Selecting a Heating System for Your Home

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Selecting a Heating System
for Your Home

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This bulletin is prepared to assist a family in the selection of a heating system for their home. It should help them choose the type of system that will best serve their need. No attempt is made to show methods of design or detailed installation procedures. In many cases, however, methods of installation are illustrated.

Emphasis is placed on explanation of the principle of operation of the various heating systems. Advantages and disadvantages of each are listed. Degree of owner satisfaction is discussed. Relative costs are considered—including initial installation costs and operation and maintenance costs.

The types of heating systems presented have all been tested and proved successful when properly installed and serviced. Some show a greater degree of comfort and satisfaction than others.

An adequate and satisfying system of heating is important. It may be the difference between a home that is comfortable, inviting, and relaxing, and one that is just livable.

Factors to Be Considered

There are several points to be considered in selecting a heating system. Chief of these are initial cost, operation and maintenance cost, convenience, and durability. The system should be capable of maintaining comfortable temperatures, be easily controlled, and require a minimum of attention. If the entire house is to be heated, these requirements are best met by a central heating system; that is, a system where the heat is centrally produced in a boiler or furnace and distributed to the various rooms by means of air ducts or water pipes. This allows for a direct flow of heat to each room of the house.

Two costs: original cost and operating cost

In selecting heating equipment for a new house or for the modernization of the old house, the homeowner should remember that there are two costs to be considered—original cost and operating cost. The cheapest heating system from the standpoint of original cost is not always the least expensive to operate.
A few dollars difference between dependable, well-made equipment and something that will have to be replaced within a few years is very small when compared with the annual expense of fuel.

Advice of an expert helpful

It is advisable to secure the services of a good heating contractor to help with the planning and installation of the heating system. If the system is to give satisfactory service, it must be adequate in size and properly installed. The heating contractor will help with these problems.

Methods of heat transfer

Within the room itself, heat is transferred from the radiator, register, stove, or other heating element to the room occupants by one or more of the three heat transfer methods—conduction, convection, and radiation.

- **Conduction.** The handle of a frying pan becomes hot to the touch of the hand even though the handle has not been in contact with the fire. Heat is conducted through the metal.

- **Convection.** An automobile heater heats air, which in turn is circulated around the passengers, warming them. Heat from the heater reaches the passengers by convection—movement of warm air.

- **Radiation.** The heat we get from the sun is radiated to the earth. Heat travels from hot or warm bodies directly through space to bodies of lower temperature. This is heat by radiation.

Some systems rely almost entirely on heat by convection—movement of warm air, while others depend primarily on radiant heat. Many systems use a combination of both radiant heat and convected heat. A family will want to consider which type of heat they prefer when selecting the heating system.

Kinds of heating systems

There is a large selection of heating systems from which to choose. The proper selection is important. Once a system is installed in your home it will be expensive to convert to some other type of heating system. If you are considering a type of system that is relatively new to the market, you should check it in actual operation to determine its merits. The heating contractor or dealer can usually arrange for you to visit a home which has such a system.
Types of residential heating systems commonly available on the market are as follows:

- Heating stoves
- Floor furnaces
- Wall heaters
- Warm-air central heating
- Hot-water central heating
- Steam central heating
- Baseboard heating
- Radiant panel heating
- Heat pump or reverse-cycle heating
- Various types of electric heating
- Fireplaces

Available heating fuel

The owner should consider the types of heating fuels available and relative costs of each, and select the heating system designed to burn efficiently the kind of fuel that he plans to use.

Heating Stove

The heating stove depends on natural circulation of warm air as a means of heat distribution. The air around the heating stove gets warm. The warm air rises and circulates throughout the room as illustrated in Figure 1. Cool air moves along the floor toward the stove. It infiltrates into the heater near the floor, replacing warm air that is continually given off around the upper portion of the heater.

The heating stove quickly warms the air in the room. It more slowly warms the walls and floor. As the air in the immediate room becomes warm, it flows slowly about the house. It gradually replaces the cold air even in the distant rooms. The cold air is forced down to the floor as the warm air gradually fills the upper portion of the room. The cold air, coming from all rooms in the house, moves along the floor to the centrally located stove. This blanket of cold air creeping along the floor makes the floor cold. It separates the floor from the warm air above. Therefore, relatively cold floors can be expected in the home that depends on a heating stove. In a more elaborate central heating system, this long passage of cold air is not required. The heating stove cannot be classified as a central heating system.

Continuous operation of the heating stove will provide a fair amount of heat in all rooms. The room in which the heater is lo-
cated, however, will always be the warmest. Natural circulation of warm air from the heating stove usually provides poor circulation and poor distribution of heat. Parts of the house may be overheated while other parts are almost unheated.

**Advantages of a heating stove:**
- Permits rapid heating of immediate room.
- Simple to install.
- Low in first cost.

**Disadvantages of a heating stove:**
- Requires burning of the fuel in the room, which is undesirable.
- Frequently causes overheated surfaces.

Figure 1. The heating stove depends on natural circulation of warm air for heat distribution. Result is uneven distribution of heat with parts of the house being overheated while other parts are underheated.
Inadequate circulation of air, resulting in drafts and uneven heat distribution.
- Takes up important space in room.
- May require the handling of fuel and ashes in the house resulting in dirt, inconvenience, and sometimes the presence of noxious gases in the room.
- Not usually adapted to automatic controls.
- Relatively high fire hazard.

Heating stoves usually burn wood, coal, oil, or gas.

With the numerous disadvantages of the heating stove, this type of heating unit is not too satisfactory. For a small, compact house, however, where all rooms to be heated closely adjoin the room in which the stove is located, fairly satisfactory room temperatures may be obtained at minimum expense. An open-style house plan similar to the one shown in Figure 2 is best suited to this type of heating system.

Figure 2. A small house with a compact arrangement of rooms may be satisfactorily heated with a heating stove if it can be centrally located in the house as illustrated.
Floor Furnace

The floor furnace is designed to fit beneath the floor with only the register at floor level, taking very little room space. No basement is required, although a small pit beneath the floor is sometimes necessary.

Figure 3. The floor furnace is installed beneath the floor with register at floor level. Fuel line at left brings fuel from storage tank for automatic firing. Combustion gases are carried through lateral vent pipe at right to chimney flue.
The floor furnace warms by convection in much the same way as the heating stove. The furnace, being located below the floor level, directs the warm air upward into the room or rooms. The warm air circulates about the house, forcing the cooler air down toward the floor. The cool air creeps along the floor and into the furnace around its perimeter. This air, in turn, is reheated and again directed upward into the room. The floor furnace is not a central heating system.

