratherm, temtrol, etc., they mean *thermostat.*

Master control, stack switch, protectorelay, saftrol, combustion, safety control, pyrotherm, etc., they mean *primary control.*

Pressuretrol, vaporstat, aquastat, etc., they mean *limit control.* Immersion aquastat, hot water supply control, summer and winter control, they refer to the alleged operating control.

FIG. 1—Elementary diagram of thermostat having heating element. The R. W. B. (red, white and blue) terminals are connected to terminals of similar color on the primary control as shown in fig. 8.

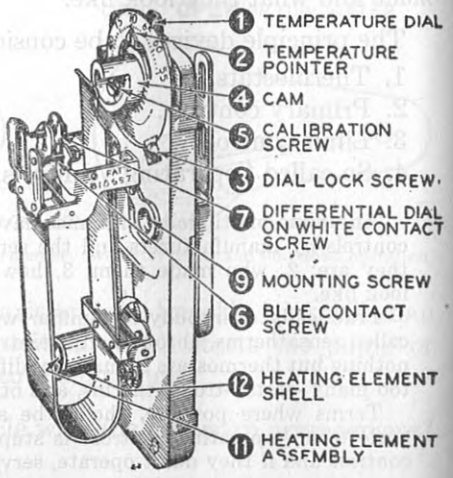


Fig. 2—Pictorial view of "Acratherm" thermostat showing various parts. This Acratherm is bi-metal actuated equipped with open contacts of platinum iridium. The heating element 11 prevents "overshooting" of room temperatures by accelerating shut down of the burner after a very slight rise in room temperature.

THERMOSTATS

There are many types of thermostats on the market, a selection of which may be made suitable for any special service. They may be classed as:

1. Regular.
2. Dual.
3. Two stage.
4. Day and night — semi-automatic, automatic.
5. Low voltage.
6. Line voltage, etc.

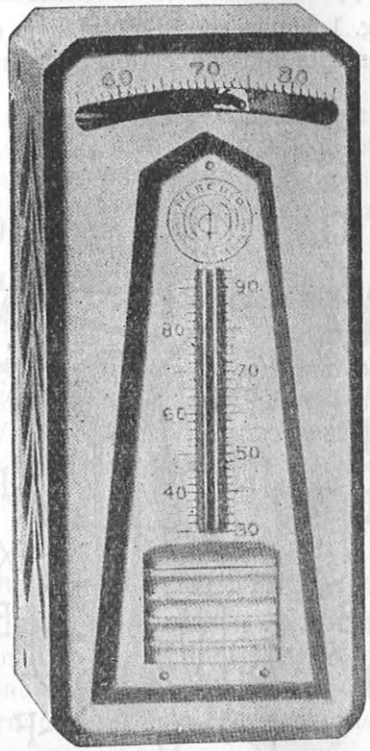


FIG. 3—External appearance of types H and R, "Sensatherms." Operates on a temperature variation of ½° above or below the point set (total differential 1° Fahr.). The mercury tube in which the switching is done remains stationary while a contact electrode is caused to move inside the tube by the influence of a small permanent magnet carried on the bimetal coil outside the tube.

