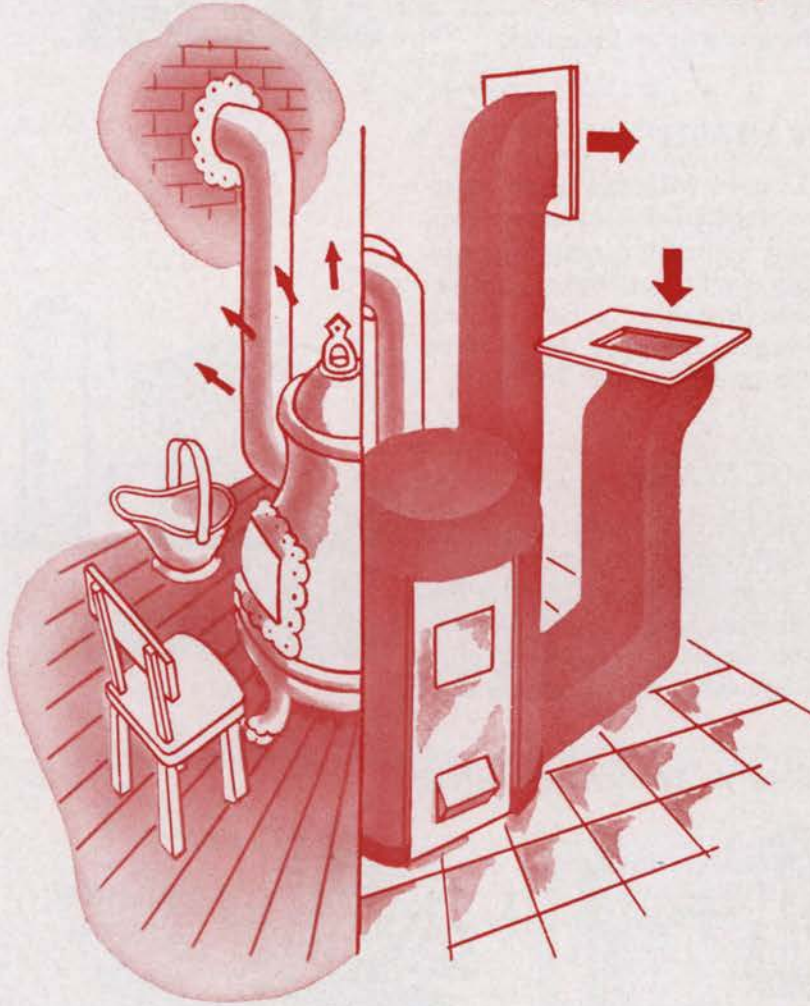


# HEATING THE HOME

## CENTRAL HEATING SYSTEMS



CIRCULAR SERIES

INDEX NUMBER **G3.1**

General  
Recommendations

Registers and Radiators

Gravity Warm Air

Forced Warm Air

Gravity Hot Water

Forced Hot Water

One Pipe Steam

Two Pipe or  
Vapor Steam

Panel or Radiant  
Heating

ISSUED BY THE SMALL HOMES COUNCIL

### UNIVERSITY OF ILLINOIS BULLETIN

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Material in This Circular Prepared by J. T. LENDRUM, S. KONZO, W. S. HARRIS,  
D. B. LINDSAY, W. F. DOOLITTLE

For copies of this Circular (G3.1) or additional information address  
Small Homes Council, Mumford House, University of Illinois, Urbana



CIRCULAR SERIES  
SMALL HOMES COUNCIL

**G3.1**



# GENERAL RECOMMENDATIONS

## A GOOD HOUSE IS EASIER TO HEAT . . .

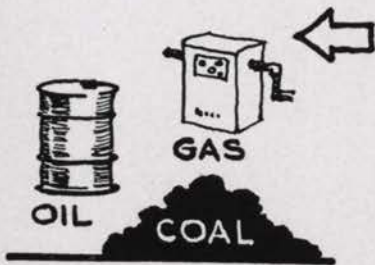


Even the best heating system would have a hard time heating a tent in winter weather. Make your house as easy to heat as possible. Use storm sash and storm doors; caulk joints around window frames; insulate ceilings and outside walls. All of these will pay back good dividends. They will reduce the initial cost of the heating system, reduce fuel bills, and increase comfort, winter and summer.



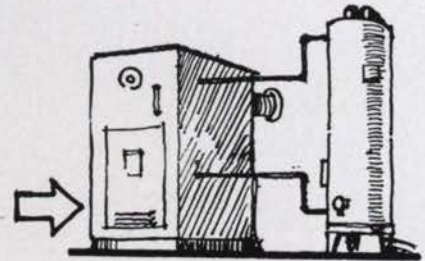
## VARIOUS TYPES OF FUEL ARE AVAILABLE . . .

Any fuel may be used with any of the heating systems described in this circular. Consult your heating contractor regarding the type of fuel that would best meet your requirements. When installing a new system insist on equipment specifically designed to burn the fuel you intend to use.

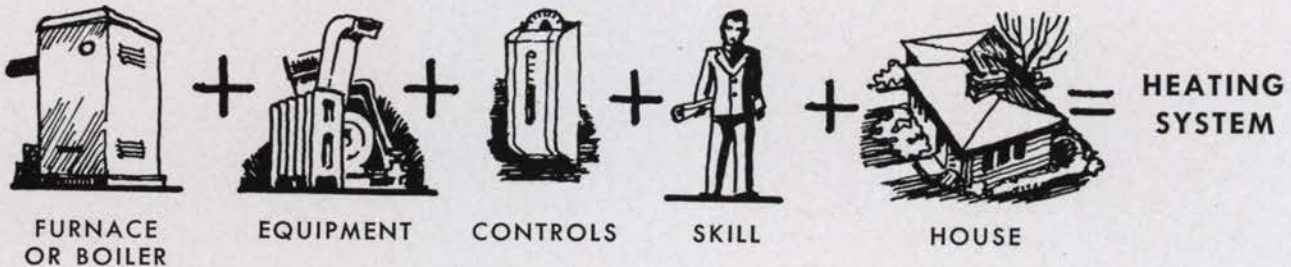


## DOMESTIC HOT WATER . . .

With some systems it is possible to use the heating plant to provide year-round domestic hot water. Such an installation eliminates the necessity of a separate water heater, and often is the cheapest means of securing an adequate supply of hot water for household use.



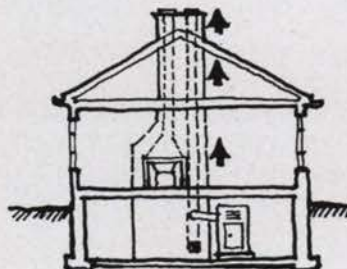
## A HEATING SYSTEM IS MORE THAN A PACKAGED UNIT . . .



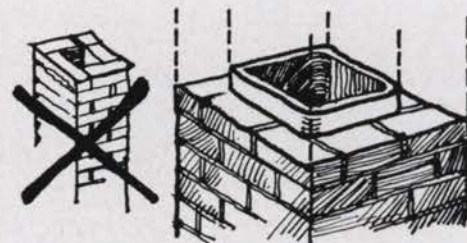
## A GOOD CHIMNEY IS NECESSARY FOR ANY SYSTEM . . .