In general, a better distribution of heat is obtained from a floor furnace than from a stove. The fact that you can put the floor furnace in a hallway, as illustrated in Figure 4, allows it to heat more than one room, permitting better heat distribution. Two or more floor furnaces may be used to provide more uniform temperatures throughout the house.

The dual wall register type of floor furnace, shown in Figure 5, is used to good advantage in many homes. In such cases, the floor furnace is located directly beneath the partition wall and delivers heat to separate rooms or separate areas of the house. Heat regu-
Figure 5. The dual wall register type of floor furnace is located beneath the partition wall with heat delivered directly to more than one room.

Valves are located in the face of the register so that finger tip control divides the heat flow into each separate room as desired.

Oil or gas fuel is normally burned in the floor furnace. The furnace must be vented to a standard chimney flue or to a flue made of other accepted noninflammable venting material. Lateral vents should slope upward at least \( \frac{\frac{1}{4}}{1} \) per foot to the vertical flue. Lateral vents more than 10 feet in length should be insulated. The insulation will prevent condensation of moisture within the pipe and preserve the life of the lateral vent pipe.

**Advantages of a floor furnace:**

- Basement not required.
- Requires little room space.
- Possibility of more advantageous location, such as in a hall, than that of the heating stove.
- Low first cost, although slightly more costly than a heating stove.
- Adapted to automatic controls.

**Disadvantages of a floor furnace:**

- Requires burning of the fuel in the vicinity of the room.
- Inadequate circulation of air—does not provide even heat distribution to all rooms of the house.
- Adapted to liquid and gaseous fuels only, with exception of those furnaces that operate on electric energy.
The floor furnace, although not a central heating system, gives quite satisfactory service when properly installed and properly located in the house. You cannot expect it to give the uniform heat distribution, however, which you would enjoy with a central heating system.

For a ranch-type house or any large home two or more floor furnaces are required to provide uniform temperatures throughout the house. The bathroom is usually cold when either a floor furnace or a stove is used to heat the home.

**Wall Heater**

Efforts to obtain the comfort of a central heating system at a smaller expense than the central system led to the development of the wall heater. The wall heater is so named because it is designed to be placed within the wall. Each wall heater has a cool-air intake and a warm-air outlet grille. The warm and cool air grilles may be located in one or more rooms depending on the location of the wall heater in the home.

The gas fired wall heater, Figure 6, is designed to be placed in a partition wall between two rooms or between a room and a hallway. Heat can then be emitted directly into each of the two rooms or areas. Hand controls make it possible to regulate the amount of warm air directed into each room. One grille may be completely closed, if desired, forcing all the heat in one direction. Single unit wall heaters which deliver warm air in one direction only are also available.

The wall heater contains a small furnace or heating element within itself. Cool air is drawn into the lower wall grille near the floor. The air is heated as it passes upward through the wall heater past the heating element. The warm air then passes out through the upper grille and circulates about the room. Wall heaters range from four feet to eight feet in height and vary considerably in size and heating capacity. The wall heater illustrated in Figure 6 has an output rating of 31,500 BTU’s per hour. Two heaters of this capacity would heat a moderate sized house.

The greater depth of the wall heater as compared to the stove or floor furnace gives definite advantages. The vertical distance between the cool-air intake grille and the warm-air outlet grille serves as a vertical flue within the wall heater. It creates a more rapid upward movement of air and therefore a greater discharge velocity. The greater air velocity is desired, within reasonable limits, as it provides a better circulation of air throughout the room. This type of wall heater, however, is not classified as a central heating system.
Figure 6. This gas fired wall heater fits in a partition wall delivering heat in one or both directions. Grilles at top and bottom remove slightly cooled air from the room and exhaust heated air back into the room.

because it does not provide a means of delivering warm air directly to all rooms to be heated.

The heater illustrated in Figure 8 is a wall heater when installed as illustrated. It is designed for installation in a corner of a room or hallway, or to be furred directly into the wall construction. The full floor to ceiling height gives a greater circulation of air than the smaller wall heaters. It is possible to connect the warm-air outlets on this heater to duct work which will carry the warm air through the attic to individual rooms of the house. When this is done, the heater is classified by the Underwriters Laboratories, Inc., as a central heating furnace.

The wall heaters discussed thus far depend on gravity flow of air for heat distribution. It is well known that warm air rises while
Figure 7. Two wall heaters installed to give adequate heat to all rooms of the house. Two small heaters will give a more uniform distribution of heat about the house than one large heater.

cold air is heavier and settles to the floor. Several manufacturers make a wall heater which utilizes a blower to direct the air into the room. This forced-air type of wall heater provides a more complete circulation of air throughout the house.

Advantages of a wall heater:
- More economical to install than central heating systems.
- Better circulation of air than obtained from stove or floor furnace.
- Requires small amount of floor space.
- Basement not required.
- Adapted to automatic controls.

Disadvantages of a wall heater:
- Does not provide even heat distribution to all rooms of the house.
- Adapted to liquid and gaseous fuels only.
A wall-heater type of heating system is generally believed to give greater satisfaction and more comfortable living to the owner than either the heating stove or floor furnace. The comfort and satisfaction, however, depend greatly on the quality of each type of heater installed. The wall heater cannot be expected to give the comfort and satisfaction provided by a central-type heating system unless more than one heater is installed.

Electric unit heaters would logically come under the classification of wall heaters. All methods of electric heating, however, are discussed together in a later section of this publication.

**Warm-Air Central Heating System**

In a central heating system the necessary heat for warming the home is produced in a furnace, boiler, or other heating element and is delivered by direct means to the various rooms of the house. The heat-producing element may be located in the basement, in the attic,
or in a first floor room. The heat is delivered to the various rooms of the house through ducts or pipes, depending on the type of system used.

A warm-air central heating system has a furnace in which to heat air. The warm air is delivered to the various rooms in the house through warm-air ducts. The cold air in each room is returned to the furnace through return-air ducts. This provides a continual change of air in the rooms with the cool air being replaced by warmer air.

A nationwide 1949 survey by *Better Homes and Gardens* magazine indicates that 60 per cent of all new home owners in the United States heat their homes with warm-air central heating systems.

Warm-air central heating systems are one of two types, gravity warm-air or forced warm-air systems.

**Gravity warm-air system**

The gravity warm-air central heating system consists of a furnace in which the heat is produced, and air ducts through which warm air and cool air move to and from the rooms by means of gravity flow. These ducts discharge the warm air into the rooms through registers located in the wall near the floor. Cool air in the room sinks into the cold air registers placed in the floor or in the walls near the floor. The cool air is returned through cold-air ducts to the furnace where it is warmed and recirculated. The circulation of air depends upon the difference in weight between warm air and cold air. For this reason, the furnace of a gravity warm-air system should normally be located below the lowest room to be heated.

