CONTROLS
FOR CENTRAL HEATING SYSTEMS

Issued by the Small Homes Council

University of Illinois Bulletin

Volume 49, Number 55; March, 1932. Published seven times each month by the University of Illinois.
Entered as second-class matter December 11, 1912, at the post office at Urbana, Illinois, under the Act of
Copyright, 1932, by the University of Illinois Press. All rights reserved. No part of this circular may
be reproduced in any form without permission in writing from the publisher.
This circular is one of a series on small homes. Other circulars are available for 15c each.
For information, write to: Small Homes Council, Mamford House, University of Illinois, Urbana.

Material in this circular by W. S. Harris, S. Konzo and R. W. Roose
of the Engineering Experiment Station

Editor: M. H. Kennedy
Editorial Writer: M. E. Hausroth
Illustrator: W. S. Pusey
CONTROLS FOR CENTRAL HEATING SYSTEMS

Controls for central heating systems help to make homes comfortable, and heating convenient, economical and safe. Every control serves one or more of these four purposes. The types of controls needed depend on the type of heating system (warm-air, hot-water or steam) and the kind of fuel burned.

In order to get the best service from controls, the homeowner should have an understanding of 1) the controls required for his heating system, 2) the location, function, and correct use of those controls, and 3) the control settings which provide maximum heating comfort. Fortunately, the control arrangement which provides maximum comfort usually results in lower heating costs. Although other factors affect comfort (the performance of the heating system, the degree of insulation of the house, ventilation, and humidity*), the discussion of comfort in this publication is limited to temperature controls.

The circular describes the common controls recommended for use with central heating systems and fuel-burning equipment for homes.

ROOM THERMOSTATS

The room thermostat is a recommended control for all heating systems. The nerve center of the system, it controls the operation of the heating plant and, therefore, the temperature of the air in a room. It does this by reacting to slight temperature changes. When the air temperature rises above or falls below the desired degree selected by the homeowner, the thermostat signals the heating equipment that less heat or more heat is needed.

Most thermostats for houses have an “off-on” action—that is, two positions. They either turn the heat on or off. The temperature is allowed to rise and fall within a small controlled range.

Some thermostats contain a time switch which makes automatic resetting of the thermostat possible—for example, for night setback.

How Thermostats Work

The operation of one common type of “off-on” thermostat depends on the action of heat on a metal strip made of two metals welded together. One metal expands more than the other when warmed. This uneven expansion causes the strip to bend and to open a switch in the electric circuit, thus turning off the heat. When the strip cools, the switch closes and turns on the heat.

Another common type of thermostat has a gas-filled bellows. When the temperature of the gas rises, the gas expands, causing the bellows to change shape and to open a switch in the electric circuit; thus, the heat is turned off. When the gas cools, the gas and the bellows contract, closing the switch and turning on the heat.

Heating Element

Many thermostats contain a small heating element which artificially raises the temperature within the thermostat casing whenever there is a call for heat and causes the thermostat to respond more quickly and more frequently. The fire is checked before the desired temperature is reached, and the residual heat from the furnace or boiler brings the room temperature up to the desired point; as a result, the house does not become overheated, and fuel is not wasted.

Where to Locate the Thermostat

A thermostat located in one room is intended to control the temperature in several rooms. Actually the thermostat is affected only by the temperature of the air coming in contact with it. For this reason, it is important that the thermostat be located either 1) where the temperature is representative of the entire house, or 2) where temperature control is most important.

Locate the thermostat:
- At a height halfway between the floor and the so-called "breathing level." A distance of 2½ to 4 feet above the floor is recommended because this position is within the space actually occupied (from the floor to six feet above the floor) and hence the temperature in this area should be relatively constant.
- At a spot where it can measure temperature which is representative of air throughout the house. Avoid locations on outside walls (they may be colder than the air in the house); locations near outside doors where air from the outside may sweep over the thermostat; locations in bedrooms where air from opened windows may blow on the thermostat.
- At a point where air circulates normally. Avoid "pockets," such as positions behind doors that usually stand open.
- Away from heat sources. Avoid walls where warm air from a register or radiator flows over the thermostat; walls covering warm-air ducts, hot-water pipes or chimney; walls which receive heat from a fireplace; walls where the sun can strike the thermostat; walls heated by a range or refrigerator motor. Do not put lamps, television set, or radio under the thermostat.
- In the room where the temperature is most important. The living or dining room is often selected.
- In a location where the thermostat is not likely to be damaged by being bumped.

Few locations fit all the recommendations. A compromise location may have to be selected.