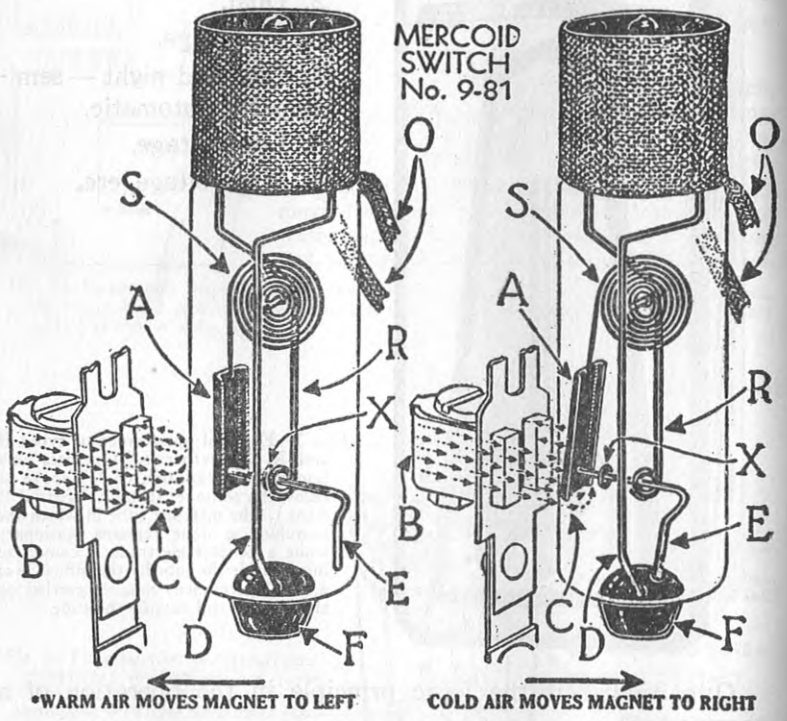
Ques. What is the basic principle in the operation of a thermostat?

Ans. Different metals, when heated or cooled expand or contract at different rates. Hence, if two different metals be joined together into a bi-metal strip, this strip or "arm" will bend

as the temperature changes and this bending movement is utilized to open or close an electrical circuit.

Ques. How is this principle applied to the actual thermostat?

Ans. The circuit diagram fig. 1, shows the bi-metal strip or arm and the other essential elements and connections. Electric



FIGS. 4 and 5—How the Sensatherm of fig. 3 works. Fig. 4 shows portion of operating parts when cool air circulates around the bi-metal spiral in which case the upright and of the bi-metal spiral which carries the magnet moves toward the glass tube or switch. As soon as sufficient magnetic lines of force get within reach of the armature *A* (determined by the instrument setting) it is pulled to the left and thereby causes electrode *E* to contact with the mercury *F* to close the circuit.

wires lead to the instrument at the terminals **R, B, W,** (red, blue, white). The terminal **W,** is fixed and blades attached to the movable arm are arranged to contact (progressively) with contacts **B** and **W.**

Ques. How does the thermostat work as the room cools?

Ans. In operation, as the room cools, the blades move toward the **B**(lue) and **W**(hite) contacts. The circuits are entirely open until the closing of the **B,** contact which energizes secondary of relay coil **D.** This causes contact **E,** to close.

Ques. What happens when the temperature of the room rises?

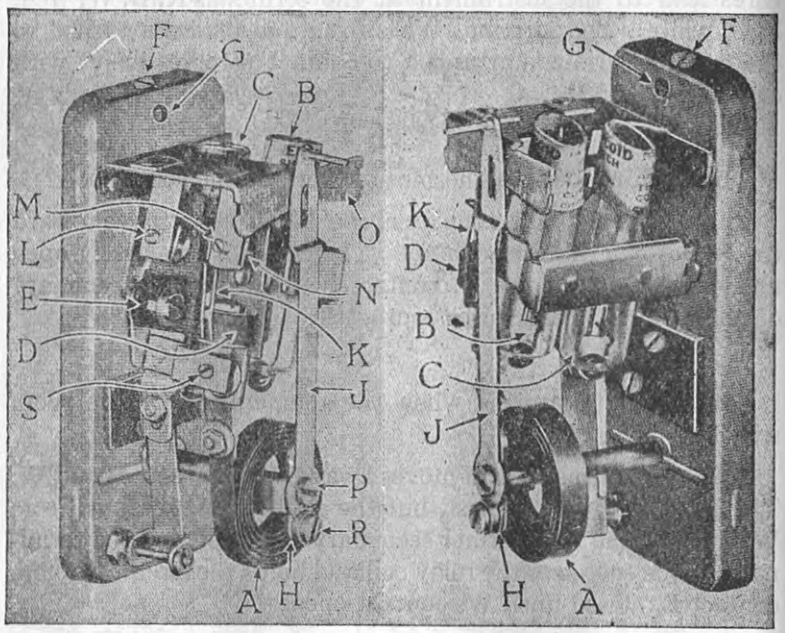
Ans. The bi-metal arm moves away from contacts **B** and **W.** The **B,** contact breaks first, but the circuit is maintained from **W,** through the transformer secondary relay coil and red terminal **R.** This energizes the relay coil and holds the circuit through contact **E,** closed until **W,** contact opens.

