Temperature controls for radiant heating with floor panels
by James E Hurtle

A THESIS submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Mechanical Engineering
Montana State University

Abstract:
There are a great many controls manufactured for radiant heating with floor panels. these controls have a price range from $22.20 for a 110-volt room thermostat controlling the circulator pump to $257.00 for an indoor-outdoor control that mixes return water with the "boiler water to give a water temperature to the panel that varies with outdoor tenpera-tune. For this thesis, a study was made and test conducted to determine if expensive controls are necessary and to determine which controls give the best results.

From the test results the following conclusions were made: 1. None of the controls tested are satisfactory for radiant heat with floor panels.

2. The simple bimetal type 110-volt thermostat Controlling the Circulator gives as good results as any of the other control systems tested and it is the least expensive system.

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ABSTRACT

There are a great many controls manufactured for radiant heating with floor panels. These controls have a price range from $22.20 for a 110-volt room thermostat controlling the circulator pump to $257.00 for an indoor-outdoor control that mixes return water with the boiler water to give a water temperature to the panel that varies with outdoor temperature. For this thesis, a study was made and test conducted to determine if expensive controls are necessary and to determine which controls give the best results.

From the test results the following conclusions were made:

1. None of the controls tested are satisfactory for radiant heat with floor panels.

2. The simple bimetal type 110-volt thermostat controlling the circulator gives as good results as any of the other control systems tested and it is the least expensive system.

Chapter I

CONTROL SYSTEM COMPONENTS

Introduction

Chapter I consists of the following topics:

- Room Thermostats
- Relays
- Immersion Thermostats
- Gas Valves
- Safety Controls
- Water Valves
- Controls Used with Tankless Domestic Water Heaters

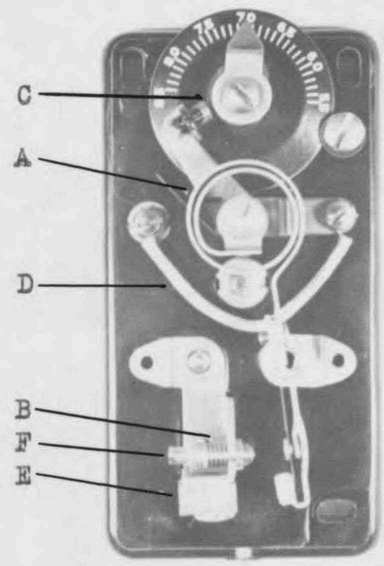
The controls described under these topics represent a cross-section of the types available at the present time. The descriptions are based on information provided by the manufacturers and visual inspection of the controls.

Special indoor-outdoor controls that vary heat input to the system depending on outdoor temperature are described in Chapter II as complete systems.

Room Thermostats

Low-Voltage Room Thermostat

The function of a room thermostat is to maintain the air in a room at a desired temperature. By low-voltage thermostat, it is meant that the thermostat energizes a relay which in turn closes suitable contacts to satisfactorily handle the full load of the circuit. A typical example of this type of control is shown in Figure 1.



Penn Low-Voltage Thermostat
Figure 1

The primary control element consists of a bimetal (A). As the room approaches the desired temperature the bimetal moves in the direction shown and the electrical contacts are broken.

The temperature at which the control breaks the contacts is adjusted by controlling the distance the bimetal is from the fixed contacts (B). This is accomplished by the cam arrangement (C).

With the simple room thermostat described, there would be a considerable lag and overrun of room temperature. This is because the bimetal will not reach the temperature at which it is set until the room has already become warm. The same effect occurs upon cooling. The room becomes cool before the bimetal. To overcome this difficulty, leading control manufacturers include a heat anticipating feature. This consists of a resistance (D) in series with the contacts. Then when the contacts are closed there is a current flowing through the resistance wire. This creates heat which causes the bimetal to break the contacts two or more degrees before the room temperature is up to the desired level. By doing this, the overrun effect is partially compensated for. Since the bimetal is then at a higher temperature than the room, it cools and closes the contacts before the room temperature drops appreciably, thereby eliminating some lag.