Controls for Different Areas of the House

Different temperatures can be maintained in different parts of the house by using separate thermostats for each zone or each room. Such temperature control is more costly than the one-thermostat installation, but is sometimes desirable for rooms or areas which may not require as much heat during the day as the rest of the house — for example, the sleeping area or a room with a large expanse of glass on the south. A single furnace or boiler for the entire house can be used for such zone-control or room-control installations. In existing houses, a change in the heat distribution system may be required.
How to Use a Thermostat

The best way to use a thermostat is to set it to the temperature at which you are most comfortable and leave it there. In determining this temperature, raise or lower the setting only one degree at a time until you feel comfortable.

A thermostat is intended to maintain a uniform temperature. It should be allowed to do its job and should not be used as a hand-operated on-off switch. Frequent adjustment is not necessary; excessive adjustment overtaxes the heating equipment and results in uneven temperatures — you may forget to reset the thermostat after such an adjustment, and the house will become too hot or too cold.

If it is desirable to raise the temperature from 65 to 72°F (such as after a night setback), set the dial for 72°F and not at the top of the scale. A setting higher than 72°F will not make the temperature reach 72°F any faster. Similarly, setting the dial at the bottom of the scale will not cool the house any faster than if the temperature indicator were lowered only a few degrees. The speed of response to a change in setting depends only on 1) the nature of the heating equipment, and 2) the construction of the house.

Some conditions justify a change in thermostat setting:

- The thermostat setting may be reduced 5 to 10 degrees F. during night sleeping hours. (This practice can result in fuel savings of 5 to 8 per cent.) Lowering night settings more than 10 degrees may overtax the heating equipment in the morning.
- During periods of inactivity, you may need 70°F to 75°F to be comfortable, instead of 68°F to 70°F.
- A poorly insulated house having low wall-surface (or glass-surface) temperatures in cold weather may require that the thermostat be reset as outdoor temperatures change.

If your thermostat is not performing satisfactorily, have your heating contractor check it to determine if the thermostat needs adjustment, repair, or replacement with a more sensitive type.

FUEL-BURNING EQUIPMENT AND HEATING SYSTEMS

Controls recommended for the various types of fuel-burning equipment — coal, coke, gas, oil — are described in the charts on the following pages. These charts also present the controls recommended for the various heat-circulating systems most often used in homes — gravity warm-air, forced warm-air, gravity hot-water, forced hot-water, steam.

Continuous Air Circulation in Warm-Air Systems

When controls are properly set in forced warm-air systems, the blower operates intermittently in mild weather and continuously at temperatures below 35°-40°F. If a blower remains off for long periods in cold weather (5 to 8 minutes or more), have your heating contractor adjust the control settings for continuous air circulation so that heat can be delivered almost continuously during all kinds of weather. (Adjustment should be in accordance with recommendations of the National Warm Air Heating and Air Conditioning Association, 640 Engineers Building, Cleveland 14, Ohio.) Generally no new equipment or major changes in the heating system are required.
Controls for Coal Stokers

ROOM THERMOSTAT
Thermostat turns on the stoker relay* when more heat is needed and turns off the relay when less heat is needed.

STOKER CONTROLS
Stoker relay operates the stoker motor. The motor operates the mechanism which delivers coal to the combustion chamber, and the fan which supplies air for combustion.
Hold-fire control, part of stoker relay, keeps fire alive in mild weather when thermostat makes infrequent demands for heat. This control can be either:
- Stoker timer or cycler which operates the stoker for a minimum period (usually about 2 minutes) each half hour, or
- A temperature-operated switch located on the smoke pipe. (When the pipe cools to a certain temperature [approximately 175°F], the stoker motor is switched on.)

DRAFT CONTROLS
Automatic draft regulator is required. This prevents excessive chimney drafts which may result in waste of fuel.

WARM-AIR SYSTEMS

<table>
<thead>
<tr>
<th>Gravity Warm-Air</th>
<th>Forced Warm-Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Fan switch (temperature-operated switch in furnace casing or plenum†) starts the blower when the air is warm enough to be circulated — 100°F to 120°F; fan switch shuts off blower when air becomes about 20 degrees cooler.</td>
</tr>
</tbody>
</table>

HOT-WATER AND STEAM SYSTEMS*

<table>
<thead>
<tr>
<th>Gravity Hot-Water</th>
<th>Forced Hot-Water</th>
<th>Steam</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Room thermostat operates circulator* (pump which circulates the water) as well as the stoker relay. Flow control prevents gravity circulation between boiler and room heating units (radiators, convectors, baseboard units). It is required with domestic hot-water coils; otherwise, optional.</td>
<td></td>
</tr>
</tbody>
</table>

SAFETY CONTROLS
High-limit control (temperature-operated switch inserted in furnace casing or plenum space above furnace) prevents furnace from overheating. Control stops the stoker if the air circulating through the furnace becomes too hot. The temperature should not exceed:
- 250°F in gravity systems.
- 200°F in forced systems.