In order to insure as good performance as possible with this type of heating system, the furnace should be centrally located in the basement, which reduces the length of lateral air ducts and aids materially in the proper distribution of warm air. All duct work must be of sufficient capacity to insure circulation of the air through the system.

The gravity warm-air system is probably the cheapest central heating system to install and maintain. The fuel cost for operation, however, is probably greater than that for a forced circulation warm-air system where more uniform heat distribution is obtained. The gravity system can be expected to give better heat distribution and more comfortable living conditions than a stove, floor furnace, or single wall heater. An air filter cannot be used satisfactorily with the gravity warm-air system.

The gravity type heater illustrated in Figure 8 may be installed either as a wall heater or as a gravity warm-air central heating system. In order for it to become a gravity warm-air central heating...
system it must be equipped with warm air ducts to carry the heated air directly to the rooms. This is one of the few gravity warm-air systems designed for installation on the ground floor level. The full floor to ceiling height of the furnace provides a vertical flue up which the warm air rises rapidly, giving the air enough velocity to carry it through the warm air ducts to the various rooms.

In spite of the recent improvements in gravity systems, the great majority of warm-air central heating systems being installed today are of the forced circulation type.

**Forced warm-air system**

Warm-air systems with forced circulation (Figure 9) are more expensive initially than the gravity systems but they have certain advantages. The furnace does not have to be below the rooms to be heated, nor centrally located, because circulation of air is controlled by a fan or blower. The greater air pressure of forced circulation means that an air filter may be used to clean the air, ducts may be longer and narrower, may run horizontally and need not all be the same length.

In the forced-circulation system, the air circulation is positive and can be accurately proportioned to each room. It is quicker in response to heating demand than the gravity system.

The conditions of comfort obtained in a room heated by a forced warm-air system are influenced greatly by the type of register used and the location of the supply registers and the return grilles. In general it has been found that changes in the type, air velocity, and location of the supply register affect the room conditions much more than the changes in the location of the return grilles. One method is to locate the supply registers near the floor, or high in the side wall on an inside wall, and the return openings near the greatest outside exposure. Another method is to locate the supply register near the floor, or high on the exterior wall, so that the warm air from the register blankets a cold wall, and mixes with the cold air descending from the exposed walls and glass. Of the two, the latter method seems more popular in the newer installations. Still another method is to place the supply register in the floor about 8 inches from the exterior wall with the warm air directed upward blanketing the cold wall. In any case, the warm-air registers should be located so that the air stream never discharges directly into space that will normally be occupied by people at rest. Tests in warm air research have indicated that continuous blower operation gave better results than intermittent operation.

A recent development in warm-air central heating is the use of “high velocity” air ducts to carry the warm air from the furnace to
the rooms to be heated. Several major manufacturers of heating equipment now incorporate the "high velocity" air ducts in their warm-air systems. The "high velocity" air duct is so called because the air is forced through a small duct at a rapid rate, creating a higher velocity air movement within the duct than in the larger air duct. With this system, a special warm-air register, or some other means, is used to diffuse the air to reduce its velocity where it enters the room. This prevents excessive warm air blasts and drafts.

Figure 9. A forced-circulation warm-air central heating system with furnace located in the basement. Warm-air ducts carry the warm air to each room of the house. Cold air grilles located in each room remove the cool air from the floor and return it through return air ducts to the furnace where it is reheated. This circulation of air is forced by means of a blower.
A warm-air central heating installation using “high velocity” air ducts and a modified system of cold air returns. A blend-air mixing chamber reduces the velocity of the air before it enters the room. In this first-floor installation the insulated air ducts located in the attic carry warm air to the concealed mixing chamber or blender in each room.

The “high velocity” air ducts are round, being 3½ or 4 inches in diameter. They fit easily between the wall studs and are equipped with flexible connectors for easy installation. A principal advantage of the smaller, higher velocity air ducts is the reduced cost of ductwork. Figures 10 and 11 show examples of “high velocity” air ducts with a special blender type register. Other manufacturers use different types of warm-air registers to obtain the necessary diffusion of the air as it leaves the high velocity air ducts.

“Perimeter heating” is a term often heard in residential heating. Perimeter heating is a recent adaptation of conventional heating methods. Almost any system of home heating that releases the heat into the rooms along the exterior wall may be referred to as perimeter heating. Some systems release heat the full length of the exterior wall—as in the case of hot-water baseboard heating and the less common warm-air baseboards. Other systems use only a single hot-water convector or warm-air supply grille in each room, located along an exterior wall. All of these systems may be referred to as perimeter heating.
Figure 11. A basement installation of the furnace illustrated in Figure 10 using a cabinet type of blender. This style of blender simplifies installation in an existing house. The recessed type of blender can also be used.

The idea of placing a blanket of warm air along the windows and the exterior walls as is done in the warm-air perimeter heating systems, is a sound principle. The blanket of warm air intercepts infiltrating cold air, mixes with it, and reduces cold drafts. The ducts carrying warm air from the furnace to the supply grilles usually are located in the floor in concrete-slab buildings and beneath the floor in joist construction.

In the case of forced warm-air heating of the house with a crawl space below the floor, there are two different methods of handling the warm-air ducts. One method is to insulate the warm-air duct to avoid a loss of heat in a well-ventilated crawl space. The other method is to seal the crawl space by covering the ground with a 2- or 3-inch layer of concrete and close the crawl space vents during the heating season. With uninsulated warm-air ducts a certain amount of heat lost to the crawl space will help warm the floor above. The latter method is becoming popular, but it must be remembered that this method is not suited where the crawl space does not have adequate drainage to keep it dry.
Figure 12. Three forced warm-air perimeter heating layouts. Top—The extended plenum with lateral supply ducts, for installation beneath joist floors. Center—Radial duct system for joist or concrete floor. Bottom—Perimeter loop system with radial supply ducts, for concrete slab floor construction.
For a small home the single, centrally located return air grille serves satisfactorily. With a larger house, or when more complete air exchange is desired, additional return air ducts will be desirable.

Advantages of the forced warm-air central heating system:

- It is less expensive to install than other equivalent systems such as hot-water or steam central heating, and radiant panel heating.
- It provides reasonably even heat distribution to all rooms of the house with properly located supply registers and return grilles.
- The forced air movement used in the system makes it possible to keep clean, fresh air throughout the house. Moisture may be added to the air if a higher humidity is desired.
- The forced warm-air furnace readily adapts itself to automatic controls and automatic firing.
- The furnace may be satisfactorily installed on the ground floor or in the attic. Thus, it is well suited to a basement-less house.