Top of chimney at least 2 1/2 feet above ridge.



Flue should be straight, without offsets.

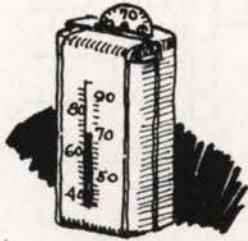


A lined flue of large cross section area is advisable.



## TEMPERATURE CONTROLS AND WHAT THEY DO . . .

Temperature controls may be added to any of the heating systems described in this circular. They are devices designed to "run" your furnace or boiler automatically, and to keep your house at an even temperature. They add to your comfort, and save your money by eliminating overheating. There are three essential factors in the control of any system.

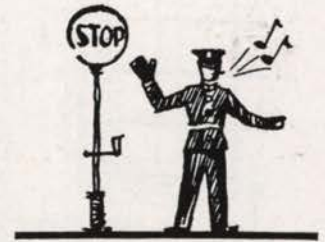


**OPERATING CONTROLS** (for forced systems only) start and stop the fan in a forced warm-air system, or the circulator in a forced hot-water system, and operate other mechanical equipment.

Zone controls are the equivalent of having a separate heating system for each wing of the house, and are not necessary in small homes. If they are used they greatly increase the cost of the system.

**SAFETY CONTROLS** shut off the draft or stop the burner in case of excessive temperature or flame failure.

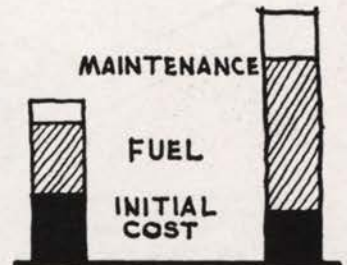
**THE ROOM THERMOSTAT** measures the temperature and operates the equipment to maintain a uniform room temperature.



## A HEATING SYSTEM IS AN INVESTMENT . . .



A heating system is expected to deliver comfort twenty-four hours a day throughout the heating season. The real cost of a heating system is *not* just the cost of the original equipment, but is equal to the initial cost plus the maintenance and fuel costs. A "cheap" heating system will surely cost more in the end than one properly designed and properly installed.



## YOUR HEATING CONTRACTOR SHOULD SUPPLY THESE . . .



ENGINEERED LAYOUTS

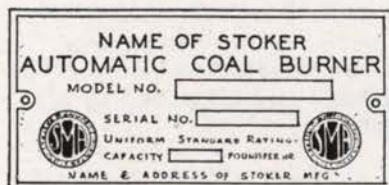


WRITTEN GUARANTEE



SERVICE AGREEMENTS

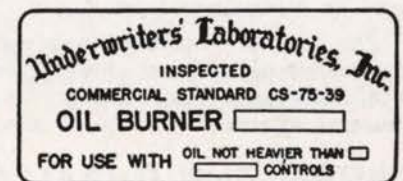
## EQUIPMENT THAT MEETS SAFETY STANDARDS BEARS THESE LABELS . . .



STOKER



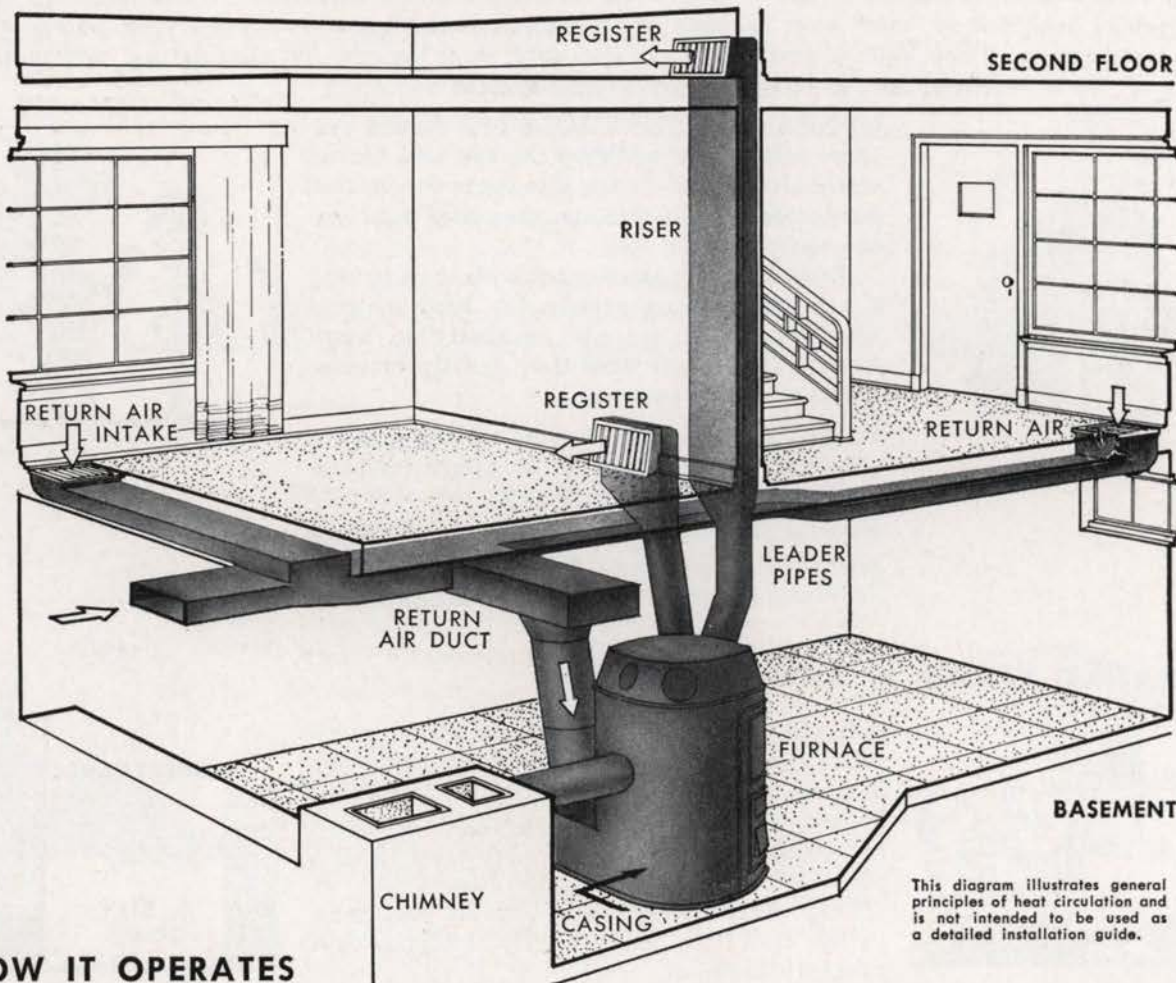
GAS



OIL



# GRAVITY WARM-AIR HEATING SYSTEM



## HOW IT OPERATES

Air circulation in this system depends upon the fact that cold air is heavier than warm air. The cooler air in the rooms flows downwards through **return-air intakes** located in first-floor rooms to **return-air ducts** which lead it to the bottom of the furnace casing. Inside this casing the air contacts the heated surfaces of the furnace, and as it becomes warmer and lighter in weight, it rises and flows out through **leader pipes** to warm-air registers in first-floor rooms, or through **risers** to registers in upstairs rooms.

