UTILIZATION OF GAS APPLIANCES

NATIONAL COMMERCIAL GAS ASSOCIATION

INCORPORATED 1912

THE RIGHT APPLIANCE IN THE RIGHT PLACE

PART III LESSON VIII

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House Heating Appliances

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Lesson on House Heating Appliances

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House Heating Appliances

HISTORY AND EVOLUTION

IN King's Treatise on Coal Gas, we find the following: "Some time between 1786 and 1801 Philipe Lebon (Le Bon), a Frenchman, patented his 'thermolamp,' a kind of stove or oven in which he distilled wood or coal in order to obtain the necessary heat for warming dwellings or work-shops and at the same time the gas for lighting them. This was more or less a laboratory experiment, but it appears to be the first recorded attempt to use gas for house heating.

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"These patents comprise the whole record of what was done in this direction down to 1840."

After this date various appliances for heating by gas were devised and a demand was created by lectures, exhibitions and other forms of advertising to increase the utilization of gas.

A letter written from London, December 24, 1849, states: "We heat offices, bedrooms, halls and a variety of places where chimney flues are objectionable and our churches have frequently gas stoves beneath the floors. Indeed every year gas is supplanting coal, and were it not that we love the sight of an open fire, it would do so much faster."

Peckston in his "Practical Treatise on the Manufacture of Gas," published in 1841, says: "Coal gas has of late years been applied to the heating of churches, chapels, shops, counting-houses, etc., ... and has been found to answer the purpose intended." The stove described closely resembled the cooking stove of 1825, except that it was provided at the top with a register instead of a flue. Peckston further states that "coal gas has also been used to some extent for the purpose of cooking by means of a gas cooking apparatus which is an arrangement nearly similar to the gas heating stove, except that it is not furnished with the internal cone."

A form of stove now very popular in England under the name of the "gas-fire," and consisting of bodies of refractory material heated to a greater or less degree of incandescence by gas burners so as to resemble a coal fire, was invented by one Edwards, who, in 1849, took out a patent for such a heater. Seven years later Nathan Defries was granted a patent for a similar device, the "argillaceous material" specified, having fibres of asbestos fastened upon it, which, upon lighting the gas, became incandescent. Here we have the forerunner of our modern asbestos-backed stove. This was followed three years later by a patent granted to Reece for a stove in which the asbestos back was the main feature.

In 1851, at the great International Exhibition in London, a heating stove was exhibited, the invention of George Knowles, which in general resembles the small cylindrical heaters of today, except that the cylinder was made of glass instead of metal. An odd feature of this stove was that it contained a central vertical pipe filled with water, surrounded by an annular space filled with sand, the water being for the purpose of "improving the quality of the heat."

In spite of the limited use of gas for fuel, in 1852 a company called "The Gas Fire Company" was incorporated for the "production of fires and heat by the agency of gas in dwellings and other buildings within England, Wales and Berwick-upon-Tweed." The charter enabled them to lay mains and carry on a general gas manufacturing and distributing business. This appears to have been the forerunner of many ill-fated attempts to do a purely fuel business by artificial gas, and appears to have met the universal fate of these, for soon after its incorporation it failed.

In America the first gas heating stoves appear to have been introduced into Boston by one Shaw, an advertisement of whose appliances, by Bramhall, Hedge & Co., 442 Broadway, New York City, appears in *The American Gas Light Journal* for August 1, 1859. These appliances were also sold by Charles Burnham & Co., 10th and Sansom Streets, Philadelphia, who also manufactured and sold a stove of the reflector type, called the Helion Gas Heating Stove. They later made a round cone heater which bore the same name.

The development and evolution of gas house-heating appliances has kept pace with the other methods for utilizing manufactured gas, and the methods of transferring heat from the gas to the rooms or objects desired to heat have been a subject of much discussion and investigation.

REQUIREMENTS FOR ROOM HEATING

HYGIENE

The object to be accomplished in room heating is not to furnish heat to the bodies of occupants of the room, but to provide conditions under which the body will not lose heat too rapidly. The body itself generates all the heat required to maintain itself at a comfortable temperature under favorable conditions.

The three methods of heat transfer known respectively as Conduction, Convection and Radiation (see Elementary Principles of Combustion and Utilization of Energy, pages 18 to 23, in Utilization of Gas Appliances Course, Part III) in their relation to room heating are most easily explained and illustrated by the case of a person sitting in front of an open grate fire and analyzing the ways in which the temperature sensations experienced are produced.

If a person continually stirs the fire with a metal poker, the end in his hand will get so warm as to be uncomfortable to hold. The manner in which heat travels along the metal rod is known as Conduction. Since heat is regarded as necessarily accompanied by vibration of the molecules of a substance, conduction of heat must simply consist of the transfer of motion of the molecules at one end of the rod to the molecules at the other end of the rod. The only reason a rug feels warmer than the tiled floor in the bathroom on a cold morning is that the rug is a poorer conductor than the tiling, and so does not conduct heat away from one's body nearly so rapidly. Light fleecy covering is a good thing to keep the heat from escaping because it is so full of small spaces containing air particles, and air, and gases generally (especially if dry) are among the best non-conductors. Two thin shirts are better than one heavy one, because a layer of air is trapped between the two shirts and is in itself a better protection than both shirts in themselves.

Air in motion, however, behaves in a different manner, or rather produces different results. While heat is conducted or transmitted *through* air but slowly, it is, so to speak, absorbed by air passing over a heated surface and this heated air is thus capable of carrying the heat to other places. A person facing an open fire becomes sensible of a current of cold air upon his back. This is produced mainly by the chimney draft, but also in part by the ascending currents of heated air passing upward over the heated front of the fireplace. The existence of these convection currents may be demonstrated by holding wisps of any light material above the fireplace, and the fact that they are effective in carrying heat upward is evidenced by the higher temperature near the ceiling. This heat is in part absorbed by walls and ceilings, and in part contributes to raise the temperature of the air in the room.

A person sitting at some little distance from a bright open fire may have his face almost blistered with the heat, but it is not by Convection, for the hot air is going up the chimney or toward the ceiling. It is because of Radiation or radiant energy which is intercepted by his body and converted into heat. Energy travels by this method at the same speed as light, that is, 186,000 miles per second. It travels in straight lines and may pass through a medium without heating it. Heat received from the sun is by radiation. During an eclipse when the light is cut off, the heat is also cut off at the same time and then reappears at the same time as the light. The radiation may be intercepted by means of a screen placed directly in front of the body to be protected and between it and the heat source. That it may not heat the region it passes through is evident from the fact that the upper layers of air are always cold. Radiation as a form of energy may be converted into heat, but is of itself neither hot nor cold.

Dull, rough surfaces radiate much more readily than smooth, polished surfaces, while the latter are much more effective *reflectors.* For this reason reflecting surfaces should be highly polished while surfaces required to radiate or absorb energy (either as light or heat), should be of dull finish. This point is of great practical importance.

Just as Conduction, Convection and Radiation are all means of getting heat into a room, and distributing it in the proper manner, all likewise play a part in the losing of heat by the human body. The rapidity with which the body will lose heat by conduction depends upon the *difference* in temperature between the body and the air in contact with it and varies directly as this difference. If the air be 30° lower than the body, the latter will lose heat twice as rapidly as with the air but 15° lower (see page 21, Elementary Principles of Combustion and Utilization of Energy, Utilization of Gas Appliances Course, Part III). Therefore, the more nearly the air approaches the temperature of the body, the less the loss of heat by conduction. With the air at 70° F. the body itself will produce enough heat to supply the loss without discomfort, and this is the temperature usually regarded as desirable in dwellings. Since, however, air is a poor conductor, the loss in this manner *in still air* is not as great as might be supposed. The heat given off by the body is not sufficient to produce effective convection currents. If, however, by any other means a fairly rapid and vigorous circulation of the air be produced, the effects of convection ensue. The cooling effect of a fan is an excellent example of the increasing of heat losses by moving air currents.