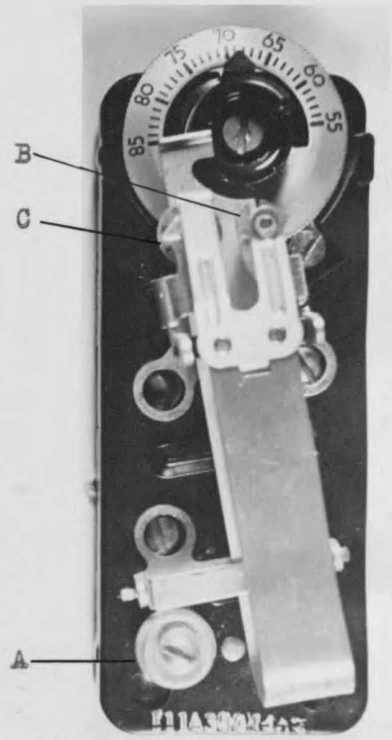
Another desirable feature of the control illustrated is the small permanent magnet (E). This gives snap action to the contacts both on make and break, thereby prolonging their life.

The differential of a control is the difference between the point at which the contacts open and close. It is adjusted by the movable contact (F). This adjustment usually has a range of from 1°F to 5°F differential.

Minneapolis-Honeywell Three-Wire Low-Voltage Thermostat

This control differs from the thermostat already described in that the heating element (A) in Figure 2 is not in series with the contacts. Instead it is in parallel with contacts (B). By using this arrangement, when the thermostat is calling for heat and the contacts are closed the heating resistor is shunted so that it does not supply heat. As the room approaches the desired temperature, contact (B) opens first. When this contact opens current flows through the heating element and adds heat until contact (C) is broken. The system is then shut down.

The advantage claimed for this type of control is that at the start of the cycle the resistance element has no effect and the heating system that it is controlling will be on until the generated heat is beginning to be felt throughout the enclosure. Then the contact (B) opens and the resistance element (A) adds heat and shuts the system down. This eliminates some lag and overrun as well as allowing a longer cycle in severe weather.



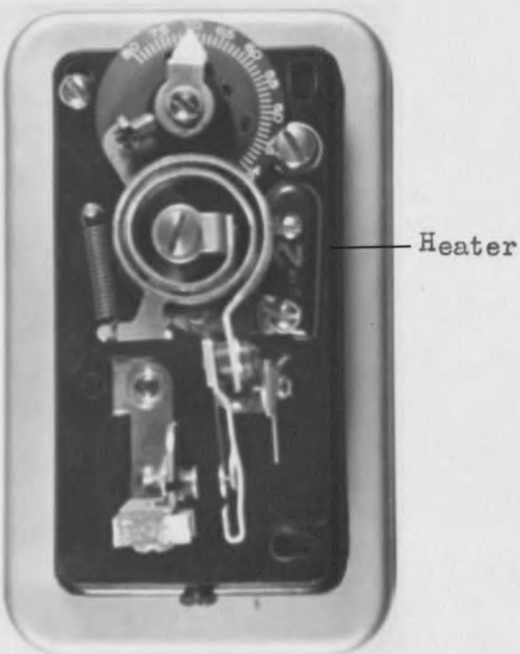
Minneapolis-Honeywell
Three-Wire Low-Voltage
Thermostat
Figure 2

110-Volt (Line Voltage) Thermostat

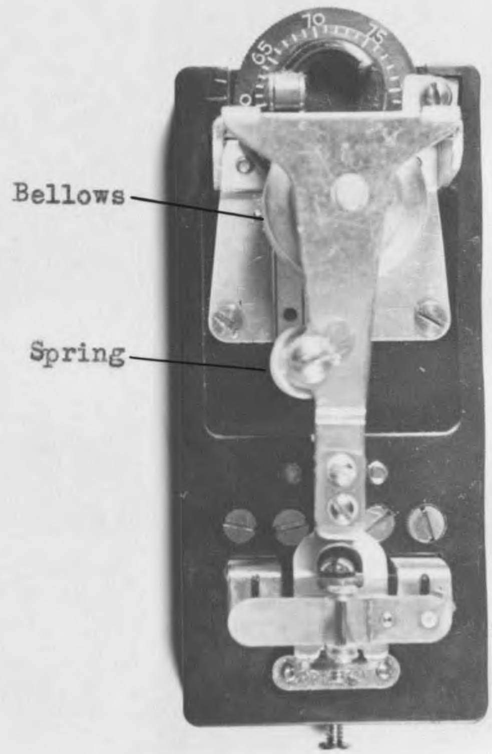
The 110-volt thermostat controls the circuit directly with the contacts in the thermostat within the current limits of the control.