## DISCUSSION

This system is *economical to install* and *simple to operate*, and is well suited to low cost homes. It has no motors or electrical connections other than those required if controls and burners are used.

The system is *responsive to rapid changes in heating demand*.

It is best *adapted to a house with a compact plan*, because the leader pipes should be nearly equal in length, and both leader pipes and return-air ducts should be as short as possible. Isolated rooms or houses of the rambling type may be difficult to heat.

The furnace must be centrally located, and the leader pipes must slope upwards to the registers or risers. These factors tend to *reduce the amount of usable basement area*.

## DESIGN AND INSTALLATION

The system should be installed in accordance with the "Code and Manual for the Design and Installation of Gravity Warm-Air Heating Systems"; published by the National Warm-Air Heating and Air-Conditioning Association, 145 Public Square, Cleveland 14, Ohio. Price 50¢.

The heating plant must be located below the level of the rooms to be heated. As a result, the system is *not suited to a basementless house*, or to the heating of isolated basement rooms such as recreation rooms and laundries.

*The air may be humidified* from an evaporating pan inside the furnace casing. *Filters are not used* in gravity systems, since they tend to restrict the flow of air.

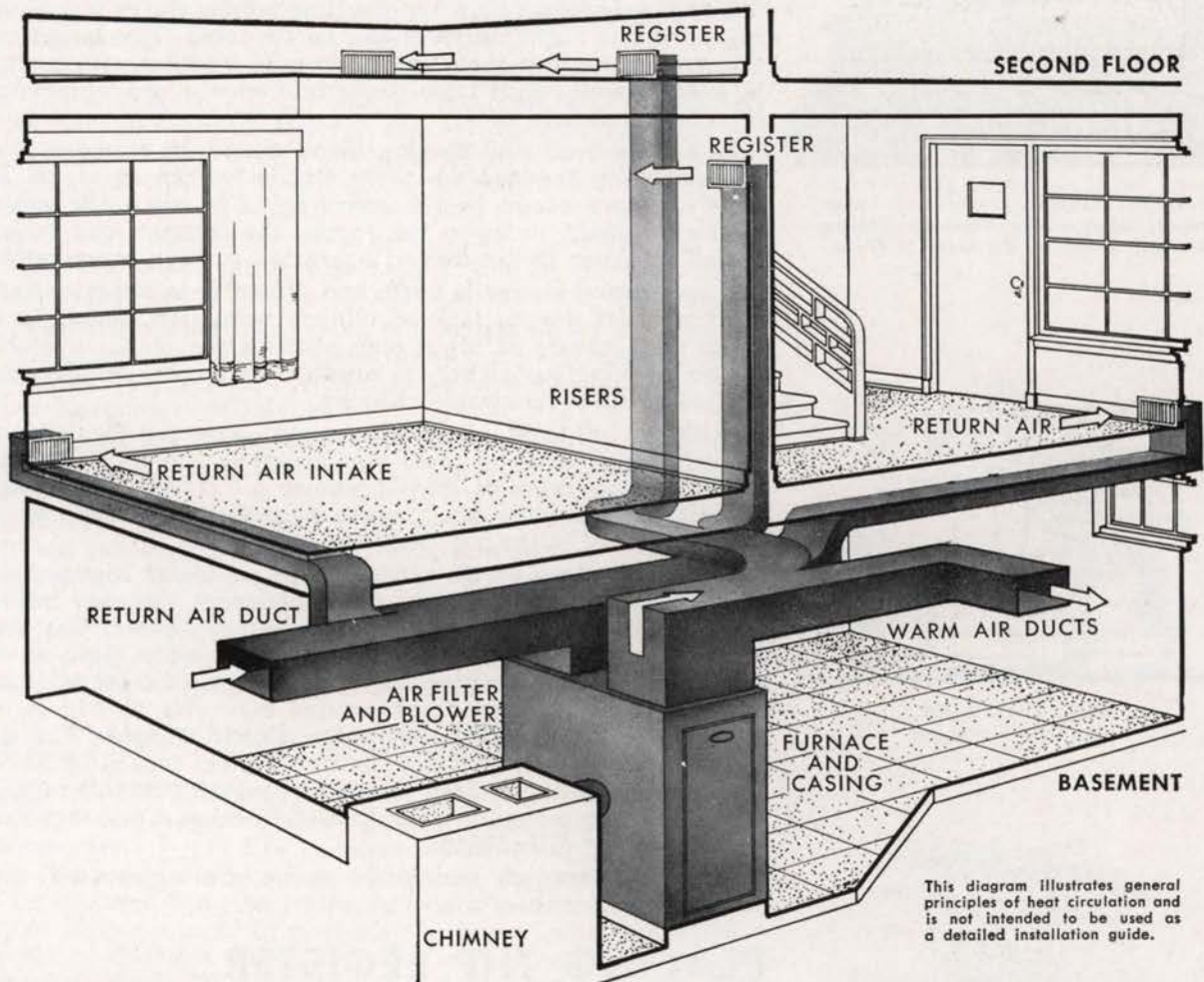
If the furnace is provided with water coils, *domestic hot water can be supplied* during the heating season.

*Maintenance* consists of periodic inspection of the furnace.

*The system can be converted* to a forced system by adding a blower and filter, and by altering the duct system.



# FORCED WARM-AIR HEATING SYSTEM



## HOW IT OPERATES

Positive, controlled air circulation is maintained by a fan, or **blower**. This blower draws the cooler air from the rooms through **return-air intakes** and **return-air ducts**, and through an **air filter**; then delivers it under pressure into the space between the **furnace** and the **furnace casing**. Here it absorbs heat from the heated surfaces and passes through the **warm-air ducts** to **registers** located in the rooms. Since a positive circulation is maintained by the blower, the air ducts can be much longer and somewhat smaller than those in a gravity system.

## DISCUSSION

This system is characterized by its *very rapid response* to changes in heating demand. It usually *costs more to install* than a gravity system, and requires an experienced installer.

Since the air circulation is maintained by the blower, the system *is adapted to large structures, to basementless houses*, and to the heating of isolated basement rooms.

*The furnace and ducts occupy less space* than those in the gravity system. The furnace need not be centrally located. The ducts are smaller and can be run horizontally at the ceiling level.

*Moisture is added* to the air by a humidifier.

*The air is cleaned* with an air filter.

*Registers can be located* in the ceiling, low or high in the sidewall, in the baseboard, or floor.

If water coils are installed, *domestic hot water can be supplied* during the heating season.

*Maintenance* consists of oiling the motor and blower; cleaning or replacing the filters.

The system is *not readily usable for summer air conditioning* without the addition of cooling coils and cooling equipment, together with provision for a large capacity blower.

*If controlled ventilation is desired*, a duct leading to the out-of-doors must be provided.

## DESIGN AND INSTALLATION

The system should be installed in accordance with the "Code and Manual for the Design and Installation of Warm-Air Winter Air-Conditioning Systems"; published by the National Warm-Air Heating and Air-Conditioning Association, 145 Public Square, Cleveland 14, Ohio. Price 50¢.