HYGIENE

The loss by radiation depends upon the relative *absolute temperatures* of the body and the walls of the room, and varies as the difference between their fourth powers. Within the limits usually encountered in room heating, however, losses by radiation may be said to vary as the difference between these temperatures. It is obvious, therefore, that even though the air in the room be maintained at what would otherwise be a comfortable temperature, the radiation losses to cold walls may be a source of discomfort. In actual practice the temperature of walls and air tends to equalize, warm walls gradually heating the air by conduction and convection, and warm air heating the walls by circulating over and giving up a portion of its heat to them. In the first case, the walls will usually be somewhat warmer than the air and in the latter somewhat cooler. The former is the more desirable condition from the standpoint of both comfort and health, since radiation losses are greater than conduction losses and since the capacity of the air for absorbing moisture increases with its temperature. This not only robs the body of its moisture, but makes the air less suitable for breathing. Furthermore the rapid evaporation facilitated by the increased capacity of the air for absorbing moisture in itself produces a cooling effect.

With the exception of the hot-air furnace system, all heating systems combine both radiation and convection in their operation. They differ chiefly in the proportion in which the total heat output is divided between radiated energy and convected heat.

The hot-water radiator, being at a comparatively low temperature, furnishes a greater proportion of convected heat than the electric luminous radiator, which is simply a large frosted incandescent lamp. In the latter, the high temperature filament is comparatively well insulated from the bulb by a vacuum, and of the total heat given off, about 50 per cent. is in the form of radiant energy, whereas, the hot-water radiator gives off but about 20 per cent. of its energy in this form.

VENTILATION

(*In this connection read "Hygienic Value of Gas Lighting"*)

Inseparably connected with heating is the subject of ventilation. Both are intimately related to health and comfort, and the design of a heating system will depend largely upon the ventilation, since the fresh air supplied must be heated and the foul air rejected carries away heat from the room. Very few dwellings are provided with any facilities for ventilation worthy of the name, depending upon the looseness of construction and the more or less (usually less) frequent adjustment of windows by the occupants. This casual and ineffective ventilation is nearly always accomplished by drafts, which accounts for the intolerable "stuffiness" usually found in rooms heated by steam, hot-water and hot-air furnaces.

In general, it may be said that rooms heated by means of a fire or flame *in the room* and discharging into an *effective* flue are incomparably superior, from a hygienic standpoint, to rooms heated in any other manner in common use.

All room heating appliances accomplish their purpose by both convection and radiation, the various types differing in the relative proportions furnished in each way. The proportion due to radiation depends upon the temperature of the parts of the apparatus. Recent tests* indicate that steam radiators distribute about 25 per cent. of their total heat by radiation; gas logs, 22 per cent.; reflector heaters, 26 per cent.; asbestos fire-backs, 38 per cent., and tubular gas-radiators, 27 per cent.

It is stated that 50 per cent. and even 60 per cent. of the total heat has been obtained by radiation in the case of English "gas fires."

BLUE FLAME VS. YELLOW FLAME HEATERS

This subject, which is the most mooted one at the present time in connection with gas house-heating appliances, has been so thoroughly covered by the report of the Committee on Utilization of Gas Appliances of the American Gas Institute which was presented at the meeting of that society in October, 1912, that portions of this report which relate to gas room heaters are here given:

> "Those types of gas heaters which are located in the room being heated, may be divided into two classes—those designed to be set in the room, here called, for convenience, 'portable heaters,' and those designed to be set in a fireplace in the room, here called 'fireplace heaters.' Each of these classes contains heaters constructed on either one or two main principles of combustion—the yellow flame type and the blue flame type.
>
> "Taking first the portable heaters, in those of the yellow flame type, the gas is burned on the same principle as in an ordinary lava tip or batswing burner; there is no pre-ad-

* Transactions American Gas Institute, 1912, page 496.

mixture of air; the burners vary in design in different makes of heaters; the oxygen for combustion is obtained from the atmosphere surrounding the flames; the flames are not permitted to come in contact with any solid body, but are free to extend into the atmosphere of the combustion chamber until the combustion has been completed. This latter point is always carefully secured in the design, because without it the heater would be rendered impracticable by the deposition of carbon which would take place on any body that the flame was permitted to touch. The products of combustion from these heaters are odorless and innocuous.

"In portable heaters of the blue flame type the gas is burned on the Bunsen principle, the burners being of various forms in different makes of heaters. There being no obvious objection, such as the deposition of carbon, to the contact of the blue flames of these heaters with solid bodies, similar care to prevent such contact is not exercised in the design; on the contrary, such contact is frequently purposely effected, especially where water is contained in the heater, and the purpose is to circulate or vaporize the water. As already explained in the report, the result of such a contact between the gas flames and a relatively cool metal surface is an incomplete combustion of the gas. This phenomenon is accompanied by an objectionable odor, which is a bad advertising medium for gas as a source of room heating.

"There is on the market a class of blue flame room heaters in which the effects just described are minimized; in this type the flames play around a plate of refractory material and so envelop it as to cause it to glow within a few minutes after the heater is lighted. This red hot plate does not reduce the temperature of the flame sufficiently to cause incomplete combustion to an appreciable extent, and consequently a heater of this type, after it has been lighted long enough to cause the iron plate to glow, is free from the two objections of incomplete combustion and an objectionable odor.

"The most serious objection to portable heaters of the blue flame type is still to be stated: this is the possibility of the burners in these heaters lighting back at the mixers. As already explained, such a burner when burning at the mixer delivers a product of incomplete combustion. Room heaters are often used in poorly ventilated rooms; the very condition of temperature which leads the consumer to light the heater, and keep it burning, also leads him to keep the windows and doors shut, thus reducing the ventilation to a minimum.

"It may be claimed that it is not probable that any one would permit the burning at the mixer to continue. The two warnings given by this condition of the heater are the odor and the noise; the former is not as pungent, nor is it as universally recognized as unburned illuminating gas, and a person even when wide awake, as in reading, might not notice this odor, which will naturally increase in intensity only gradually. Very drowsy persons, or those more or less under the influence of intoxicants, would be very apt not to notice it. The same may be said of the noise; this varies from a hiss to a roar and is loud enough to be noticed by many persons. On the other hand, others would not notice it, and still others, noticing it, would not take any steps to stop the cause of it.

"But, it may be said, certain classes of blue flame heaters are more efficient than yellow flame heaters, and if gas companies adopt the practice just recommended, they will be compelled to sacrifice something in efficiency. Such is not the case, but as there is considerable confusion on the subject of the efficiency of gas heaters, we think the subject of enough importance to warrant our considering it in some detail. The complete combustion of a cubic foot of gas will produce the same number of heat units, whether the gas is burned in a yellow flame or in a blue flame burner; and as all the heat generated is delivered into the room, there being no flues to heaters of this class, it follows that one type is as efficient as the other. But different heaters distribute the heat they generate in different ways, and it is a common opinion that those heaters which send out the largest proportion of heat in the radiant form are the most efficient. So far as engineering, or mechanical, efficiency is concerned, this opinion has no foundation in fact. The total quantity of heat generated in such a heater may escape from it in one of three ways—by conduction through the floor and pipe connection, by radiation through space, and by convection through the heated air currents and products of combustion arising from the heater. The heat given out by conduction is too small in amount to warrant consideration. The heat escaping in the form of radiant energy is intercepted by the floor, walls and ceiling of the room, and by the objects in it, each of these substances being warmed by this radiant energy, so that they in turn become secondary heaters, each one starting convection currents of its own by warming the air in contact with it. As the atmosphere of a room is a perfect fluid, starting in motion on the slightest change in density due to a change in temperature, there is in a room warmed by a source of heat within it, under similar conditions of loss of heat through the walls, etc., a constant relation between the temperature of the air at the ceiling and the temperature at the floor; it follows that whether all the heat generated be carried in one convection current from the heater toward the ceiling, or whether only a portion of it be so carried, the balance being radiated to the walls and furniture, and by them sent through convection currents toward the ceiling, the result is the same: the room is heated to a desired temperature with equal speed, or is maintained at a desired temperature with the same consumption of gas. Assuming complete combustion in each case, the mechanical efficiency in heating the atmosphere of a room is the same in a heater with a minimum of radiated heat as it is in one producing a maximum of radiated heat.