Ques. What is the object of the resistor or heating element **F**?

Ans. When contact **W,** is closed, current is carried to the small heating coil in the thermostat, that is, when the thermostat is calling for heat. This speeds up the heating of the bi-metal arm and provides closer room temperature control.

The coil **F** (sometimes called the heat accelerating coil) due to its heating effects causes the thermostat to stop the burner a little before it normally would, shortening the burner operating period before too much heat can be generated.

After the burner has been turned off, the heat accelerating coil **F,** stops producing heat within the thermostat and this reduces the time before the burner will start again, thus preventing a noticeable drop in room temperature.



FIGS. 6 and 7—***Two stage*** Sensatherm. ***The parts are***: ***A,*** bimetal coil; ***B,*** and ***C,*** mercury switches; ***D,*** and ***E,*** permanent magnets; ***F,*** instrument mounting screw; ***G,*** peep hole; ***H,*** adjustable cross bar piece; ***J,*** range lever; ***K,*** stabilizer; ***L,—M,*** and ***S,*** are factory adjustments and should not be touched; ***N,*** stop pin; ***O,*** temperature dial; ***P*** and ***R*** lock screws. ***In operation*** this thermostat is actuated by a single bi-metal coil ***A,*** Two magnetic switches ***B*** and ***C*** are used. The bi-metal coil ***A,*** moves with change of termperature and actuates magnets ***D.*** and ***E.*** which in turn open or close the circuit of switches ***B, C, In operation*** (type H BH) assuming that the room is above temperature at which the instrument is set, both switches will have their circuits open. As the temperature starts dropping the bi-metal coil moves the magnets toward the glass tubes and first permits switch ***C*** to close, which controls the low fire medium if the low fire is sufficient to cause a rise in room temperature, switch ***C*** will again open its circuit. When switch ***C*** is closed and operating the heating equipment at low fire, should the temperature continue to drop, switch ***B,*** which controls the high fire medium, will then close its circuit. As the temperature rises switch ***B,*** will open its circuit, but as switch ***C,*** still has its circuit closed the heating equipment will operate at low fire. Should the temperature drop from this point, switch ***B,*** will again close its circuit and the heating equipment will operate at high fire. After switch ***B*** has opened its circuit, should the temperature continue to rise, switch ***C,*** will open its circuit and stop the heating equipment. On cooling type instruments, the operation is the same as above except that the respective circuits close rather than open on a rise of temperature.

Day and Night Twin Type Thermostat.—This is an assembly of two thermostats mounted on a single base with one cover. The electric clock can be set to throw the temperature controls from one thermostat for the day time onto the other for night at a pre-determined time setting, on the clock and vice versa. This conveniently permits a low temperature at night as should be, and normal temperature during the day. Modern heating thermostats are built to incorporate a "heat leveling" or heat anticipation device. A heating coil consisting of a high resistance unit of very low current draw, is automatically connected in the thermostat circuit when the thermostat contacts close as it calls for heat.

Ques. Describe the heat anticipation feature.

Ans. After the burner (or stoker as the case may be) has been in operation a short time, the heating coil warms up slightly which in turn has a warming effect upon the thermostat mechanism, thus causing the contacts to open in "anticipation" of the heat that has been generated in the boiler or furnace, but has not yet reached the room.

Ques. How is the heating coil* mounted?

Ans. It is carried in two spring clips.

Ques. What is omitted on the night thermostat?

Ans. It has no heating coil.

Ques. What is the object of the slotted knob protruding through the clock cover at the bottom?

Ans. It is a convenient switch for manually cutting out the clock control as desired.

*NOTE.—The oil burner thermostat uses a heating coil with a red band on it and the stoker thermostat coil has a yellow band.