Research has been conducted for over twenty years at the Warm-Air Heating Research Residence, University of Illinois.

## NIGHT ROOM TEMPERATURES . . .

IF THE ROOM TEMPERATURE is reduced at night about five to ten degrees below the daytime temperatures, a fuel saving of five to eight per cent can be expected. The larger percentages of savings are obtained in mild weather, and little or no savings will result from the reduction of room temperature in severe weather.

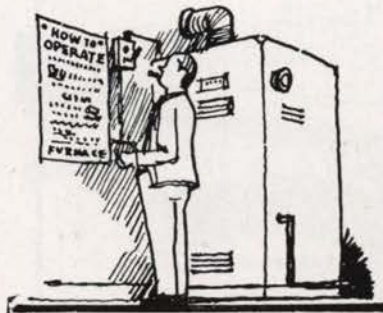
- In a hand-fired coal heating plant, the night temperature is automatically reduced when the fire is banked at night. The disadvantages occur in the morning; for when the system is started again to warm the rooms, the furnace may be subjected to abuse by prolonged operation at high temperatures.

- If a soft-coal stoker is used, and difficulty is experienced in mild weather due to lack of clinker formation, reducing the room temperature at night may prolong the stoker operation in the morning sufficiently to produce the higher temperatures needed to form removable clinkers.

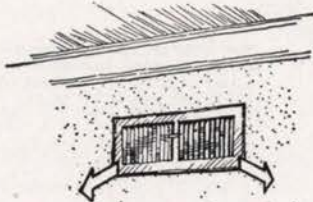
- With an oil-fired plant, there may be no difficulties encountered by reducing room temperatures at night. The minimum burning rates of most pressure oil burners are usually sufficient to provide the reserve capacity necessary for the "pick-up" load in the morning.

- With a gas-fired plant, extra furnace or boiler capacity may have to be provided (that is, the next larger size may have to be used) if reduced night temperatures are desired. Gas burners are normally selected with capacities very close to the actual load, thus providing a narrow margin of reserve. If this condition exists, room temperatures may rise slowly in the morning, and only a slight reduction should be made. The sudden load on the local gas distribution system caused by having a large number of gas-fired plants all operating at full capacity at the same time may, in some localities, cause a pressure drop, with resulting difficulties.

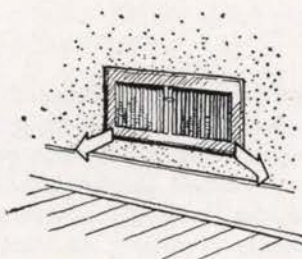
- The disadvantages mentioned above are aggravated when outdoor temperatures are extremely low.



POST INSTRUCTIONS  
NEAR HEATING PLANT



HIGH SIDEWALL REGISTER FOR  
FORCED WARM-AIR SYSTEMS

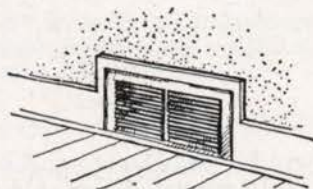


LOW SIDEWALL REGISTER

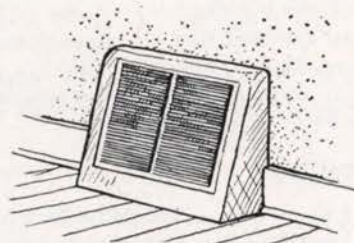
## PLACING THE REGISTER . . .

FOR FORCED WARM-AIR HEATING SYSTEMS, the registers should be of the *adjustable vane type*, capable of discharging the air downwards and to the sides. *Supply registers* should be on inside walls, and may be located in the baseboard, low in the sidewall, or near the ceiling. Registers should be located so that air will not be discharged directly against occupants of the rooms. The high sidewall location, about seven feet from the floor, or at least one foot below the ceiling, is becoming more common, as it does not interfere with furniture arrangement. The *return-air intakes* for both gravity and forced warm-air systems are usually located on outside walls, at the foot of stairs, or at other cool spots.

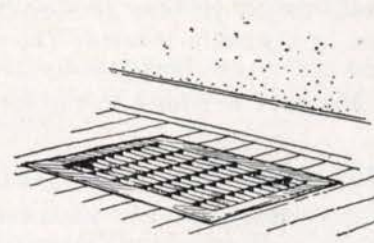
FOR GRAVITY WARM-AIR SYSTEMS, the registers should be located in the baseboard on inside walls. *Floor registers should be avoided* unless building construction is such that a baseboard register cannot be installed. With any register *the seal* between the register frame and the wall must be tight in order to prevent dirt streaks from forming. Better registers are provided with a flexible gasket for making this seal.



BASEBOARD REGISTER



BASEBOARD GRAVITY REGISTER



FLOOR REGISTER



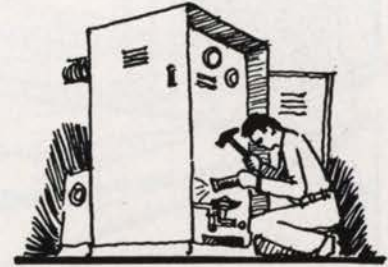
## OTHER SUGGESTIONS . . .

A NUMBER OF IMPORTANT FACTORS directly related to heating the home are frequently overlooked, or regarded as "extra" items of additional expense:

- **Fuel delivery, fuel storage, and ash removal**, in the case of solid fuels, deserve careful study. The coal bin should be located both for ease of delivery and convenience in firing. It should be so situated that it can be filled without the necessity of carrying the fuel or of having the delivery truck drive over the lawn. Bins should be made dust-tight.
- **With oil as a fuel**, there is less of a delivery problem, but the size and location of the storage tank should be in conformity with the regulations of the National Board of Fire Underwriters.
- **If plumbing or electrical work** will be necessary in connection with the installation of a heating plant, a statement should be obtained from the heating contractor as to how much of this work is included in his estimate.
- **In new construction** it is highly desirable to consider the heating plant in its relation to the total house construction, before any actual work is started. Careful cooperation between the general or carpentry contractor and the heating contractor often will result in savings and in the elimination of much of the mutilation so frequently observed in new house construction. By planning the placement of pipes or risers ahead of time, the framing members of the building can be located to allow passage of ducts or pipes without the cutting and resultant weakening of the structural frame of the building.



The I=B=R Research Home at the University of Illinois where research in steam and hot-water heating is conducted.



DO NOT TAMPER WITH THE SYSTEM

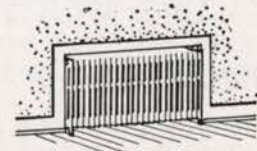
## SELECTING THE RADIATOR . . .