High-limit water-temperature control (temperature-operated switch in or on boiler, or on supply pipe above boiler) prevents boiler from overheating. Control stops the stoker if the water in the boiler becomes too hot. The temperature should not exceed:
- 200°F in open systems; 240°F in closed systems.
Control also operates circulator, forcing overheated water away from boiler.

Pressure control (pressure-operated switch connected to boiler) stops the stoker when desired operating pressure is obtained (usually 5 pounds or less). Low-water cut-off (float in boiler) stops the stoker if water level in boiler becomes too low. Water must be added before burner will operate.

Safety valve, in the event of excessive boiler pressure, opens to relieve pressure.

* Domestic hot-water coils in forced hot-water and steam systems require a low-limit water-temperature control. This operates the stoker relay to maintain a minimum water temperature whether the thermostat calls for heat or not. Water will be warm enough for most home uses if this low-limit control is set at 155°F.

A reverse-acting water-temperature control is strongly recommended for a forced hot-water system when instantaneous type coils for domestic hot water are used in the boiler. This control turns off the circulator when the temperature of the water in the boiler becomes too cool for domestic use. By setting this control at 150°F, an ample supply of hot water for domestic use will be insured.

† Plenum is the enclosed space above furnace where the warm air collects before being circulated.

University of Illinois Small Homes Council Circular G3.2
Controls for Gas Burners

ROOM THERMOSTAT

Thermostat turns on automatic gas valve* when more heat is needed and turns it off when less heat is needed.

BURNER CONTROLS

Gas pressure regulator reduces the gas pressure from supply lines or tanks to the exact amount needed in the burner.

Automatic gas valve operates gas burner. The action of the valve is controlled by the thermostat or high-limit control.

Automatic pilot ignites the gas entering burner and prevents flow of gas if pilot flame goes out. See manufacturer's directions for relighting the flame.

DRAFT CONTROLS

Draft hood prevents excessive chimney drafts or down drafts, thus resulting in economical operation and also preventing pilot light from going out.

---

WARM-AIR SYSTEMS

<table>
<thead>
<tr>
<th>Gravity</th>
<th>Forced Warm-Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Fan switch (temperature-operated switch in furnace casing or plenum space above furnace) starts the blower when air is warm enough to be circulated — 100° to 120° F.; fan switch shuts off blower when air becomes about 20 degrees cooler.</td>
</tr>
</tbody>
</table>

HOT-WATER AND STEAM SYSTEMS*

<table>
<thead>
<tr>
<th>Gravity</th>
<th>Forced Hot-Water</th>
<th>Steam</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Room thermostat operates circulator* as well as automatic gas valve. Flow control prevents gravity circulation between boiler and room heating units (radiators, convectors, baseboard units). It is required with domestic hot-water coils; otherwise, optional.</td>
<td></td>
</tr>
</tbody>
</table>

SAFETY CONTROLS

High-limit control (temperature-operated switch inserted in furnace casing or plenum space above furnace) prevents furnace from overheating. Control stops the burner if the air circulating through the furnace becomes too hot. The temperature should not exceed:

- 250° F. in gravity systems.
- 200° F. in forced systems.

High-limit water-temperature control (temperature-operated switch in or on boiler, or on supply pipe above boiler) prevents boiler from overheating. Control stops the burner if the water in boiler becomes too hot. The temperature should not exceed:

- 200° F. in open systems; 240° F. in closed systems.

Pressure control (pressure-operated switch connected to boiler) stops the burner when desired operating pressure is obtained (usually 5 pounds or less).

Low-water cut-off (float in boiler) stops burner if water level in boiler becomes too low. Water must be added before the burner will operate.

Safety valve, in the event of excessive boiler pressure, opens to relieve pressure.

* Domestic hot-water coils in forced hot-water and steam systems require a low-limit water-temperature control. This operates the burner to maintain a minimum water temperature whether the thermostat calls for heat or not. Water will be warm enough for most home uses if this low-limit control is set at 165° F.

A reverse-acting water-temperature control is strongly recommended for a forced hot-water system when instantaneous type coils for domestic hot water are used in the boiler. This control turns off the circulator when the temperature of the water in the boiler becomes too cool for domestic use. By setting this control at 150° F., an ample supply of hot water for domestic use will be insured.
Controls for Oil Burners

ROOM THERMOSTAT
Thermostat turns on oil-burner relay* when more heat is needed and turns it off when less heat is needed.

BURNER CONTROLS
Oil-burner relay operates oil burner. In normal operation, relay is operated by room thermostat; in emergencies, the flame-failure switch or high-limit control can prevent operation. (Vaporizing or pot-type burner operates continuously but at a minimum rate between calls for heat. This burner has an oil-flow control valve which functions in the same way as the oil-burner relay.) Automatic ignition is provided to ignite the oil after it is mixed with air. (This is accomplished in pressure and rotary burners by a high voltage spark; in pot-type burners by a pilot flame.) Automatic ignition control is usually a part of oil-burner relay.