The Primary Control

Ques. How is the thermostat connected to the primary control?

Ans. The **B, W** and **R,** contacts shown in fig. 1, are connected to the **B, W** and **R,** terminals on the thermostat and these are wired to **B, W** and **R** terminals on the primary control.

Ques. How do you change the operating point?

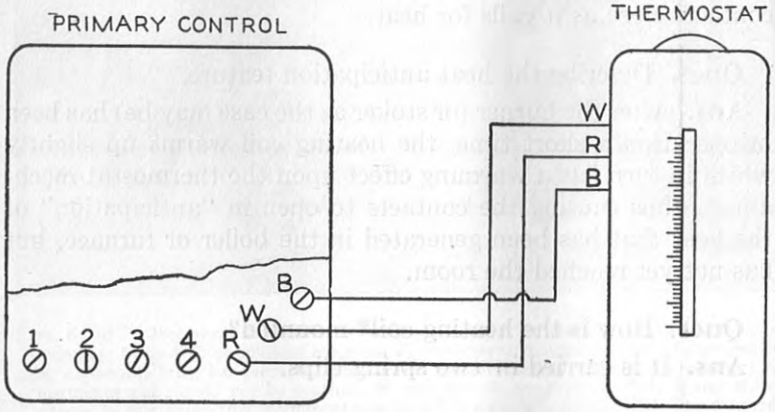


FIG. 8—Elementary diagram showing hook up of thermostat to primary control. The numbered terminals of the primary control are connected thus: No. 1 to hot or live side of the 110 volt house service; No. 2, to ground side of the house service and to the ground wires from the motor and ignition transformer; No. 3, to the motor; No. 4 to the ignition.

Ans. Turn the spring cap, up or down. Turn down to obtain *higher* pressure (or temperature). Turn up to obtain lower pressure or temperature.

Ques. What happens when all three contacts are closed?

The Primary (or master) Control (objectionably called the "Stack Switch")

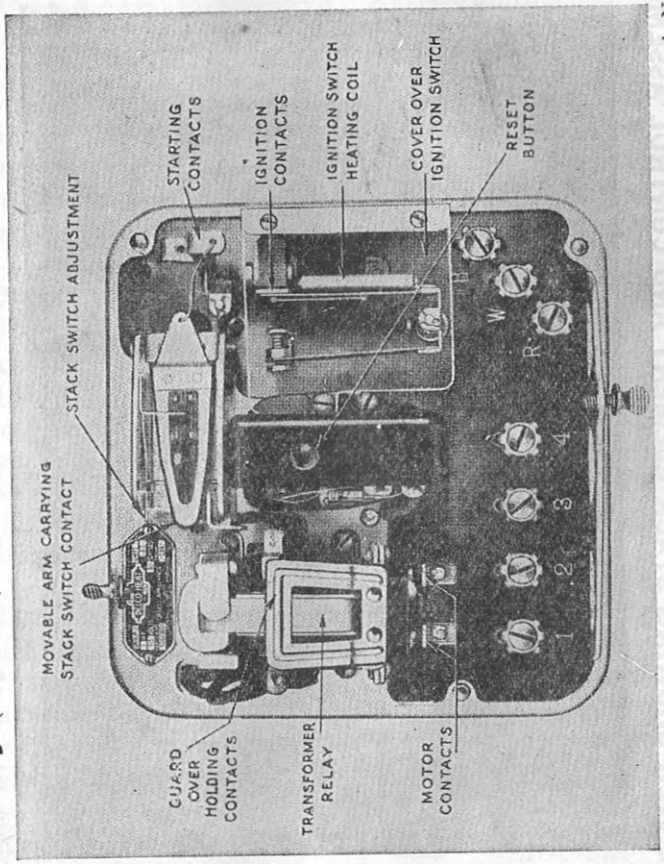


FIG. 9—Delco primary control. Front view with cover off showing various elements. The ***hot*** line connects to the No. 1 terminal and the ***ground*** line to the No. 2 terminal. Do not short circuit the three thermostat terminals to operate burner control without a thermostat. To do this connect B and W terminals only. Be sure to remove the temporary connection as its presence will eliminate the thermostat from the circuit.