HEATING UNITS used to transfer heat from steam or water to the air in the rooms are of two general types: the *radiator* and the *convector*. ¶ (1) *The cast-iron radiator* may be installed in the open under a window or against an outside wall. It may be recessed into the wall construction, or it may be partially or fully enclosed in a cabinet. *If the radiator is recessed*, it is very important to insulate the wall behind it. A minimum of one inch of rigid insulation board, or one reflective surface, or both, should be used. *A shield* at the top reduces the tendency of dirt streaks to form and while sides and a front may be added to conceal the radiator, they must be easily removable for cleaning. ¶ (2) *In the convector type*, the steam or hot water is circulated through a small core or tube, to which are attached a number of thin "fins," or metal plates. These fins are heated from the core, and in turn warm the air as it flows between them. The core and fins are enclosed in a cabinet which promotes a more rapid air flow over the heated surfaces. *No "radiant" or heated surfaces are directly exposed to the rooms.* The convector may be completely recessed in the wall, with only two grilles (cold-air intake below, and warm-air outlet above the unit) exposed; or it may be enclosed in a "cabinet" and placed in the room.

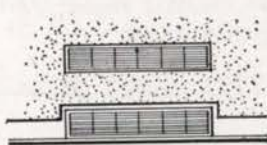
TESTS are being conducted at the I=B=R Research Home to study the qualities of a baseboard radiator which might be installed in the place of the usual wall baseboard, thus doing away with the necessity of having ordinary radiators or convectors in the rooms. While these radiators are not yet available, the tests seem to indicate that they will offer many distinct advantages when they do appear on the market.



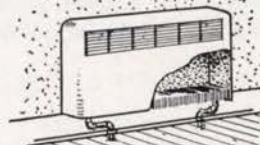
CAST-IRON RADIATOR WITH SHIELD



RECESSED CAST-IRON RADIATOR



RECESSED CONVECTOR



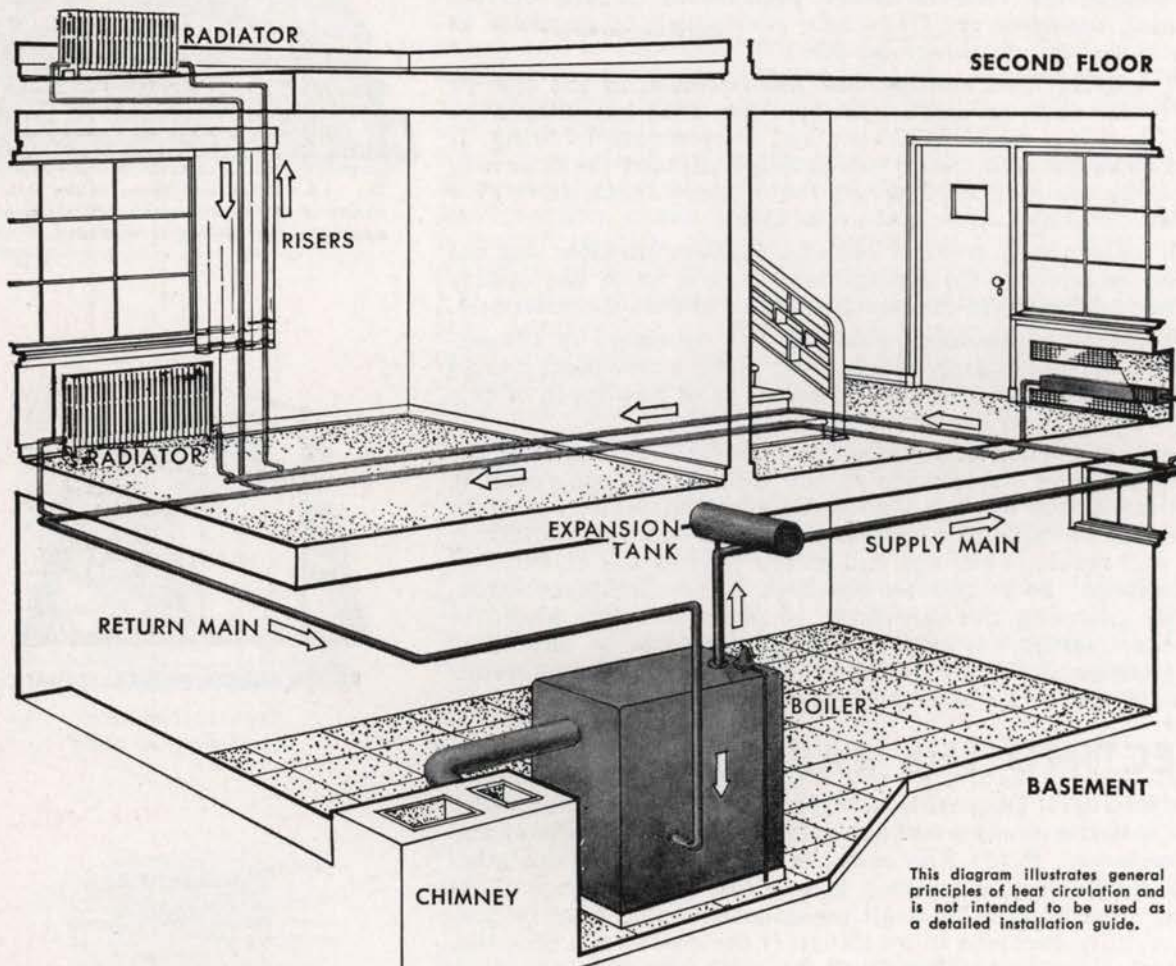
CABINET-TYPE CONVECTOR



BASEBOARD RADIATOR



# GRAVITY HOT-WATER HEATING SYSTEM



This diagram illustrates general principles of heat circulation and is not intended to be used as a detailed installation guide.

## HOW IT OPERATES

Circulation in this system depends upon the fact that cold water is heavier than warm water. The cooler water flows downwards through return risers and mains to the bottom of the boiler. Inside the boiler the water is heated, and as it becomes warmer and lighter in weight, it rises and flows out through the supply main and risers to the radiators in the rooms.

## DISCUSSION

This system is *economical to install*, as it requires a minimum of special fittings or devices. It has no electrical connections, other than those required if controls and burners are used.

Since the circulation is by gravity action, the *supply and return mains must be large* in order to reduce friction. The *mains should be insulated* to prevent excessive heat loss into the basement. Since the boiler must be located below the level of the radiators, the system is *not suited to a basementless house*, or the heating of isolated basement rooms.

The system is somewhat *slower in responding* to temperature changes than a forced hot-water system, due to the larger volume of water retained in the pipes and radiators.

*Maintenance* consists of periodic venting of radiators and convectors; particularly the latter.