Disadvantages of forced warm-air central heating system:

- There is a definite temperature drop of a few degrees between the time the thermostat cuts off the flow of warm air and again turns it on. This is true in all automatically controlled systems but it is slightly more noticeable by the occupant of the room with a warm-air system than with a hot-water system.
- The temperature drop and heat loss between the furnace and the room supply register is greater than that between the boiler and room convector in the case of a hot-water system. This is a definite disadvantage for warm-air heating in the long, spread out house.

The furnace for a central heating system may be designed to burn wood, coal, sawdust, oil, or gas. Attic installations would be limited to liquid and gaseous fuels. The forced circulation warm-air heating system can reasonably be expected to provide greater comfort and more satisfaction to the owner than a heating stove, floor furnace, wall heater or a gravity warm-air system. It is a very popular type of heating system in modern homes.
Hot-Water Central Heating System

The hot-water central heating system uses hot water to convey heat from the boiler to radiators or convectors located in the rooms of the house. It consists of a fuel burning boiler which is connected by a system of pipes to radiators or convectors in the individual rooms. The boiler, piping, and radiators, or convectors are filled with water. The water is heated in the boiler. It is then circulated through the system of pipes to the various radiators or convectors throughout the house where it gives off heat. The cooler water then returns to the boiler to be reheated and recirculated.

Figure 13. A two-pipe hot water central heating system equipped with pump for forced circulation. The supply main carries hot water to each radiator or convector. Cool water is returned to the boiler through the return main. The forced circulation system can be satisfactorily installed in the utility room or other first floor area if desired.
Recent developments in hot-water heating include the recessed and concealed type convectors which are rapidly replacing the open style radiator. This attractive recessed convector has concealed pipes and controlled air circulation. It requires less room space than the free standing radiator.
Hot-water radiators or convectors are used in the room itself to transfer heat from the hot water to the air in the room. Radiators are normally made of cast iron. They usually sit on the floor close to the wall and below a window. The radiator is not designed to be recessed into the wall and requires special insulation when so used. The radiator transfers heat into the room by radiation and by convection air currents.

Convectors are designed to be set directly against the wall or to be recessed into the wall as illustrated in Figure 14. Convectors usually contain finned tubes through which the hot water is circulated. The coils, or finned tubes, warm the air that comes in at the bottom and flows out at the top. The major heating surfaces are not exposed to the room. Convectors are rapidly replacing radiators in hot-water systems.

Hot-water central heating systems, like the warm-air systems, may be either gravity or forced circulation.

Gravity hot-water system

Gravity hot-water systems depend upon the difference in density between hot and cold water for the circulation of the water. Water heated in the boiler becomes lighter and rises as the heavier, cold water of the heating system moves in to lift it. As this process continues in the boiler the heated water flows up to the radiators or convectors and in giving off its heat there it cools and returns by gravity to the boiler. It is then reheated and recirculated.

Forced-circulation hot-water system

In the forced-circulation hot-water system a pump is used to circulate the water to the various radiators or convectors in the house. The gravity systems are rapidly becoming obsolete; the trend is almost entirely to the forced-circulation systems.

The pump, motor, and controls of a forced-circulation system add to its cost over a gravity system. Smaller pipes can be used, however, resulting in less heat loss than in the larger pipes of the gravity system where the flow may be slow and uncertain.

Radiators cannot be located below the boiler in the gravity system, while water can be satisfactorily pumped anywhere in the house with the forced-circulation system. The forced system can be installed on the first floor of a basementless home.

The forced-circulation system may be either a one-pipe system or a two-pipe system, while the gravity system usually is a two-pipe system. In a one-pipe system, the water main makes a complete circuit from the boiler, about the house, and back again. Two risers
extend from the main to each radiator or convector. Water is diverted through the radiator by means of a scoop fitting or other device.

The one-pipe system takes less pipe than the other, but it has a disadvantage. The water that has passed through one radiator and cooled is mixed with the water flowing through the main, so that each succeeding radiator receives cooler water. Allowance for this must be made in choosing the right size for radiators or convectors. This is a job for an experienced heating engineer or contractor.

With a two-pipe system, hot water is delivered to each radiator or convector through the hot water main. A second pipe—the cold water return—collects cool water from each radiator or convector and returns it to the boiler to be reheated.

Forced hot-water heating probably ranks second to warm-air heating in popularity for residential heating in the United States. It is a central heating system.

**Advantages of forced hot-water central heating systems as compared to warm-air, steam, and other central heating systems:**

- It has less heat loss between boiler and radiator or convector than between the furnace and register used in the warm-air system. It also has a smaller heat loss than that encountered with a steam system. This low heat loss in distribution of heat makes it ideal for use in large, rambling houses where heat must be conveyed over a great distance.

- Surface temperature of the radiator or convector is lower than that for steam; therefore, less chance of burns.

- Pipes and radiators are free of disturbances (hammering) which are not uncommon in steam installations.

- Better adapted to hand firing (if desired) than the warm-air system, as heat stored in the water prevents rapid drop in room temperatures during periods when the fire is low.

**Disadvantages of forced hot-water system as compared to warm-air and steam central heating:**

- High first cost. A hot-water system can be expected to be 25 to 35 per cent more expensive to install than a warm-air system.

- Radiators or convectors, common to both hot-water and steam systems, may interfere with placement of furniture and with the cleaning of the house.

- Hot-water pipes are subject to freezing if the furnace fire dies out.

- Air humidity and circulation of air are not as readily controlled as in a warm-air system.
A hot-water central heating system may be expected to provide the same comfortable living temperatures throughout the house that one would expect from warm-air or other central heating systems. Radiant panel heating and baseboard heating are other methods of central heating which may rely on hot water as a medium of heat distribution. Each of these methods of heating is discussed later in this publication.

Steaming Central Heating System

Another type of central heating uses steam as the carrier of the heat from the boiler to the space to be heated. Water in the boiler is heated into steam. The steam flows in pipes to radiators which are located in the various rooms of the house. The steam gives off heat while in the radiator and condenses into water. If the water drains back to the boiler through the single pipe which delivers the steam to the radiator, it is known as a one-pipe steam heating system.

Other steam-heating systems have a pipe delivering steam to the radiators and a second pipe through which the water returns to the boiler. Such a system is known as a two-pipe steam and vapor system. The two-pipe system has a greater initial cost, but it is more efficient and more dependable.