A bimetal type is shown in Figure 3. The operation of this control is the same as that in Figure 1. By comparing the two figures, it may be seen that the 110-volt thermostat has heavier contacts and therefore a correspondingly heavier bimetal. This added weight of parts tends to make the 110-volt thermostat less sensitive than the low-voltage thermostat.

Another type of 110-volt thermostat is shown in Figure 4. This control is actuated by a bellows instead of a bimetal. The bellows contains a limited charge of liquid and vapor. The charge is such that the pressure exerted in the bellows for any temperature that the control will



Penn 110-Volt
Thermostat
Figure 3



Perfex 110-Volt
Thermostat
Figure 4

operate is a straight-line function. Methyl chloride is a typical substance used for this.

By limited charge it is meant that liquid and vapor exist in the bellows at all times. As the temperature increases, more liquid will vaporize and will cause a pressure increase corresponding to the saturation pressure for that particular temperature.

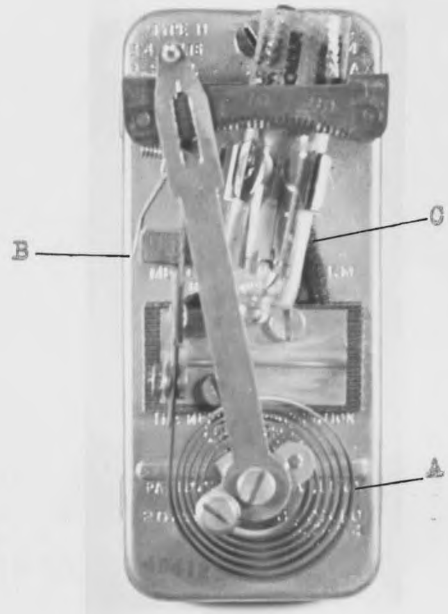
This force exerted by the bellows is then balanced by a spring. The temperature at which the control operates is adjusted by increasing the spring tension to raise the temperature and decreasing the spring tension to lower the temperature. This type of control, like the bimetal type, has an inherent differential. A minimum differential of 1°F may be obtained by careful selection of spring and bellows.

Mercoid Thermostat

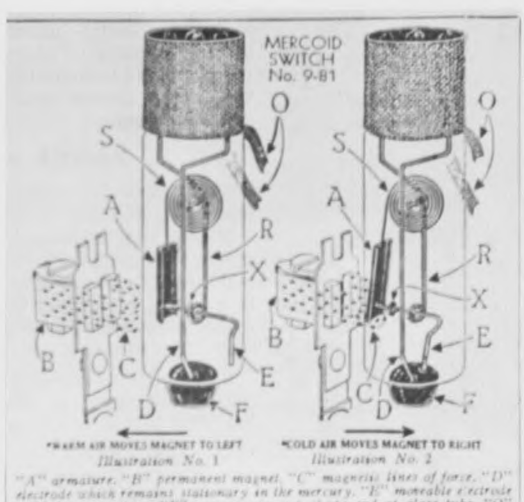
This control (Figure 5) consists of a bimetal (A), a permanent magnet (B) and a mercury switch (C). It may be seen from Figure 6 that when the thermostat is calling for heat the magnet moves close to the glass covering of the mercury switch. This causes the armature (D) to move toward the magnet. The electrode (E) then enters the mercury pool (F) and completes the circuit. Because of the light force required to make contact, this type of control is very sensitive.