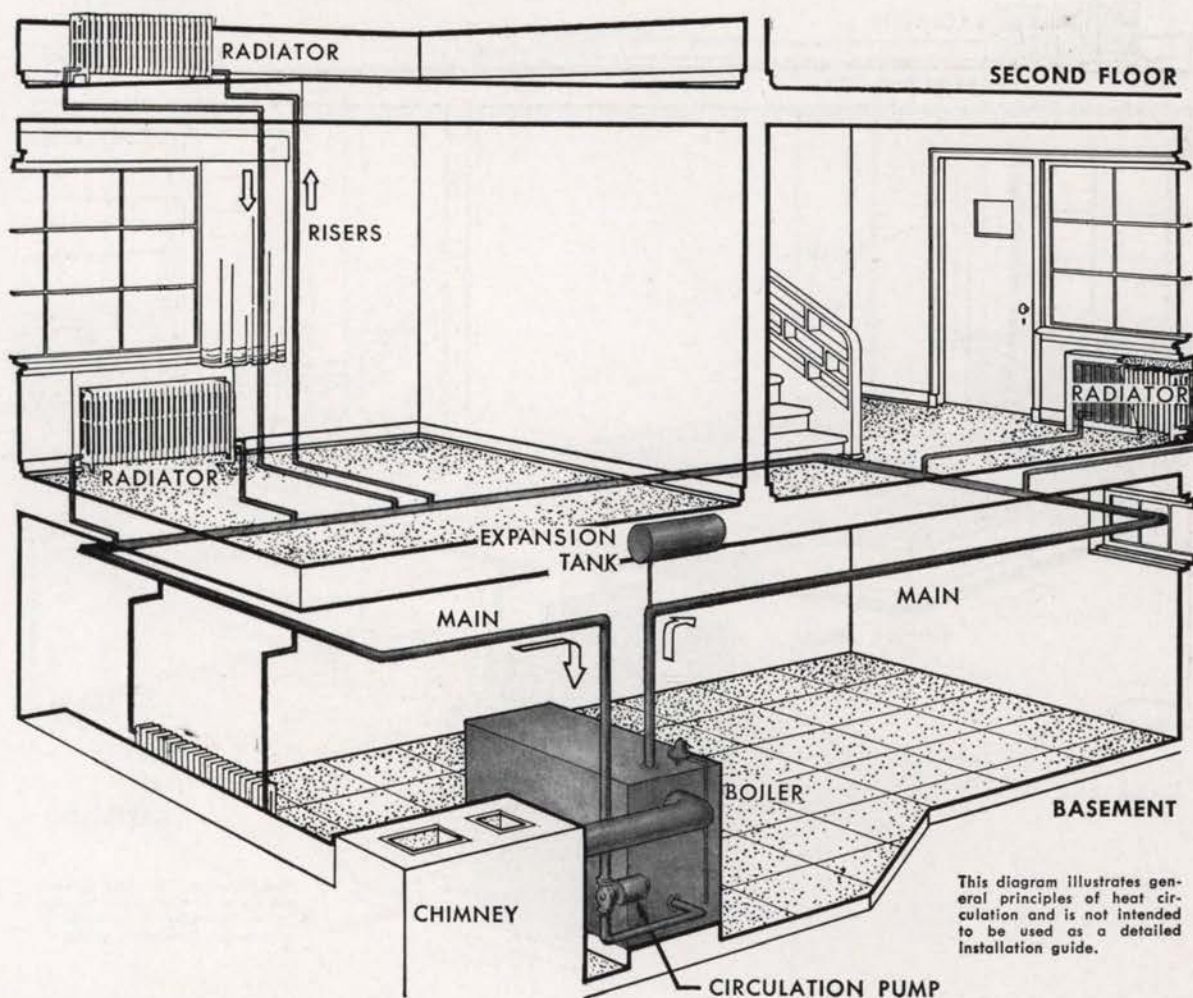
This system *may be operated either as an "open" or as a "closed" system*. In the open system, the expansion tank is located above the highest radiator, and the water is "open" or exposed to the air. In the closed, or pressure, system (*shown above*), the expansion tank may be located near the boiler, and as the heated water expands, the air in the tank is compressed. Since an increase in pressure raises the boiling point of the water, higher temperatures may be maintained in the closed system without forming steam in the radiators. These higher temperatures *permit the use of smaller radiators* than those needed for the open system.

## DESIGN AND INSTALLATION

The design and installation of this system should be the work of competent men and firms experienced in gravity hot-water heating.



# FORCED HOT-WATER HEATING SYSTEM



## HOW IT OPERATES

The circulation of water is positively maintained by the action of a **circulating pump**. The water is heated in the **boiler** and is forced through the **pipes (mains and risers)** leading to radiators. Two basic types of piping systems are in common use. In the **One-Pipe System** (*shown above*) a single pipe or **main** serves both to supply the heated water to the radiator and to return the cooled water from the radiator to the boiler. In the **Two-Pipe System** the heated water is supplied to the radiator through a **supply main**, and the cooled water is returned to the boiler through a separate **return main**.

## DISCUSSION

This system is characterized by its **rapid response to changes in heating demand**. The radiator temperatures can be modulated or varied in accordance with changing weather, so that uniform room air temperatures are maintained.

This system usually **costs more** to install than the gravity system, due to the addition of the circulating pump and special fittings.

Since the circulation of water is maintained by a pump, radiators may be located either above or below the level of the boiler, making the system **adaptable to basementless houses** and to the heating of isolated basement rooms.

Since the pump is capable of circulating water against high friction heads, it is possible to use small pipes for the mains and risers, resulting in a **large amount of usable basement space**. Since the smaller surface area of the pipes reduces the heat loss, it is **not usually necessary to insulate the mains**.

The circulating pump is motor driven, **requiring electrical connections**.

**Maintenance** consists of oiling the motor and of venting the radiators and convectors.

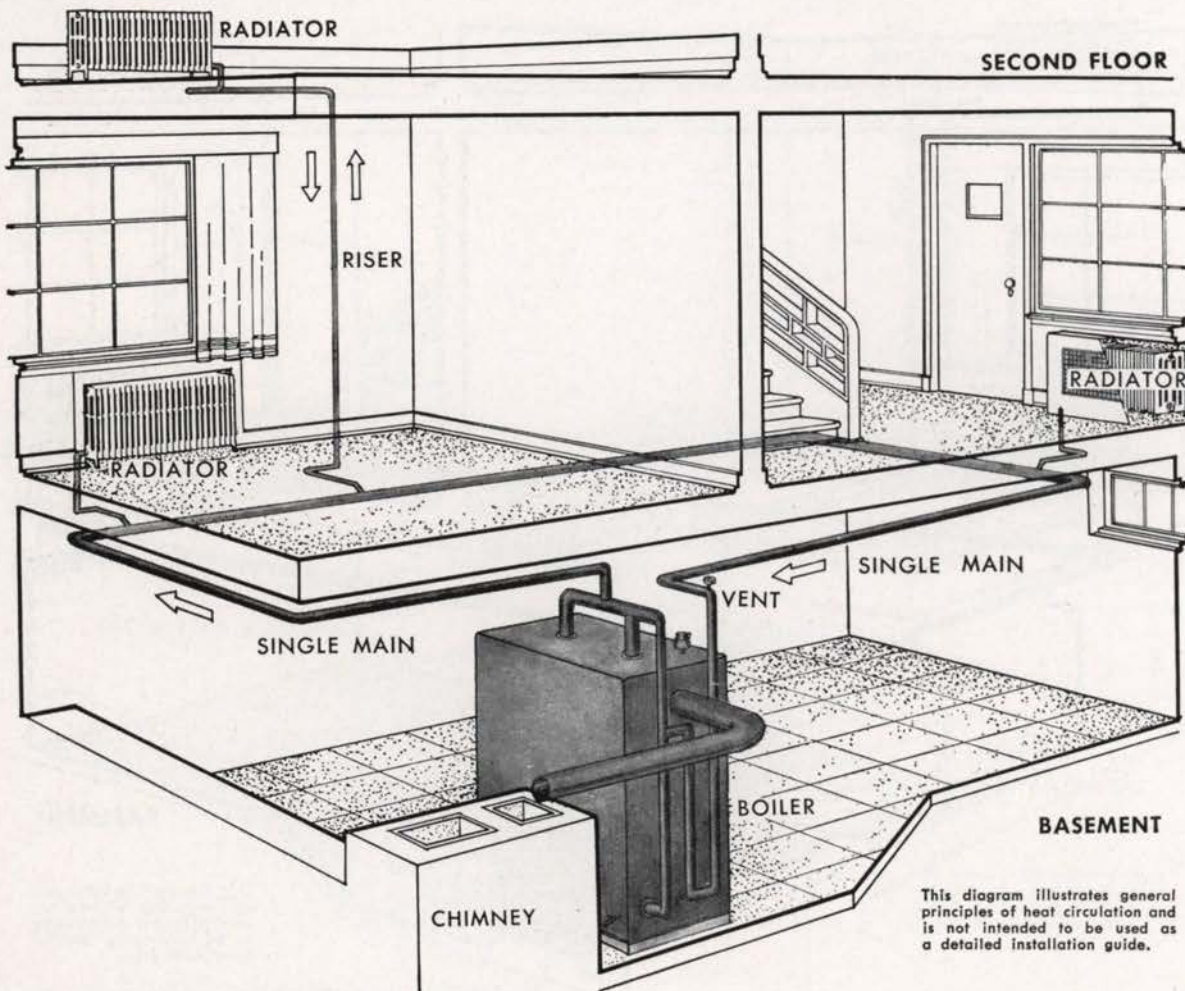
The heating system may be used to provide **year-round domestic hot water**, when heating coils are installed in the boiler.