Steam heating systems have very few advantages over hot-water and warm-air heating. At the same time they have the disadvantages of being slightly more expensive to install, having the undesirable higher surface temperature at the radiator, and being subject to noise disturbances in the return pipes.

A very small percentage of residences are heated by steam. It is better suited to auditoriums, schools, and large buildings.

Baseboard Heating

Baseboard heating is a hot-water or steam-heating system in which baseboard convectors replace the standard wall convector. As hot water is more common than steam in this type of system, all following discussion on baseboard heating will be in reference to hot-water baseboards.

In baseboard heating, a boiler is used to produce the hot water the same way it is produced for conventional hot-water systems. This hot water is forced, by a pump or circulator, through convector heating elements within specially built metal baseboards. The baseboard runs in a continuous loop around the exposed walls of the house with a separate loop for each floor (see Figure 15). Base-
Figure 15. Drawing of cutaway house showing typical installation of baseboard heating in a two-story residence. System is installed in the form of a loop, one for each floor. This system requires less piping than the conventional hot-water heating system. The heating element is also the heating main.

Board heating is sometimes called “perimeter” heating because the convectors or heating elements are located around the perimeter of the house. It is normally not necessary to use the baseboard on interior walls.

A finned heating element fits behind the specially designed metal baseboard along the exposed walls of each room. Air enters through a space below the baseboard enclosure. It passes over the heating element, is warmed, and comes out at the top as is illustrated in Figure 16. This is convector baseboard heating.

Some manufacturers make “radiant” baseboards. The radiant baseboard is usually made of cast iron. It is heated by water pipes carrying hot water through the baseboard. The baseboard in turn radiates heat to the room.
Figure 16. Drawing shows air movement in hot-water baseboard design. Air enters at floor line, is warmed as it passes over heating element, then comes out the top just below metal molding. Partially flattened heating element reduces necessary thickness of baseboard. Overall size of baseboard is 2½ inches by 8½ inches.

Both the convector baseboard and the radiant baseboard give some heat by radiation. Each also heats by convection or by air currents. The radiant baseboard emits a higher percentage of radiant heat and a smaller percentage of heat by convection than does the convector baseboard.
Baseboard heating is relatively new. It is a central heating system, as it delivers heat directly to each room of the house. Baseboard heating is making rapid progress in the field of residential heating. It is also used very satisfactorily in larger public buildings.

The baseboard units which fit against exposed walls of each room may vary from 2 inches to 3\(\frac{1}{2}\) inches in thickness, and are approximately 8 or 10 inches in height. This is all the space required in the room for the convvector or heating element. In most cases the baseboard may be painted to harmonize with the color scheme in each room.

Baseboard heating is a new adaptation of a tried and proved method of heating—forced-circulation hot-water heating. Sound heating principles are applied and the cost of installation is not excessive. One can expect to install baseboard heating for no more than the cost of other hot-water systems, and in many cases, as much as 10 to 20 per cent less.

**Advantages of baseboard heating:**

- Simplicity of piping saves on installation cost, as compared to other hot-water systems.
- Baseboard convvector is located along the exposed wall and intercepts cold air as it enters the house, thus eliminating cold spots in the room. It also tends to keep exterior walls warm.
- Heat source is distributed full length of one wall in the room instead of being concentrated in one spot. This helps to eliminate the cold floor problem in basementless homes.
- The heating element is also the main distribution pipe. This eliminates separate distribution pipes in basement or beneath house.

Baseboard heating has the disadvantage of possible freezing pipes if the furnace fire dies out the same as in other hot-water systems. In the kitchen where wall space may be covered by base cabinets, it may be necessary to install an ordinary wall convvector.

Homes relying on baseboard heating can be expected to have at least the same degree of comfort and satisfactory heating conditions that would be obtained from other central heating systems.

**Radiant Panel Heating**

Radiant heating is as old as history. Recent discoveries have found that the ancient Koreans used the principle of heating their dwellings by an indirect method. Excavations at Rome show that the
Figure 17. Radiant panel heating in a two-story residence with basement. Heating tubes may be installed in floor, walls, or ceiling with floor and ceiling installations being more common. Rooms are warmed by heat being radiated from heated floor or ceiling panel.
Romans were familiar with its use, and heated by means of masonry ducts beneath floors and within walls.

Radiant panel heating is a system of heating a room by raising the temperature of one or more of its interior surfaces (ceiling, floor, or walls) instead of heating the air—primarily a radiant heat. The tubes carrying the heat are placed in the ceiling, floor, or walls to form a heated panel.

During recent years, a great deal of research and development work has been conducted on this type of heating. Radiant heating installations are in operation throughout the country and are quite common in many areas.

There are two generally known types of radiant panel heating—electric and hot water; the hot water panel is the more common.

In electric radiant panel heating, the radiant panels are heated by means of electric resistance wire embedded within the panel. This system does not require a furnace, other fuel, or chimney common to conventional types of heating. Although many electric panel systems have been installed, this method of heating is still in its infancy in residential heating.

Radiant panel heating using a network of hot-water pipe within the panel to provide the heat has become quite popular for residential heating. It is a hot-water central heating system with the water being heated in a boiler by any conventional means. This heated water is pumped through circuits of pipes embedded in the various ceiling, floor, or wall panels, heating the panels. The heated panels, in turn, radiate heat to the room. Several pipe circuits are required within a house to insure a balanced heating system. Thermostatically operated controls insure a continuous supply of heat. Copper or steel tubing is commonly used in the hot-water radiant panels, although other pipes may give equally satisfactory service under proper conditions.

Although the wall can serve as the radiant panel, the use of the floor or ceiling panel is more common. In homes and other buildings having concrete slab floors, water pipes embedded in the concrete keep the floor warm and dry as well as providing a comfortable heat. Ceiling installations have also proved to be very satisfactory. When the ceiling is used as the radiant panel, the normal practice is to fasten the tubing to the bottom edge of the ceiling joists directly beneath a metal lath base and cover the pipe with plaster. An optional method of installation places the metal lath beneath the tubing. The plaster panel serves nicely to radiate heat downward into the room. Insulation, preferably of the reflective type, should be placed above the tubing to reflect the heat downward.
The radiant panel heating system must be carefully designed to insure good service. Skilled personnel should be consulted with this matter. When the panels are heated by hot water it is important that the design temperature of the water not be exceeded greatly during operation. Unnecessarily high water temperature in floor installations may be destructive to floor coverings, besides being uncomfortable for the occupants.