"But in reaching this conclusion the whole story has not been told; the mechanical efficiency is not in this case the real measure of the relative usefulness of gas heaters; it is not the real measure, because of the human element which becomes a factor in the problem by the effect on the occupant, or occupants, of the room by those waves of radiant energy which impinge directly on the body. After all, rooms are heated for the purpose of making them comfortable and healthful to the occupants, and in the attainment of these ends the actual temperature of the air at a level within six feet of the floor as determined by a thermometer that is screened from the direct effect of radiant heat is not the sole factor. If there be in the room a source of radiant energy, some of the rays from which are permitted to fall directly on the human body, these rays, which in their passage through the air do not warm it, are very effective in producing a sensation of warmth of the body. A person who is so situated in a room that his body intercepts the waves of energy from a source of radiant heat will be comfortable at a lower temperature of the air (measured by a screened thermometer) than the temperature that is needed for comfort in a room with no radiant source of heat, or in case a source exists, if the person be screened from the direct effect of the rays.

"Thus we see that there is another kind of efficiency—it might be called the 'physiological' efficiency—the degree of which is dependent on the percentage of the total generated heat that is emitted in the form of radiant energy; and the room heater which attains a high physiological efficiency is more effective, not in heating the air of the room, but in making it comfortable for the occupants, than is the heater in which such efficiency is low. It is, therefore, a matter of interest to inquire whether of the blue flame type or of the yellow flame type of room heater either one has an advantage over the other in the generation of radiant energy. To the best of our knowledge, no reliable figures are available for the final determination of this point, but tests made indicate the lines on which further investigation should be made. In the absence of definite results it may be stated that it is the belief of the committee that the two types of heaters are about equal in this respect; as they exist on the market, there is little to choose between them on the score of the emission of the heat in the form of radiant energy.

"Fireplace heaters, while subject to the same general principles as those governing portable heaters, demand some additional consideration. Of that class, which, while designed to be set in a fireplace, yet is not designed to make use of the flue leading from the fireplace, for the purpose of carrying away the products of combustion, it may be said that the heaters belonging to the yellow flame type are unobjectionable; the products all mix with the atmosphere of the room but they are odorless and innocuous. On the other hand, the blue flame type of this particular class of heaters is, generally speaking, even more objectionable than the same type of portable heaters; this is due to the fact that the shape that such heaters must assume in order to accommodate themselves to the fireplace construction is a shape in which it is almost impossible to secure perfect combustion of the gas; the combustion surfaces of such heaters must be set in a generally vertical position, and it is impossible to burn gas through ports in a vertical metal surface (where the flames issue horizontally) and at the same time secure perfect combustion; each flame as it issues bends itself upward, and the upper portion of the flame licks against the metal surface, thus being cooled, and delivering some products of incomplete combustion, with their accompanying odor.

"Another cause of incomplete combustion in these heaters is the vitiation of the secondary air supply to the upper rows of burner ports; the products of combustion from the lower ports rise over the face of the upper ports, so that the latter are compelled to burn the gas issuing from them in an atmcsphere that is deficient in oxygen.

"In many heaters these effects are enhanced by the attachment of some non-combustible substance, like fibrous asbestos, on the face of the combustion surface; this material, introduced for the purpose of imparting a pleasant glow to the heater, is an important factor in the prevention of complete combustion; it blocks the gas ports to a greater or less extent; it accumulates dust and dirt, still further blocking the ports, and it brings additional obstruction to the passage of secondary air to the flames. A careful inspection of a heater of this type in operation will frequently reveal an intermittent extinguishing and relighting of the small flames issuing from a number of the ports. These heaters are also subject to the same objections from the backfiring of the burners at the air mixers, as have already been described in the case of portable blue flame heaters.

"Of the fireplace heaters that do make use of the flue, these are practically all of the blue-flame type, and as the products of combustion are carried out of the room—even the products of a back-lighted burner being thus removed—there seems to be no objection to this type. Gas logs and similar heaters of this class are unobjectionable, so long as the flue to the fireplace in which they are set is effective as a flue and is not a flue in appearance only; otherwise they are open to all the objections that have been raised against flueless blue-flame fireplace heaters. In setting these heaters, if a damper exists in the flue, the damper should be so adjusted that the flue cannot be entirely cut off.

"An objection that is frequently urged against heaters of this class is that only a portion of the total quantity of heat generated by the gas is utilized in heating the room, the balance escaping up the chimney, where it is wasted. While this is true, yet it should be borne in mind that this is the most healthful method of room heating by gas, in that there is not only no dilution of the air by products of combustion, but on the contrary there is a direct ventilating effect caused by the air withdrawn from the room by the heater. At prevailing prices for gas, there are many consumers who, if they are made to realize the force of this argument regarding sanitation, will gladly adopt this method of heating in preference to any method that delivers products of combustion into the room.

"In this connection it should be pointed out that in this class of heaters it is only the heat given out in the form of radiant energy that is effective in heating the room or in warming the occupants; all of the convected heat is carried up the flue. In discussing this subject in connection with portable heaters, we found that although the extent to which those heaters emit heat in the radiant form is in a certain degree a measure of their excellence, yet we were able to show that the distinction between heat convected and heat radiated from such heaters was not an important one in its effect on the warming of the room. In the class of heaters we are now considering it is evident that this distinction becomes of the greatest importance; if all of the convected heat is wasted, the design of the heater should be such as to reduce this loss to a minimum, and conversely to increase the amount of heat generated in the radiant form to a maximum. Your committee thinks it probable that there is room for the design of more efficient heaters of this class than have yet been produced."*

In considering the foregoing report, it must be borne in mind that some of the strictures refer only to certain types on the

* The classification in the above report by which Portable Room Heaters include all types not designed for location in fireplaces is *not* followed in any other portion of this paper.

American market. For instance, the difficulty of obtaining complete combustion in the blue-flame fireplace heater under normal conditions of operation does not hold in the least in the case of a well-designed gas fire. While the possibility of "flashing back" in blue flame heaters is regarded as a danger-hazard of considerable importance by some authorities, others believe that this hazard is exaggerated, and hold that the same variations in gas quality and pressure which introduce this hazard in the blue flame heater are likely, in the yellow flame types, to produce a very undesirable incompleteness of combustion, the result of which is an unpleasant odor.

The concensus of opinion seems to be that as far as actual service is concerned, there is not as much to choose between the relative desirabilities of the two types as is indicated in the above report. On the other hand, the installation without an effective flue connection of any gas-burning domestic appliance consuming more than 25 cu. ft. per hour, for continuous service, is, to say the least, a questionable procedure.

TYPES OF INDIVIDUAL ROOM HEATING APPLIANCES

Gas Fired Room Heating Appliances may be divided into five classes with reference to the manner in which the heat is transmitted from the flame into the room as follows:

I—*incandescent radiators, in which the flame is incandescent, as an open yellow gas flame, radiating energy directly into the room, or in which a blue flame is directed through or upon refractory material, which becomes incandescent and radiant. This material may be asbestos, iron, fire-clay, etc. The yellow and the blue-flame incandescent radiators

* For purposes of classification, all *luminous* radiators—blue- or yellow-flame, are embraced under this head. In the trade "incandescent" usually refers to heaters of the blue-flame type.

are thus analogous to the open-flame and the incandescent gas lamp, the radiating material of the former being derived from the gas, and that of the latter introduced as a separate, permanent substance.

II—REFLECTOR RADIATORS, in which the radiation from the flame itself is reflected into the room from a polished metal surface, usually copper. These are usually known as "Reflector Heaters."

III—GAS RADIATORS, in which the hot products of combustion transmit their heat to the shell of the appliance (usually of sheet iron) which forms the radiator proper.

IV—GAS HOT-WATER RADIATORS, in which water heated by the flame transmits its heat to the radiating surface.

V—GAS STEAM RADIATORS, similar in principle to the above, but using steam instead of hot water.

INDIVIDUAL ROOM HEATING APPLIANCES, as here described, will embrace those appliances which are self-contained, requiring only connection to a gas outlet, and in some cases to an existing flue.