## DESIGN AND INSTALLATION

One-pipe systems should be designed and installed in accordance with the "I=B=R Installation Guide No. 1," for forced-circulation hot-water heating systems; published by the Institute of Boiler and Radiator Manufacturers, 60 E. 42nd St., New York 17, N. Y. Price 25¢.



# ONE-PIPE STEAM HEATING SYSTEM



## HOW IT OPERATES

Steam is generated in the boiler, and as it rises through the single main and individual risers to the radiators, it forces the air out of the system through air valves, or vents, located on each radiator and at the end of the main. The steam is condensed in the radiators, and the water, or condensate, is returned to the boiler through the same pipes. Since both steam and water are present in the main, the pipes must be somewhat larger than those of other boiler systems, and the slope or pitch must be very accurately maintained in order to avoid water pockets and "hammer," or pounding, in the mains.

## DISCUSSION

This type of heating system is *economical to install*, making it suitable for low cost homes.

It has *no motors or electrical connections* other than those required if controls and burners are used.

The disadvantage of this system lies in the fact that the *heat cannot be modulated or varied*. The steam must be all-on or all-off, in order to prevent the radiators from filling with water. Hence the system is *not as responsive to changing demands* as the two-pipe steam (see *opposite page*) or hot-water systems.

The boiler must be located below the level of the rooms to be heated, which makes this system *unsuited to basementless houses*, or to the heating of isolated basement rooms such as recreation rooms and laundries.

*Maintenance* consists of checking the operation of the air vents on each radiator, and in maintaining the level of water in the boiler.

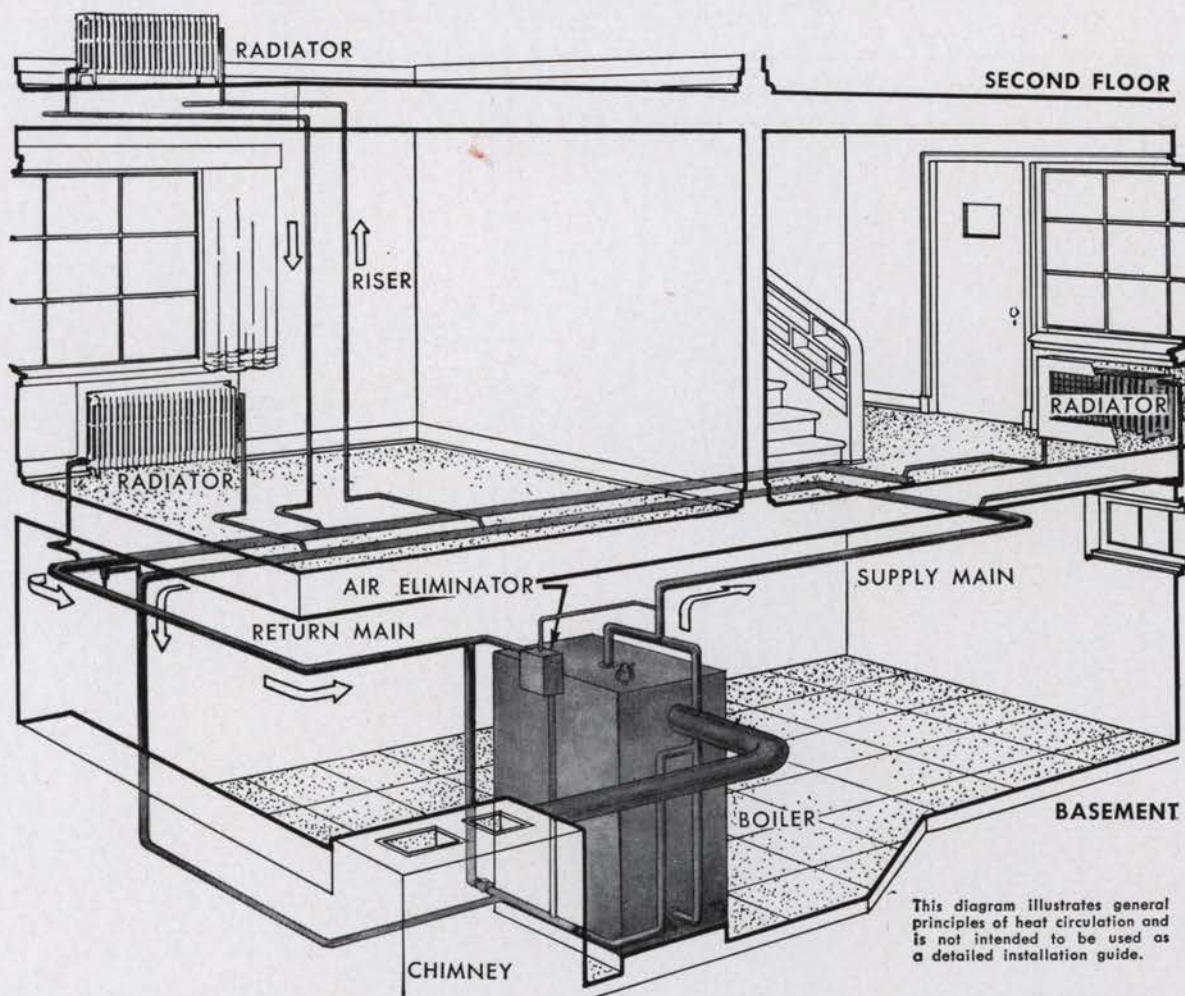
If heating coils are installed in the boiler, *domestic hot water* may be obtained from the heating system *all year round*.