THE PRIMARY (OR MASTER) CONTROL

SIDE VIEW SHOWING STACK ELEMENT AND CONTROL ASSEMBLY

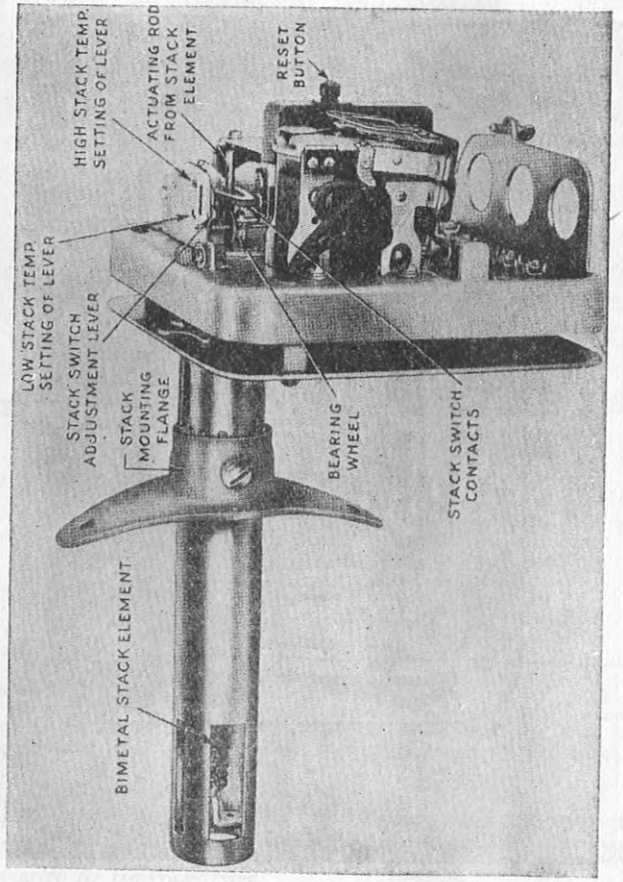


FIG. 10—Side view of Delco primary ("master") control.

Ans. The operation of the burner causes a rise in room temperature. This in turn, due to unequal expansion in the bi-metal element, causes the blades to move away from the **B** and **W**, contacts. **B**, breaks first, the relay coil remaining energized until **W**, opens.

Stack Switch.—The stack element of this control consists of a bi-metal helix which has one end attached to the end of the control mounting tube. The other end of the helix is attached to a rod which extends into the control panel and actuates the stack switch contact with a rise or fall in flue gas temperature.

Ques. Describe operation and construction of the stack switch.

Ans. When the thermostat calls for heat, it closes the relay and starts the burner. The heat of the flue gases in the stack passes over and around the stack element and causes the helix to expand. This drives the rod attached to the helix which travels toward the control and opens the stack switch contact **H**, (fig. 11) by means of a friction clutch action of the rod sliding through the movable contact arm.

Safety Switch.—If the stack switch fail to open the stack switch contacts in 90 seconds, the safety switch **L**, fig. 11, "warps out" and opens the control relay **G**. Another burner start cannot be attempted until the safety switch has been manually reset by pressing and then releasing the button which protrudes from the front of the control.

Ignition Switch.—Cut off of ignition is not dependent upon stack temperature as it is operated by a heating coil attached to the bi-metal arm that carries one of the ignition primary circuit contacts.