INDEPENDENT ROOM HEATING APPLIANCES FOR INSTALLATION IN ANY DESIRED LOCATION

INCANDESCENT RADIATORS—YELLOW FLAME

There was an early style of heater of this class which was sold under the name of "Brilliant." The unique thing about this heater was the burner which used an illuminating sheet flame instead of having drilled ports. The air to support combustion was superheated before it combined with the gas.

Another form of this type, still manufactured to a certain extent, is similar in appearance to that shown in Figs. 1 and

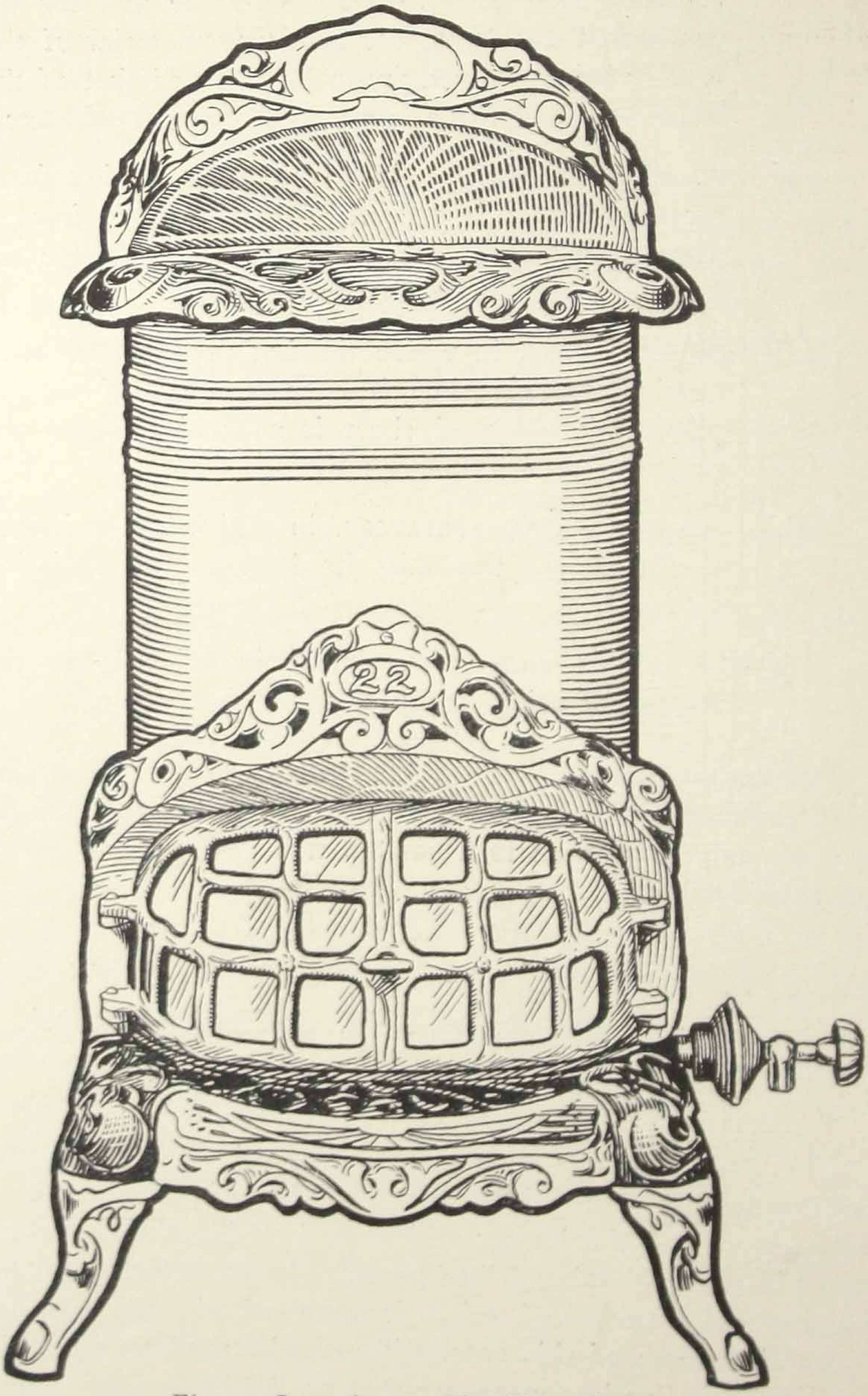

Fig. 1.—Incandescent Blue-Flame Radiator.

1a, but employing a yellow flame. In this heater direct radiation from the flames into the room takes place through the mica-glazed doors, and to a considerable extent from the

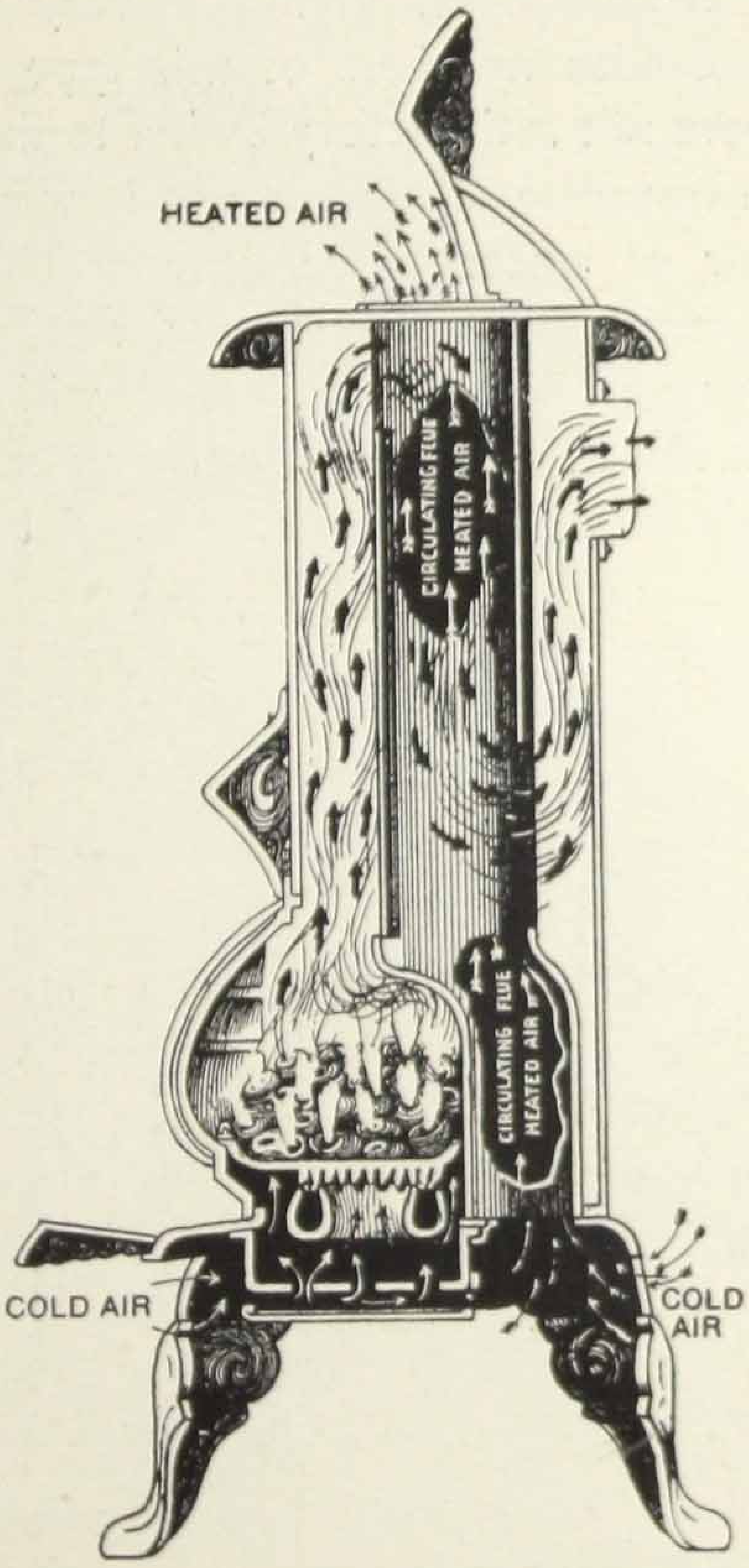

Fig. 1a.—Cross-section through Fig. 1.

metal parts. A current of heated air is also discharged by convection from a vertical flue.