## DESIGN AND INSTALLATION

This system should be designed and installed in accordance with the "I=B=R Installation Guide No. 2," for one-pipe steam heating systems; published by the Institute of Boiler and Radiator Manufacturers, 60 East 42nd St., New York 17, N. Y.



# TWO-PIPE STEAM OR VAPOR SYSTEM



## HOW IT OPERATES

Steam, generated in the boiler, rises through supply mains and risers to the radiators, forcing the air in the system through thermostatic traps which are located at the radiator outlets. These traps are designed to pass the air and water, but not the steam, into return mains, where they proceed to an air eliminator which expels the air through a vent and allows the water to return to the boiler. In this way the air may be kept out of the system for a number of hours, and the boiler may generate steam (vapor) in a partial vacuum, with a correspondingly reduced steam temperature. Since there are separate supply and return mains, the supply valve can be partly opened without the danger of having the radiator fill with water. Thus, in this system, there are two points at which the temperature may be controlled: (1) The boiler, where a variation in steam temperature is possible, and (2) the radiator, where the amount of steam admitted can be varied.

## DISCUSSION

This system usually *costs more to install* than the one-pipe steam or the hot-water systems. It requires special traps and valves, as well as separate supply and return mains. It is extensively used in larger residences and public or commercial buildings.

*Maintenance* consists of regular check on water level in the boiler.

The system is *not suited to a basementless*

*house*, or to the heating of isolated basement rooms, without the addition of a condensation pump which returns the condensed steam to the boiler, or a vacuum pump which maintains reduced pressures in the system. These pumps add materially to the cost of the system.

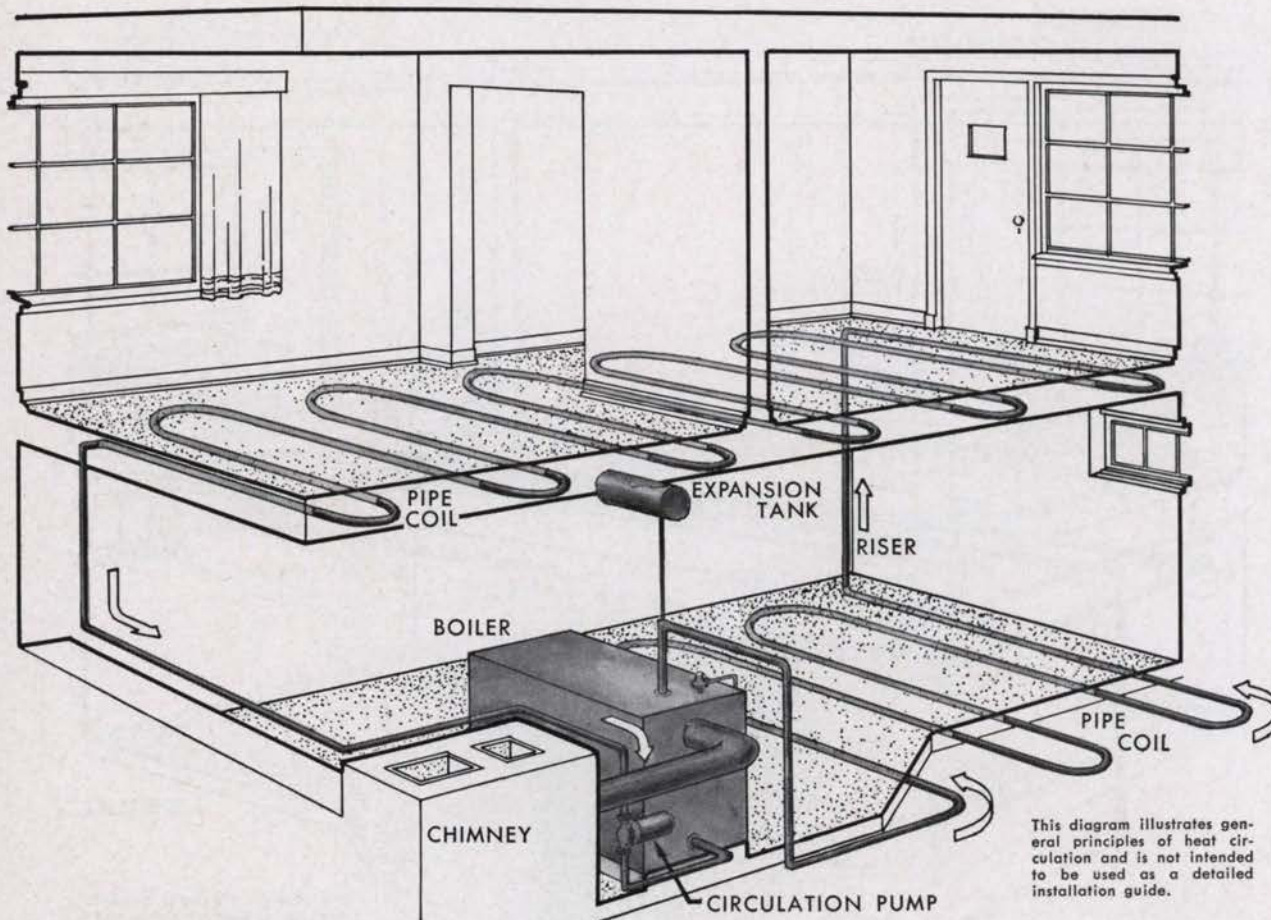
If heating coils are installed in the boiler, *domestic hot water* may be obtained from the heating system *all year round*.

## DESIGN AND INSTALLATION

The successful operation of this system depends on correct design and installation. This can be assured by hiring competent men who have had experience with steam and vapor heating systems.



# PANEL HEATING SYSTEM



## HOW IT OPERATES

In this system, the building structure itself is heated directly with pipe coils (shown above) or with warm air ducts, located beneath the surfaces of ceiling, floor or wall. The heated surfaces, in turn, warm the objects and the air in the rooms. Either hot water, steam, or warm air may be used. With a panel system there are no heating units, such as radiators or registers, visible in the living quarters. Buildings are designed for maximum temperatures of 85 degrees for floors, and approximately 115 degrees for sidewalls or ceilings. The actual air temperatures required for comfort are close to 70 degrees Fahrenheit.

## DISCUSSION

The panel system is well adapted to basementless houses, but usually costs more than the conventional systems, since the house must be specifically designed for the heating plant.

A conventional boiler or furnace is used.

It is adapted to ordinary thermostatic controls, but may be subject to overheating or underheating during periods of rapid outside temperature change. This is especially true if extensive masonry slabs are heated.

## DESIGN AND INSTALLATION

Panel heating systems are still in the development stage, and require careful designing by experienced engineers who are familiar with this type of heating.

## RADIANT HEATING SYSTEM

In the true radiant heating system heat is "radiated" from glowing surfaces, such as electrical coils, whose temperatures are of the order of 1200 degrees Fahrenheit or higher. In such a system heat is localized, and the heating elements must be carefully placed in order to avoid "hot spots." The air temperature may be maintained well below 70 degrees Fahrenheit and still permit the direct radiation to provide comfort.



COMMON FORM OF RADIANT HEAT