**Advantages of radiant panel heating:**
- The heating system is completely hidden in the rooms. The elimination of radiators and grilles gives more floor space.
- There are less restrictions on furniture arrangement.
- Less streaking of dust on walls and ceilings. The lower velocity air currents and absence of high temperature concentrations will eliminate dust streaks.
- Radiant panel heating insures warm floors when coils are installed in the floor.
- Radiant panel heating should provide economical operation due primarily to a smaller heat loss from the house. This reduced heat loss can be expected because of the lower air temperature maintained in the rooms.
- The lower room temperature is believed to be more desirable physiologically.

**Disadvantages of radiant panel heating:**
- Changes in the system, or repairs, are difficult once the system is installed.
- Radiant panel heating does not provide the ventilation and constant circulation of air which some systems provide. However, less ventilation is required with radiant heating because the cooler air seems fresher and is free from the “stuffiness” of overheated air.
- Radiant heating does not respond quickly to rapid temperature changes.

Radiant panel heating systems using hot water as a heating medium can be expected to provide comfort and satisfactory heating conditions that compare favorably with other central heating methods. For homes with concrete slab floors, the floor panel installation should provide greater comfort than most other heating systems. The cost of installation for the radiant panel system is a little more than that for a good warm-air central heating system. It usually is slightly less expensive than the conventional hot-water system.
The Heat Pump or Reverse-Cycle Heating System

Perhaps the most radical new development in home heating in recent years is the heat pump. It burns no fuel and therefore requires no furnace or chimney. Usually, its source of power is electricity. The heat pump utilizes the natural heat of the outside air or earth. Best results have been obtained by using water from the earth as a heat source, but in a mild climate where the temperature remains above 30°F, sufficient heat may be extracted from the air to heat the home. The heat is taken from the water or air by a simple process of reverse refrigeration.

When water is used as the heat source it may be pumped from a deep well taking advantage of the warmth several feet below the surface of the earth. Or, water may be pumped through a network of coil buried in the earth, allowing the water to absorb heat from the earth. Heat for the home is extracted from the water. The process is similar to that used by your mechanical refrigerator in absorbing heat to keep the storage compartment cold. The water comes from the earth at its usual temperature. Well water varies from a temperature in excess of 70°F in southern United States to between 45°F and 60°F in northern United States. A higher water temperature makes it possible to extract more heat from a given quantity of water, thus requiring less water to provide the necessary heat. In other words, the warmer the water, the less water required.

Heat taken from the water is made available for heating the home by the reverse refrigeration process. The heat may then be distributed about the house by the conventional warm-air distribution system or the hot-water system.

The heat pump can quickly and simply be switched from the heating cycle to the cooling cycle, making it a very desirable installation in areas with extreme summer heat. The cooling cycle merely reverses the process, taking cool water out of the earth to absorb the heat in the refrigeration machine, blowing cool air throughout the house and returning heated water to the earth.

The more successful heat pump installations in the Pacific Northwest use well water as a heat source. The water is pumped from the well into the water radiator of the heat pump unit (Figure 18). The water coming from the well will have a constant temperature, usually around 52°F to 55°F. As the water passes over the coils in the water radiator, heat is extracted from it by a cooler refrigerating fluid within the coils. This fluid is usually Freon. After passing through the water radiator of the heat pump, the water will be cooler by about 4 to 10 degrees. The cooler water is wasted into an open stream or disposed of by other means.
Figure 18. Heat pump or reverse-cycle system with heating cycle of unit (top) taking heat from earth by means of water. In the cooling cycle (bottom) the path of the refrigerant is reversed with the hot refrigerant vapor being passed to the water radiator and the air radiator used to vaporize the refrigerant gas.
The refrigerant, in a loose gaseous state, leaves the water radiator carrying the heat of the water and moves within its pipes to the compressor. Here the refrigerant, or Freon gas, is compressed to a pressure of approximately 160 pounds per square inch, thus raising its temperature to approximately 130° F. Passing on, the compressed gas moves through the air radiator. Here, as it goes through tiny passages, it gives off heat, which is blown by the blower through air ducts that distribute warm air throughout the house.

As the blower operates in the air radiator, the Freon refrigerant is cooled to a temperature of about 75 degrees. It passes out of the air radiator in a liquid form and continues on to a receiver which is merely a storage reservoir. Still in liquid form and still at a pressure of 160 pounds per square inch it continues on to the expansion valve. The expansion valve releases much of the pressure of the refrigerant, reducing it to about 37 pounds per square inch and reducing the temperature greatly. At a temperature of about 40°, the refrigerant converts to gas as it enters the water radiator to absorb more heat from the well water, thus completing the cycle.

By closing two hand valves and opening two others, the heat pump is converted to cooling, as illustrated by the cooling cycle in Figure 18. This merely reverses the process, allowing cold water from the earth to absorb heat from the refrigerating machine. Cool air is blown throughout the house while slightly heated water is returned to the earth or discharged into an open stream.

At present, there are several things hampering extensive use of the heat pump method of heating. There must be plenty of water available. A minimum of 10 gallons per minute is recommended. The power rate should be within reason. With a power rate of 2 cents per kwhr the operating cost will be just double what it will be with a rate of 1 cent per kwhr. The initial installation costs are high. The first cost or installation cost for the heat pump heating system may vary from $2,000 to $3,400.* Added to this will be the cost of the source of heat, usually a well, plus a pump and motor to pump the water.

The cost of operation of the heat pump is less than most other heating systems providing the electric power rate is 1 cent or less per kilowatthour.

* Cost based on 1953 prices.

Advantages of the heat pump:
- No chimney flue necessary—eliminates cost of chimney and heat loss up the chimney.
- It is a clean heat—no soot, gases, ashes, smoke, or dirty fuel.
- It can be used for both heating and cooling.
Economical operation—cost of operation should be less than that of any other central heating system with present Pacific Northwest power rates.

Disadvantages of heat pump:

- High cost of installation.
- Well water or other heat source may be difficult to obtain.
- System of disposing of waste water is problem in town areas.
- Using the earth as a heat source usually requires larger area than standard city lot.

The heat pump uses warm air or hot water to distribute heat about the house. This provides the same degree of winter comfort that could be expected from other central heating systems. It provides greater summer comfort because it can be used to cool as well as heat with no additional installation costs. The furnace equipment is more bulky than most other systems. (See Figure 19.)

Figure 19. Basement installation of the heat pump or reverse-cycle system. This plant requires no chimney and no fuel storage. It is more bulky than most conventional installations. This system can be quickly converted to cooling, making it well suited to areas of excessive summer heat.
Electric Heating

Up to this point the heating systems described have been classified according to the type of system and not with respect to the fuel used in the system. It seems desirable to treat electric heating systems separately even though all types of electric systems might be included in the other classifications.