INCANDESCENT RADIATORS—BLUE FLAME

Typical of this design is the heater shown in Figs. 1 and 1a, in which the incandescent "fuel" forms the radiator.

One of the earliest types of blue-flame heaters was a stove, square in shape, with an asbestos back, Fig. 2. In construction it was open at the bottom and at the front, divided in depth back to front by a piece of sheet steel projecting upward and forward to within about 2 inches of the front and 2 inches of the top, and covered with loose asbestos fibres which became incandescent, giving a very cheerful effect. While there have been numbers of this type of stove manufactured they were not satisfactory owing to the asbestos fibres interfering with complete combustion and causing the stove to give off an odor of unconsumed gases. There was also a cylinder stove manufactured which had an inverted cone inside the cylinder and above the burner with the small end of the cone immediately above the burner and the cone itself covered with asbestos fibre. This type had the cylinder per-

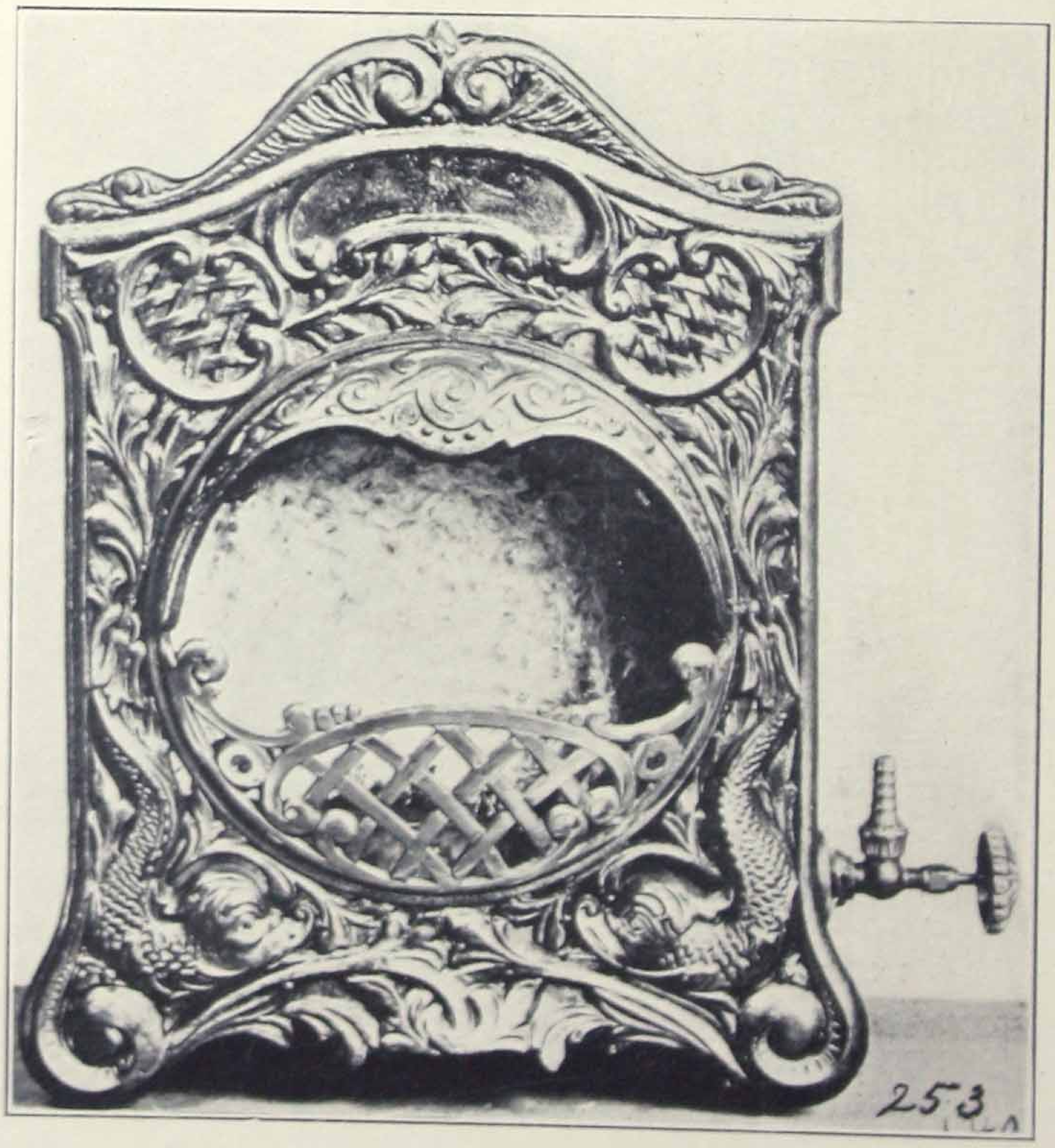

Fig. 2.—Incandescent Blue-Flame Radiator.

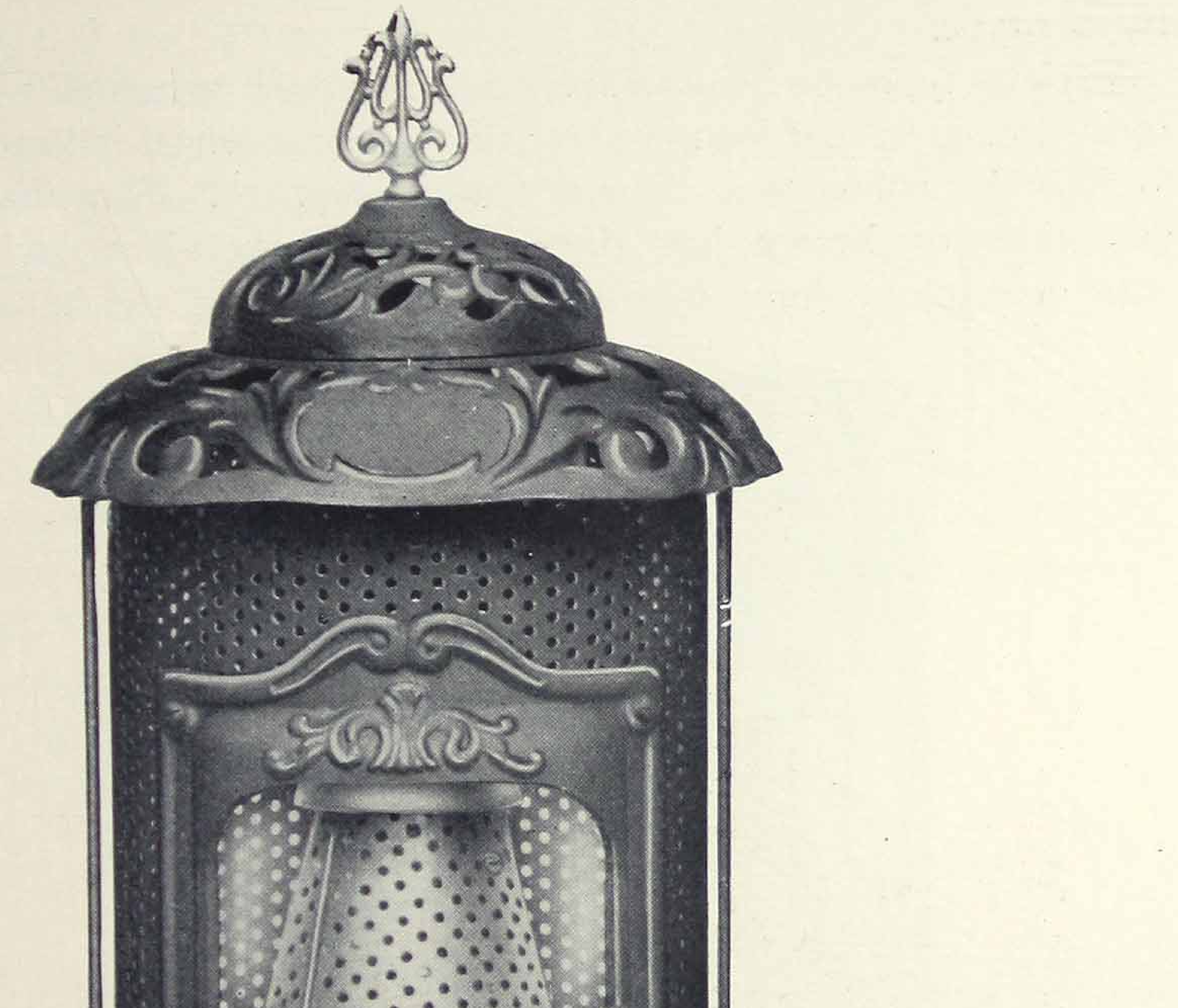

Fig. 3.—Incandescent Blue-Flame Radiator.

forated or partly cut away. It had the same fault as the former type.