ELECTRICAL HOOKUP AND CON

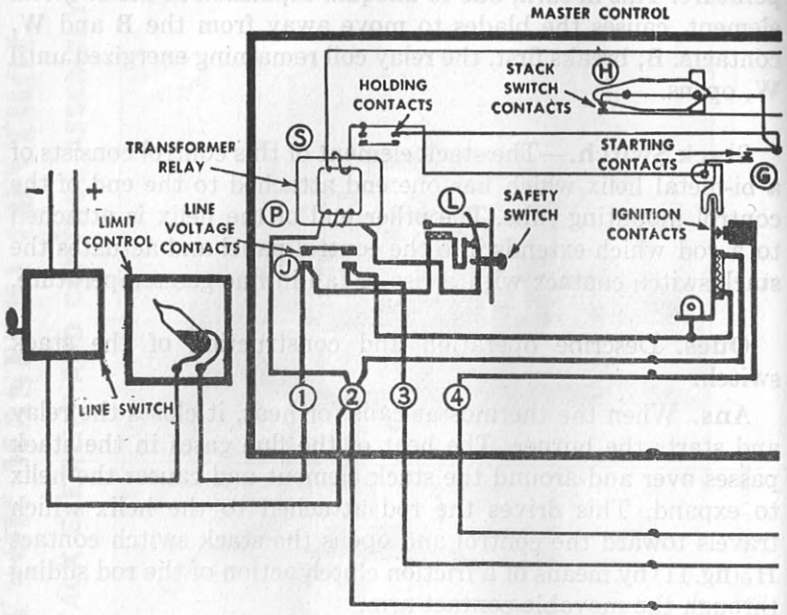
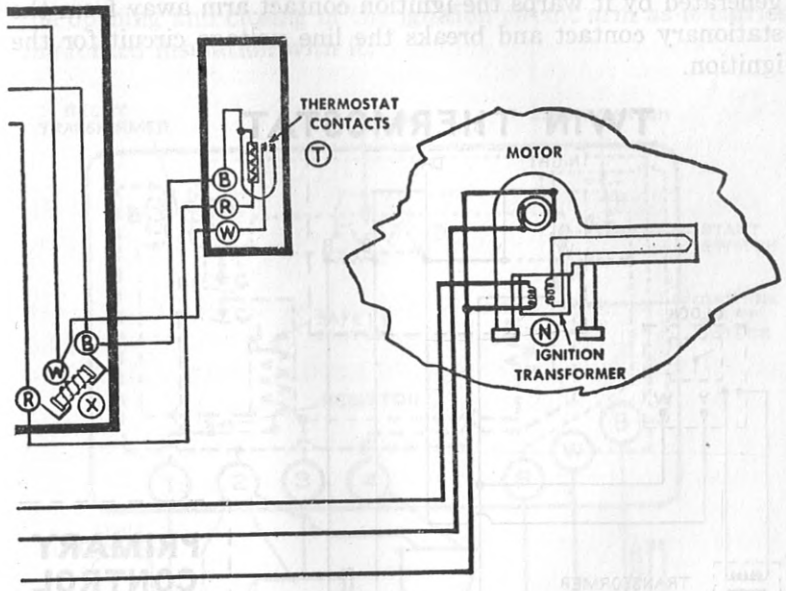


FIG. 11—Electrical circuit diagram of Delco primary (Master control) with connections

LEGEND

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

NECTIONS OF PRIMARY CONTROL



to: 1, thermostat; 2, motor; 3, ignition transformer; 4, limit control and 5, line switch.

LEGEND—*Continued*

L—Safety Warp Switch
N—Ignition Transformer
P—Primary Winding of Relay Transformer
S—Secondary Winding of Relay Transformer
T—Thermostat
X—Resistor

Ques. What happens when the relay closes?

Ans. The heating coil is connected in circuit and the heat generated by it warps the ignition contact arm away from the stationary contact and breaks the line voltage circuit for the ignition.