The use of electricity for residential heating is greatly dependent upon the power rate and power supply. A large number of homes now depend almost entirely on electric power for heat. Additional homes are continually being added to this power load. The use of electric energy for heating homes, however, will probably never become predominant or even generally established throughout the country—at least not for a period of several years. Electrically heated homes will likely always be confined to those regions where the power rates are low. Two regions of the country, that served by the Tennessee Valley Authority and the Pacific Northwest served by the Columbia River development, are using electric energy extensively for domestic heating. Even in these areas power companies discourage electric heating systems because the power demand could quickly exceed the power output.

A wide variety of electric furnaces and electric space heaters are now in operation. Electric furnaces may be used in connection with warm-air or hot-water central heating systems. Electric floor furnaces are popular in some areas.
The electric heating system which has generally proved most satisfactory is made up of one or more heating units in each room. These are not units of the portable type, but are permanently fixed in place and each is equipped with its own thermostat. These heaters are usually placed between the studding in the wall with the bottom of the heater only a few inches from the floor. The electric units vary greatly in capacity but usually run between 2,000 and 3,500 watts.

The heating element in the electric unit heater consists of a series of resistance wires which become hot when the power is on. Cool air is normally drawn from the floor and enters the heater at the bottom replacing warmer air which leaves the heater near the top. The movement or circulation of air may be increased considerably through the use of a fan within the unit heater. When a fan is used, some manufacturers prefer to force the warm air out near the bottom of the heater while taking cooler air in near the top. A thermostat temperature control on each unit heater makes it possible to maintain desired temperature in each room of the house.

Figure 21. A 3,000-watt electric wall heater installation without fan. Heat is distributed by direct radiation and by gravity circulation of air through the heater.
It is wise to consult a heating contractor or other experienced personnel to assist in determining the size of heaters needed and the most desirable location for them. The unit heaters may be located on either exterior or interior walls. Placing units in outside walls results in the wall itself being warmed to a certain extent, which is desirable and frequently minimizes cold air draft across floor.

In selecting a unit heater, one must choose between the units with a fan and those without. The fan gives a more positive circulation of air about the room, but can also be expected to produce some noise during operation.

Advantages of the electric unit heater are:
- Low cost of initial installation. A system of electric unit heaters may be installed in a house at less cost than any other automatic heating system of comparable comfort.
- Installation is simple and easy.
- Long life of the unit heaters results in low maintenance costs.
- Temperature of each room controlled by thermostat in the room assures proper amount of heat.
- No basement or chimney is required.
- No handling of fuel necessary.

Disadvantages of electric unit heaters are:
- High surface temperature of the heating elements in the unit may be undesirable.
- The cost of operation may be prohibitive. The power rate or cost of electricity per kilowatthour should not exceed $7.5$ mills or $\frac{3}{4}$ of a cent if the cost of operation is to be competitive with other kinds of fuel. However, because of its advantages of convenience, cleanliness, and flexibility, many people are willing to pay the higher cost of electricity. The use of adequate home insulation is recommended to help maintain reasonable operating costs.
- Electrical power must be continuously available without prolonged interruptions.

A well-designed system of electric unit heaters can be expected to give comfort and satisfaction equivalent to that of other central heating systems. It is probably the most convenient heat available. Since operation costs are a vital consideration in electric heating, the following information is offered as sample operation costs. This cost of operation data is a record of electric power consumption and cost for a residence in Klamath Falls, Oregon.
### Power Consumption and Cost for Electric Heating Installation*

<table>
<thead>
<tr>
<th>Date</th>
<th>Total household consumption</th>
<th>Heating only</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Kwhr</td>
<td>Cost</td>
</tr>
<tr>
<td>1949</td>
<td></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>962</td>
<td>$10.72</td>
</tr>
<tr>
<td>November</td>
<td>1,314</td>
<td>15.69</td>
</tr>
<tr>
<td>December</td>
<td>1,797</td>
<td>19.56</td>
</tr>
<tr>
<td>1950</td>
<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>3,136</td>
<td>$30.27</td>
</tr>
<tr>
<td>February</td>
<td>2,144</td>
<td>22.33</td>
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<tr>
<td>March</td>
<td>1,638</td>
<td>18.28</td>
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<td>April</td>
<td>1,176</td>
<td>14.59</td>
</tr>
<tr>
<td>May</td>
<td>996</td>
<td>13.15</td>
</tr>
<tr>
<td>June</td>
<td>351</td>
<td>7.76</td>
</tr>
<tr>
<td>July</td>
<td>171</td>
<td>7.32</td>
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<tr>
<td>August</td>
<td>161</td>
<td>7.32</td>
</tr>
<tr>
<td>September</td>
<td>215</td>
<td>7.32</td>
</tr>
</tbody>
</table>

† Minimum.

The electric rate charged by the California Oregon Power Company of Klamath Falls, Oregon, was the standard residential service rate. It was as follows:

- 3.50¢ per kwhr for the first 50 kwhr
- 3.00¢ per kwhr for the next 75 kwhr
- 2.00¢ per kwhr for the next 125 kwhr
- 1.25¢ per kwhr for the next 150 kwhr
- 0.80¢ per kwhr for all over 400 kwhr

The home was a one-story, two-bedroom residence, and was adequately insulated so that heat losses were limited to a degree satisfactory to the utility.

The residence was equipped with six (6) unit resistance heaters, with a total capacity of 18.3 kw.

Klamath Falls, Oregon, having an elevation of 4,105 feet, has an average January temperature of 28.7° F.

In summary, a heating system of this type should find its greatest application where quality heat is desired, where complete insulation is installed, and where utility rates are low enough to justify its use.
The Fireplace

Except for extreme southern areas of the United States, the fireplace is not considered a heating system for the home. Throughout the country the fireplace is popular, however, for providing supplemental heat. Frequently the fireplace can be used, for a short period in the early morning or in the evening, to take the chill out of the air. This can eliminate short-period operations of the regular heating system.

Developments in fireplaces have kept pace with those in other heating systems. Several manufacturers make air-circulating metal forms about which the fireplace is constructed. The air-circulating metal form is a correctly designed and proportioned firebox, manu-

Figure 22. Front cutaway view of an air-circulating metal form for fireplace. Cool air inlets and warm air outlets make possible a gravity flow movement of air upward through the two-wall metal form.
Figure 23. Back cutaway view of an air-circulating metal fireplace form showing how air movement pattern covers major portion of fire box. Warmed air flows into room through warm air outlet.
factured with throat, damper, smoke shelf, and heating chamber. It provides a form for the masonry. This predesigned metal form assures a smokeless fireplace and simplifies construction.