DRAFT CONTROLS
Automatic draft regulator prevents excessive chimney drafts from affecting the fire.

WARM-AIR SYSTEMS

<table>
<thead>
<tr>
<th>Gravity Warm-Air</th>
<th>Forced Warm-Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Fan switch. (Same operation as for gas burners. See page 6.)</td>
</tr>
</tbody>
</table>

CIRCULATING OR OPERATING CONTROLS

<table>
<thead>
<tr>
<th>SAFETY CONTROLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-limit control. (Same as for gas burners. See page 6.)</td>
</tr>
</tbody>
</table>

HOT-WATER AND STEAM SYSTEMS*

<table>
<thead>
<tr>
<th>Gravity Hot-Water</th>
<th>Forced Hot-Water</th>
<th>Steam</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Room thermostat operates circulator* as well as the oil-burner relay. Flow control. (Same operation as for gas burners. See page 6.)</td>
<td>None</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HOT-WATER AND STEAM SYSTEMS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-limit water-temperature control. (See page 6.)</td>
</tr>
<tr>
<td>Safety valve. (See page 6 for details of operation.)</td>
</tr>
</tbody>
</table>

* See footnote, page 6.

Controls for Panel Heating

Automatic fuel-burning equipment (see above and pages 5 and 6) is necessary for panel heating installations.

WARM-AIR: Controls for warm-air panel installations are the same as those for conventional forced warm-air systems. In some cases, a combination of an indoor and outdoor thermostat will give better regulation of temperature than the use of an indoor thermostat since the indoor-outdoor thermostat gives advance warning of any change in the amount of heat required.

Some control settings differ slightly from those recommended for conventional forced circulation systems. The fan switch for panel installations should be set to start the blower when the air to be circulated reaches 100°F. In this way, the blower will operate continuously when outdoor temperatures are below 40°F. The high-limit temperature setting should be 140°F, to prevent excessive surface temperatures.

HOT-WATER: Controls for hot-water panel heating are the same as those for conventional forced hot-water systems with the possible addition of an indoor-outdoor thermostat. (See section opposite.) Circulation should be controlled so that it is almost continuous throughout the heating season.

The recommended water temperature for ceiling panels having coils embedded in the plaster is 140°F. For floor panels, 120°F is generally recommended. Night setback of the thermostat is not recommended.
**ROOM THERMOSTAT**

Thermostat regulates fire by operating **damper motor**.

**DRAFT CONTROLS**

Damper motor operates simultaneously:
- **Draft damper** which regulates the air supply to increase the fire (the more air, the more fire).
- **Check damper** which opens to allow the air to by-pass the fire, thus decreasing the fire.

**Automatic draft regulator** is strongly recommended. This prevents excessive chimney drafts and "runaway fires."

---

**WARM-AIR SYSTEMS**

<table>
<thead>
<tr>
<th>Gravity Warm-Air</th>
<th>Forced Warm-Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Fan switch (temperature-operated switch in furnace casing or plenum space above furnace) starts the blower when air is warm enough to be circulated — 100° to 120° F.; fan switch shuts off blower when air becomes about 20 degrees cooler.</td>
</tr>
</tbody>
</table>

**HOT-WATER AND STEAM SYSTEMS**

<table>
<thead>
<tr>
<th>Gravity Hot-Water</th>
<th>Forced Hot-Water</th>
<th>Steam</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Room thermostat operates circulator as well as the damper motor.</td>
<td>None</td>
</tr>
<tr>
<td>High-limit water-temperature control (temperature-operated switch inserted in furnace casing or plenum space) prevents furnace from overheating. Control slows fire by operating the damper motor if the air circulating through the furnace becomes too hot. The temperature should not exceed: 250° F. in open systems; 240° F. in closed systems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-limit water-temperature control (temperature-operated switch in or on boiler, or on supply pipe above boiler) prevents boiler from overheating. Control slows fire by operating the damper motor if the water in boiler becomes too hot. The temperature should not exceed: 200° F. in open systems; 240° F. in closed systems. Control also operates circulator, forcing overheated water away from boiler.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure control (pressure-operated switch connected to boiler) slows fire by operating damper motor when desired operating pressure is obtained (usually 5 pounds or less). Low-water cut-off (float in boiler) operates damper to slow the fire if water level in boiler becomes too low. Water must be added before dampers will permit boiler to operate.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**SAFETY CONTROLS**

High-limit control (temperature-operated switch inserted in furnace casing or plenum space) prevents furnace from overheating. Control slows fire by operating the damper motor if the air circulating through the furnace becomes too hot. The temperature should not exceed: 250° F. in open systems; 200° F. in closed systems.

---

* Coils for domestic hot water are not recommended for furnaces or for hand-fired boilers because there is no means to control the temperature of the water.