Various types of heaters are made in which a hollow perforated cone of cast iron or some refractory material is heated to incandescence by a Bunsen flame (Fig. 3). Sometimes this class of heater has the shape of a box-like jacket with open or perforated front. The flame from the burner

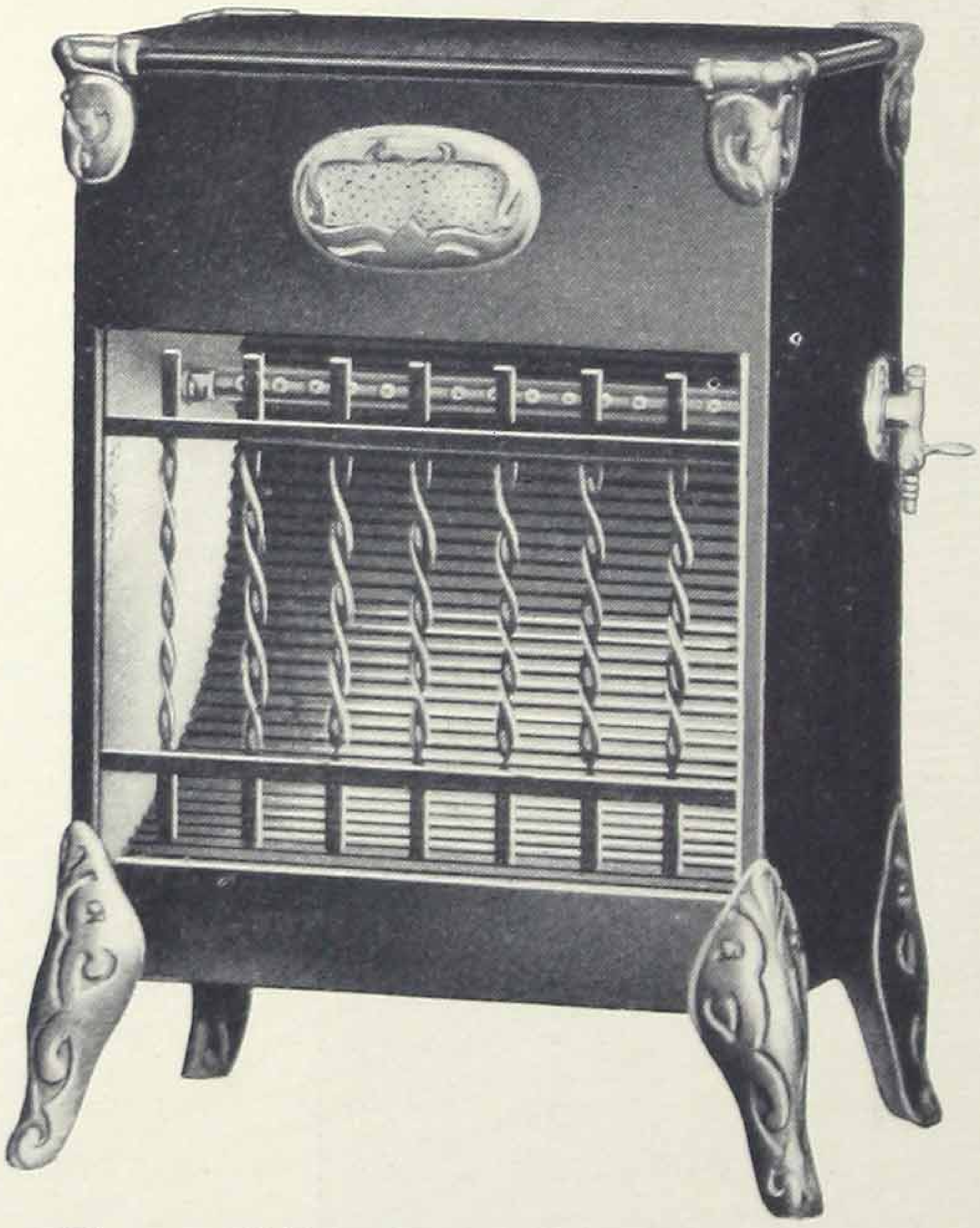

Fig. 4.—Yellow-Flame Reflector Radiator.

enters the large end of the cone and passes out through the contracted or smaller end of the cone into the chamber formed between the jacket or body and the heated member itself. Heaters of this type are usually designed to consume about 30 cu. ft. per hour. A smaller size consuming 15 cu. ft. per hour is also on the market.

REFLECTOR RADIATOR—YELLOW FLAME

This type of heater (Fig. 4) was one of the earliest and is made in both cylindrical and square shapes, and so named from its method of heating. Being equipped with a highly polished corrugated or fluted copper reflector, the energy radiated by its flames is reflected into the room by the bright surface. These heaters are made with burners either above or below the reflector according to the ideas of manufacturers and their engineers in meeting the demands of the consumers. The burner is generally either wrought iron pipe or a cast burner with open-flame tips.

Air for the support of combustion is taken from the front of the heater. The heated air passes off from the top of the heater, often being baffled by a piece of sheet steel placed above the flame. Heaters of this type are made in various sizes and with different numbers of open-flame tips. Each tip consumes about 1¾ cu. ft. of gas per hour.

GAS RADIATORS—YELLOW FLAME

Single Cylinder Type (Figs. 5 and 5a)

These consist, in general, of a bottom or base, burner, top and cylinder. The burner is always in the lower part of the cylinder directly above the base. The top casting generally rests on the cylinder and is usually cast in an open design to allow the heated air to escape readily. Air to support combustion is supplied through the base below the burner. This type of heater is furnished with a shield to protect the flames from drafts. Various devices are used to baffle the products of combustion in their course through the cylinder permitting more heat to be absorbed by the metal casing and thus increasing radiation. Without these expedients most of the heat produced is carried upward by convection currents and the farther and lower portions of the room are heated very slowly.

The burner used in these stoves is either of brass tubing made star-shaped with six or eight arms screwed into a central hub, not unlike the spokes of a wheel, with each arm drilled with a series of holes (about No. 70 Morse Twist