The heating chamber is provided with cool air inlets and warm air outlets. Thus, cool air is taken from near the floor into the heating chamber where it is heated, and by gravity circulation it flows out through the warm air outlets into the room. A fireplace incorporating the air circulating unit is known to give out more heat than one without the unit. It also provides a more general circulation of air about the room and does a better job of heating it. It is possible to have the fireplace in one room with the warm air outlets discharging the warm air into the room back of the fireplace and by this method provide some heat in two or more rooms. The use of the air-circulating form does not add appreciably to the cost of the fireplace. The form replaces a major portion of the firebrick and

Figure 24. Typical fireplace installation using air-circulating metal form. In this case cool-air inlets are in the baseboards with warm-air outlets located near the ceiling.

_Courtesy Heatilator, Inc., Syracuse, New York_
Figure 25. Air-circulating fireplace installation with wide mantel. When fireplace projects into the room a sufficient distance, the cool-air inlets may be located on sides of fireplace if desired. In this installation the warm-air outlet is located directly above the fire box.

greatly simplifies construction. These factors will nearly offset the cost of the unit. A minimum life of 20 years is claimed for the type and thickness of metal commonly used in these units.

The nature of operation of the fireplace, with the unavoidably large quantity of heated air passing up the stack, makes the inherent efficiency of any fireplace relatively low. Therefore, claims for an increased efficiency of the air circulating type of fireplace should be understood merely as constituting an improvement over the ordinary fireplace.
Heating Fuels

The choice of a heating fuel is as much dependent upon the individual person and his willingness to pay for additional conveniences as on the fuel itself. Generally speaking, the more economical fuels require bulky storage, and are less easily adapted to automatic firing than the more expensive fuels. Fuels produced locally are usually less expensive than fuels which are shipped in from other regions of the country. Fuels which are stored and delivered to the furnace in tanks and pipelines offer a greater degree of cleanliness than fuels openly stored and handled by hand methods.

The more common heating fuels in the Pacific Northwest area are sawdust, wood, coal, fuel oil, city gas, and butane and propane gas. Electric energy is frequently used for residential heating also.

Sawdust

Sawdust, a byproduct of the lumber industry, is usually available in lumber-producing areas of Oregon. It is an inexpensive fuel. A large storage space is required for sawdust and considerable handling is necessary getting it to and from storage. The sawdust supply is uncertain in some localities.

Wood

Wood may or may not be a byproduct from lumbering. Wood offers a cheerful fire and a quick increase in heat. Large storage space and considerable handling are necessary. A wood fire requires frequent attention. Wood is a low-cost fuel.

Coal

Coal, like wood and sawdust, requires a storage room. Coal usually requires considerable handling, but it is possible to provide a hopper-type storage bin and obtain complete automatic firing. It is dirty and smoke producing. A steady heat is readily obtained through the use of an automatic-fired coal furnace. The cost and availability of coal varies greatly from area to area.

Fuel oil

Fuel oil is clean, convenient fuel. It has a high heat value, requires only a small amount of storage and is easily adapted to automatic firing. It offers a quick increase in heat when needed. Fuel oil is available in most areas of the country with the cost varying considerably between localities. The supply of fuel oil is sometimes uncertain. It is a popular heating fuel.
Gas

Gas is a clean fuel that is easily controlled. City gas is piped directly to the residence with a constant supply available. It provides a quick increase in heat and offers convenient automatic firing. City gas is unavailable in some localities. Butane and propane gases require private tank storage. These gases offer the same cleanliness and convenience of handling provided by city gas. Butane and propane gases are common in rural areas not served by city gas.

Electricity

From the standpoint of cleanliness, there is no question that electricity and electric heating systems rank first. Electricity offers convenience, flexibility, and ease of control. No labor is required for handling fuel, and no storage facilities are necessary. The oxygen content of the air is undisturbed. If electric power was in sufficient supply and power rates were low enough to offer competitive costs, electricity would rapidly become the accepted source of heat for residential heating. The power rates vary greatly between localities. The supply is not adequate for heating purposes in many areas even within the Pacific Northwest.

Determining relative fuel costs

With fuel prices varying from area to area it is difficult to establish a cost comparison for fuels that would serve more than one locality within a state (see page 47). The table, however, offers a ready calculator for determining relative fuel cost in any area by applying local fuel prices. By completing the table one can determine the amount of heat in BTU’s (British thermal units) that could be received per dollar cost. This gives a ready cost comparison for available fuels.
## Determining Relative Cost of Available Heat in Various Fuels

<table>
<thead>
<tr>
<th>Fuel or energy</th>
<th>Unit</th>
<th>Available heat per unit at normal burning efficiency*</th>
<th>Cost per unit</th>
<th>Heat received per dollar cost†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fir sawdust</td>
<td>1 unit, 200 cubic feet</td>
<td>BTU</td>
<td>Dollars</td>
<td>BTU</td>
</tr>
<tr>
<td>Fir slab, wood</td>
<td>1 cord</td>
<td>BTU</td>
<td>Dollars</td>
<td>BTU</td>
</tr>
<tr>
<td>Coal, average</td>
<td>1 ton, 2,000 pounds</td>
<td>BTU</td>
<td>Dollars</td>
<td>BTU</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>1 barrel, 42 gallons</td>
<td>BTU</td>
<td>Dollars</td>
<td>BTU</td>
</tr>
<tr>
<td>City gas</td>
<td>1,000 cubic feet</td>
<td>BTU</td>
<td>Dollars</td>
<td>BTU</td>
</tr>
<tr>
<td>Butane gas</td>
<td>1 gallon</td>
<td>BTU</td>
<td>Dollars</td>
<td>BTU</td>
</tr>
<tr>
<td>Propane gas</td>
<td>1 gallon</td>
<td>BTU</td>
<td>Dollars</td>
<td>BTU</td>
</tr>
<tr>
<td>Electricity</td>
<td>1 kilowatt-hour</td>
<td>BTU</td>
<td>Dollars</td>
<td>BTU</td>
</tr>
</tbody>
</table>

\* The available heating value per unit is calculated on average burning efficiencies in residential heating systems. These figures can be expected to vary, and should be taken only as an approximation.

† To compute heat received per dollar cost: Divide available heat per unit (Column 3) by cost per unit (Column 4), which can be obtained from local fuel distributor. Example: If fuel oil, in your community, costs $6.72 per 42-gallon barrel, put that figure in Column 4 under cost per unit. Then divide the available heat per unit (5,180,000 BTU for fuel oil) by the cost per unit ($6.72) and the heat received per dollar cost is found to be 770,833 BTU. Enter this in the last column and compare with the other types of fuel at local prices.