Fenwal Thermoswitch

This control is of unusual design. Its action is derived from the difference in expansion of the outside shell (A), Figure 7, and the

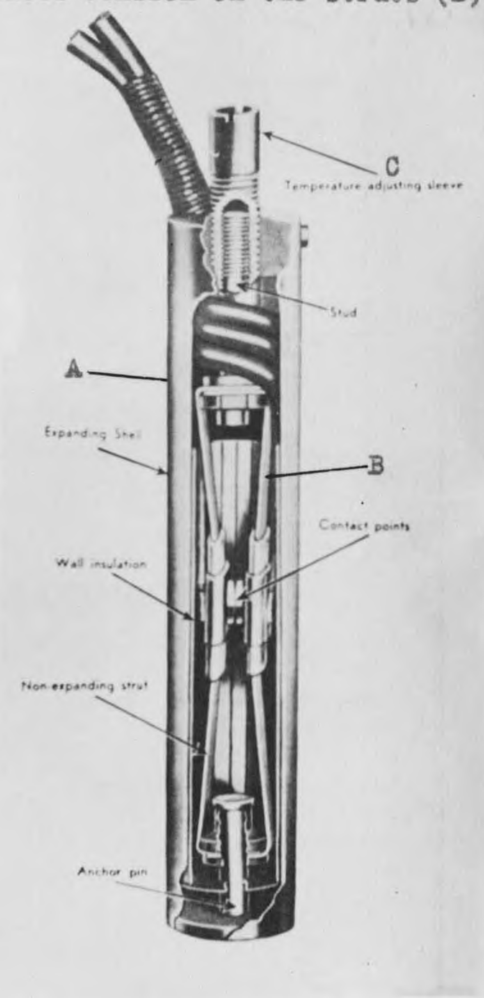


Mercoid Low-Voltage
Thermostat
Figure 5



Mercoid Switch Used in
Mercoid Thermostat
Figure 6

nickel iron struts of low expansion coefficient (B). When the temperature rises, the outside shell expands. This places tension on the struts (B) which causes them to move apart and break the contacts. The temperature at which the contacts will open is adjusted by the sleeve (C). Turning this sleeve clockwise will increase the tension on the struts and lower the temperature at which the control will operate.



Fenwal Thermoswitch
Figure 7

Thrush Radiant Heat Thermostat

This thermostat, Figure 8, is actuated by a bellows inside the protective cover. In addition to the room temperature actuating the bellows, there is a capillary tube from the bellows to a remote bulb. This bulb is fastened to a return water line from the room. When the room temperature is below the setting of the thermostat the contacts are closed and the circulator will run until the room reaches the desired temperature. Then the bellows actuated by the room temperature will break the contacts and shut down the system. However, as soon as the water temperature drops in the return line the return water bulb will again start the circulator

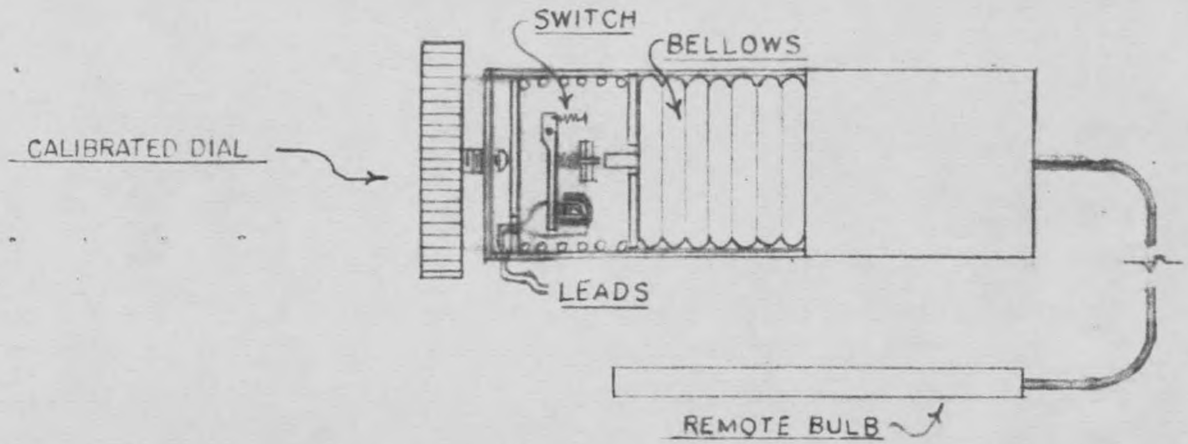


FIG. 8. THRUSH RADIANT HEAT THERMOSTAT