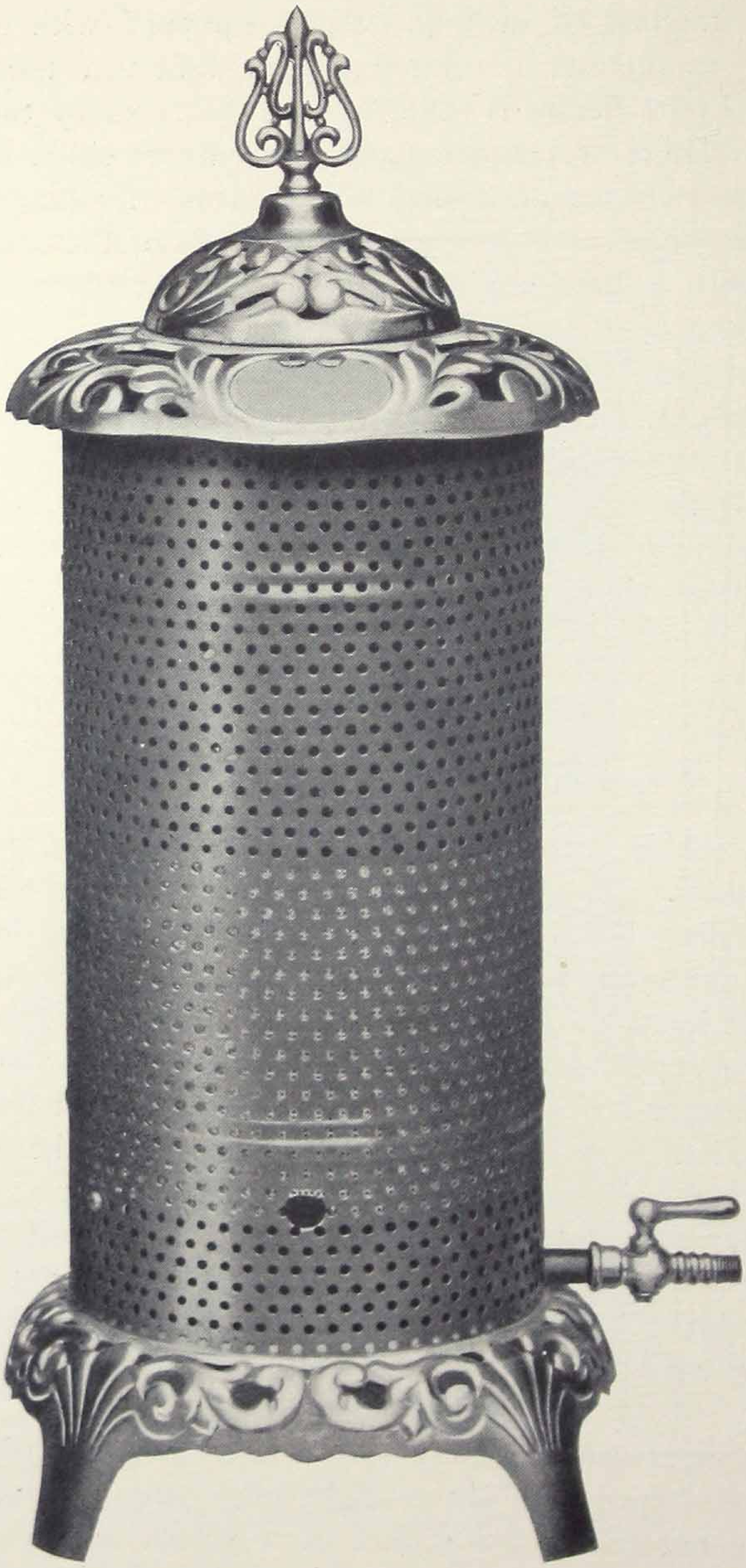

Fig. 5.—Yellow-Flame Gas Radiator.
(Single Cylinder Type.)

Drilled Gauge) so that the flame projects upward, or of hollow castings circular in shape fitted with open-flame tips. Though of apparently simple design, much experimenting was required to determine the location and extent of openings in the shell to ensure proper combustion and the best distribution of heated air.

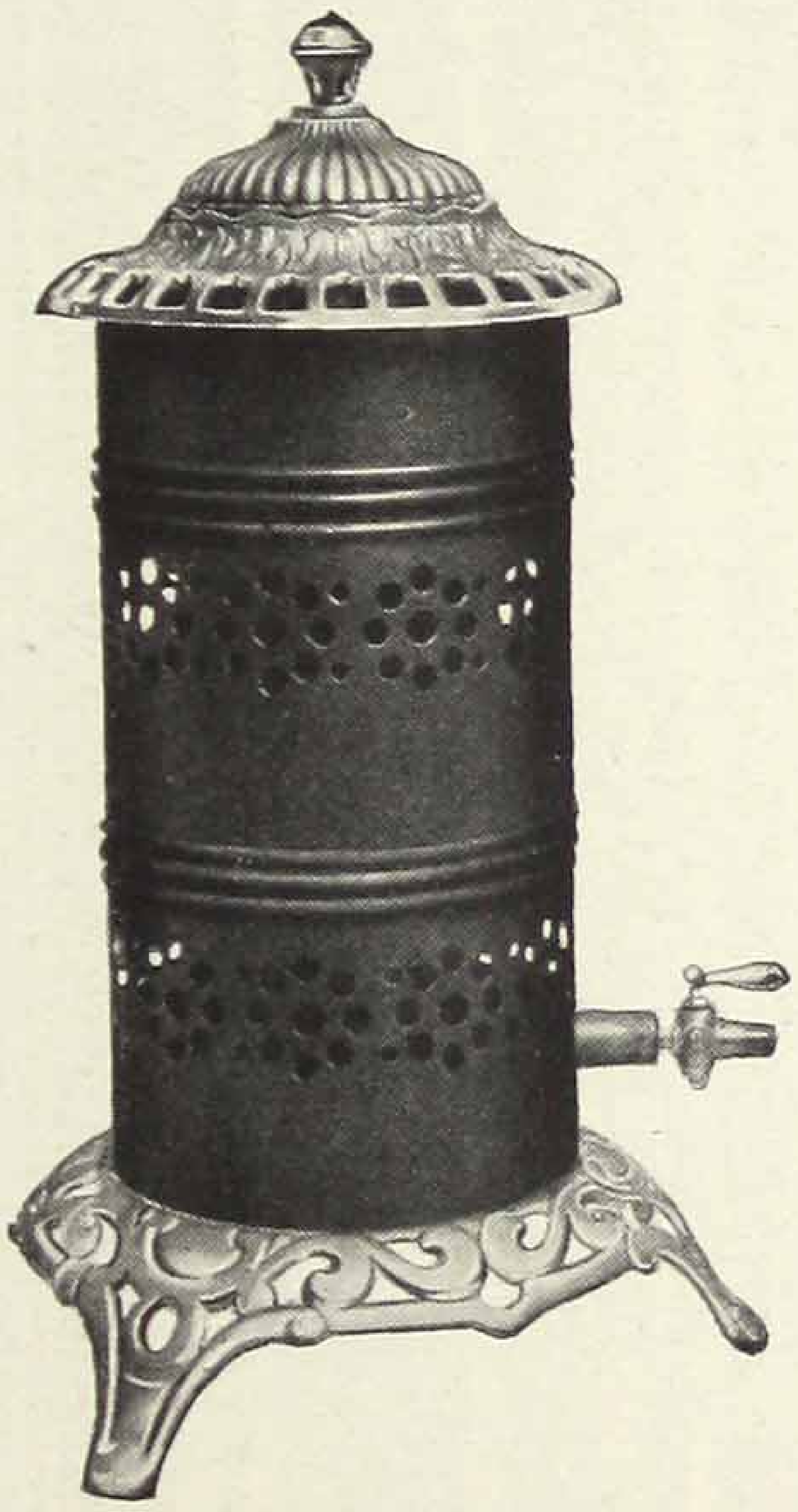

Fig. 5a.—Yellow-Flame Gas Radiator. (Single Cylinder Type.)

On the cheaper types of these stoves the valves are regular hose cocks—while the better grades are often equipped with hose cocks and pilot lighter. These heaters are made in different sizes, consuming from 25 to 30 cu. ft. per hour.