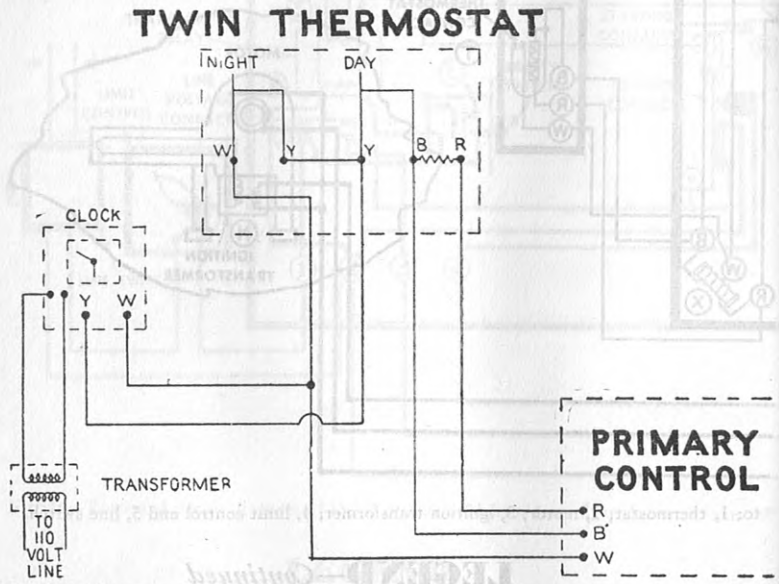


FIG. 12—Diagram of twin type thermostat showing all wiring connections between clock and primary control

A small amount of current flows through the heating coil during the burner operation which keeps the ignition contacts K fig. 13 apart.

Ques. How is the ignition bi-metal arm constructed?

Ans. It has a fork shaped piece of insulation **F**, fig. 13, attached to a right angle shaped metal arm with the starting switch contact on its outer end.

Ques. How is the metal arm mounted and actuated?

Ans. It swings on a hinge pin and its action is controlled by the opening and closing of the ignition circuit arm as it carries the forked insulation with it.

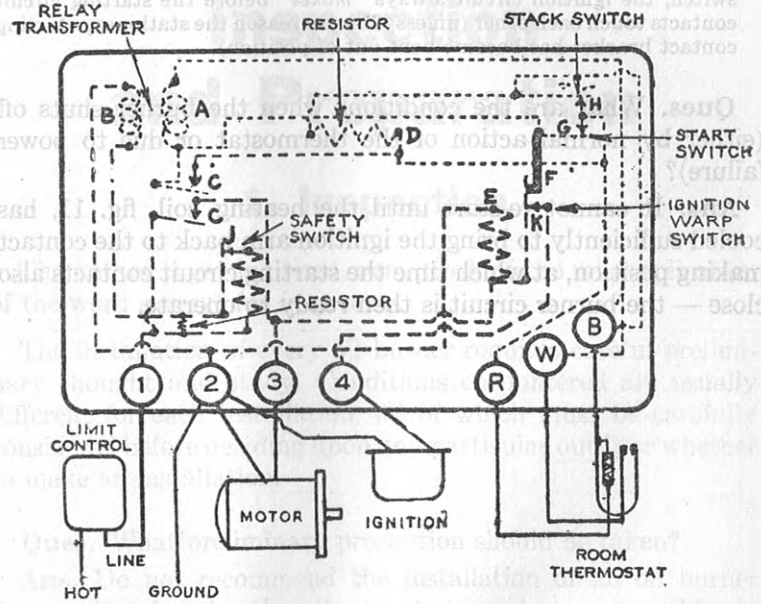


FIG. 13—Wiring diagram of Delco primary ("master") control.

Ques. Describe the circuit conditions when the ignition contact arm is in a closed position.

Ans. The contact on the small metal arm is touching a stationary contact **G**, fig. 13, to complete the starting circuit.

Ques. What happens when the ignition arm is warped away from its companion contact?

Ans. The forked insulation is carried with it and likewise the small metal contact arm which breaks the contacts of the starting circuit.

In this way the burner motor can never start until the ignition circuit is completed and due to the unique construction of the combination switch, the ignition circuit always "*makes*" before the starting circuit contacts touch each other (unless for some reason the stationary starting contact bracket has become bent out of position).

Ques. What are the conditions when the burner shuts off (either by normal action of the thermostat or due to power failure)?

Ans. It cannot re-start until the heating coil, fig. 11, has cooled sufficiently to bring the ignition arm back to the contact making position, at which time the starting circuit contacts also close — the burner circuit is then ready to operate.