Multi-Cylinder or Tube Radiator Type (Fig. 6)

This gas radiator, or as it may be termed the multiple cylinder heater, when put on the market met with instant approval. It consists of a number of cylinders or tubes being separated for the circulation of air between them and each cylinder

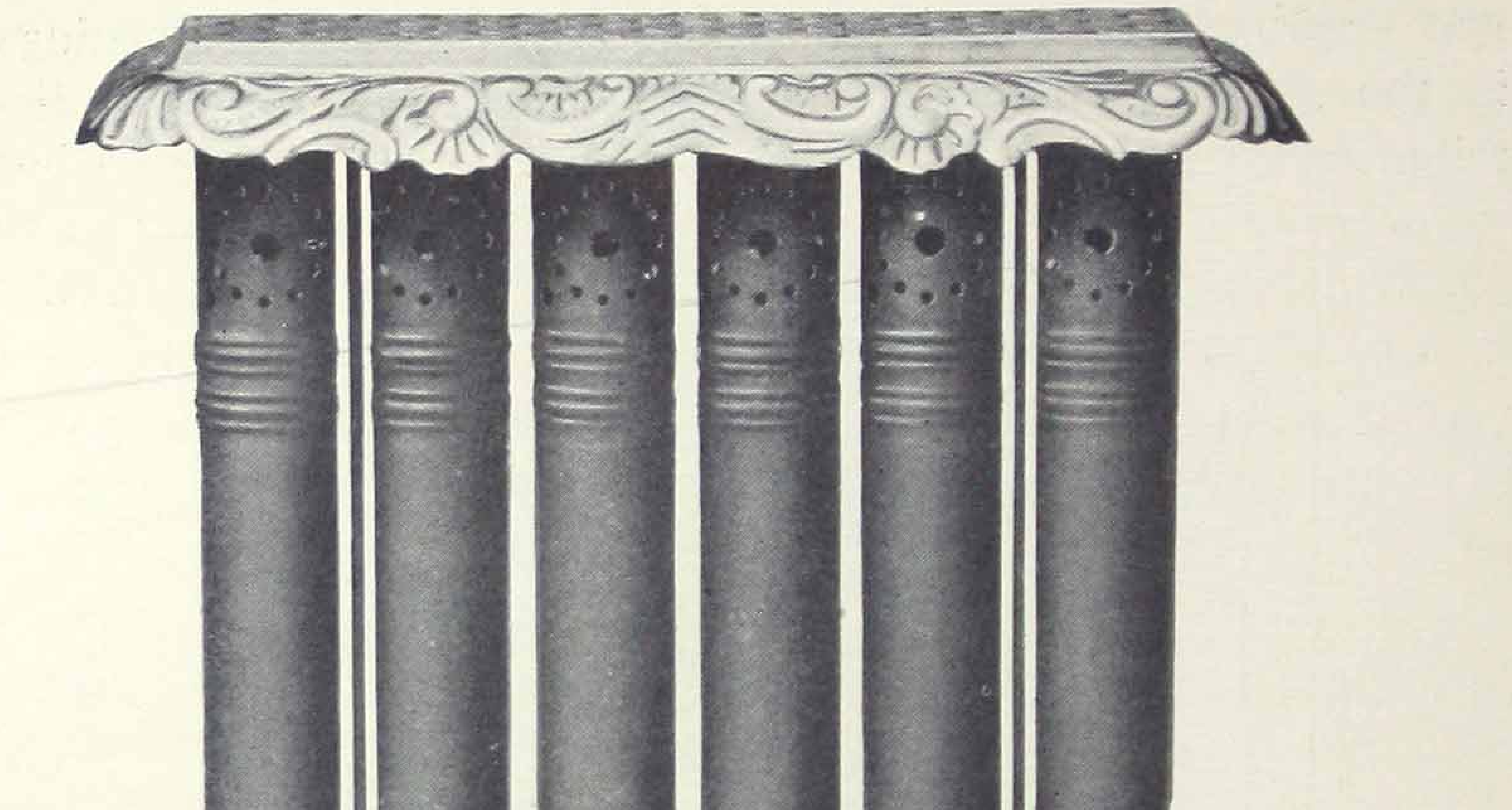

Fig. 6.—Yellow-Flame Gas Radiator.
(Multi-Cylinder Type.)

having at its lower end a casting for holding colored glass jewels, the colors being discernible when the radiator is lighted

One of the faults of these gas radiators was the inability to make the flame flash from burner to burner, or from tube to tube, necessitating the lighting of each burner individually. This defect was overcome by equipping them with a flasher or spreader. This device was of sheet steel and attached to the door in the base, the burner being used as an axis about which it worked. In operation the action of opening the door pulled the spreader over the burner so that when a match

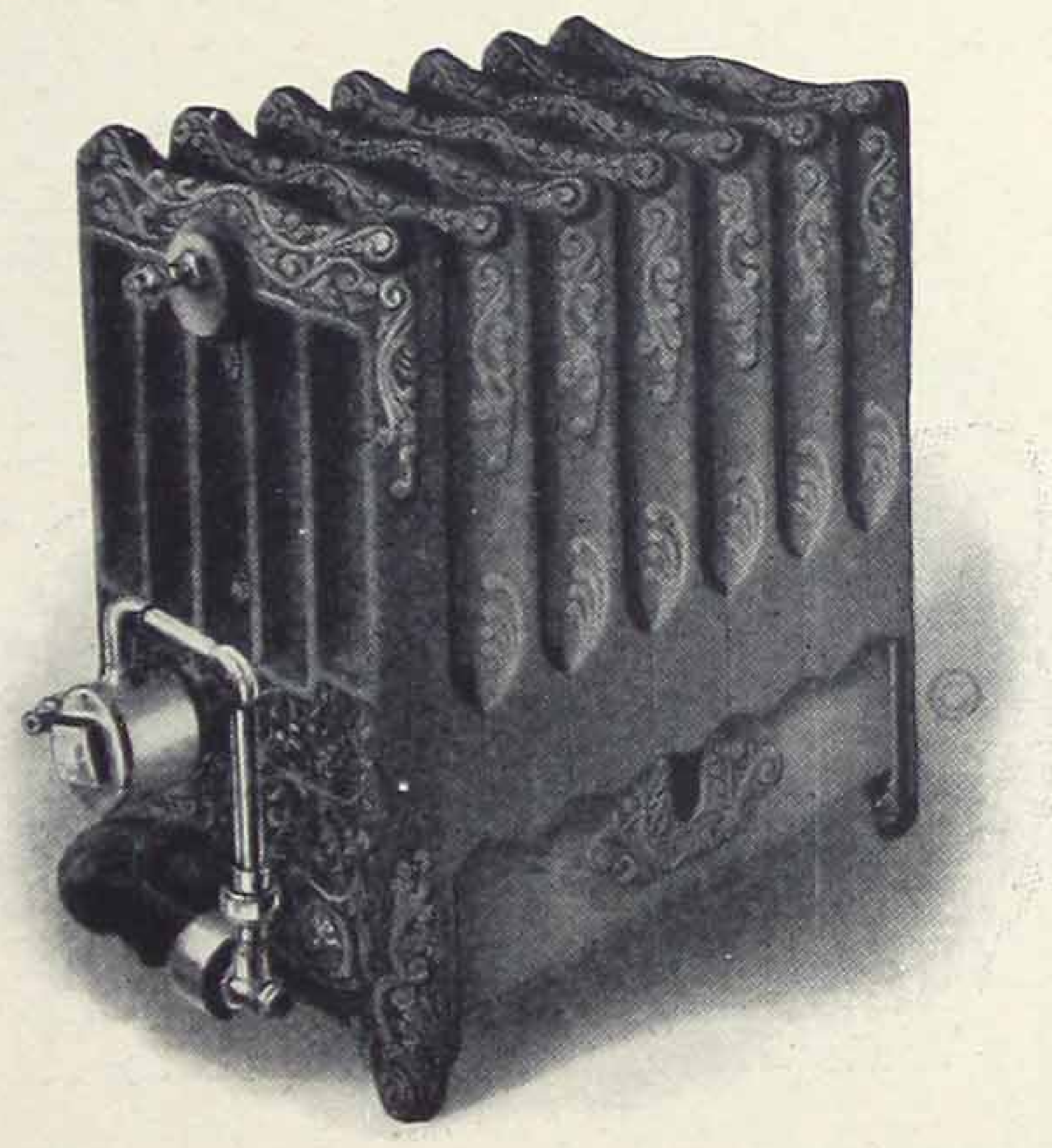

Fig. 7.—Gas Hot-Water Radiator.

was applied at any one burner, the flashing was positive and immediate. The action of closing the door removed the spreader, allowing the flame to burn properly and freely into each tube without any obstruction. This appliance is made in different sizes, having from 4 to 8 tubes, each containing two open flame tips. The usual consumption is about 8 cu. ft. per hour for each tube.

The adaptability of the radiator for small rooms, or where space is limited, and for large rooms, when plenty of heat is required, make it a most desirable appliance. This has lead to the designing of a circular heater which can be placed around columns in large halls and buildings, thus giving a great quantity of heat with the utilization of a small amount of floor space.

GAS HOT-WATER RADIATORS (Fig. 7)

In this type of device the radiators are filled with water which is circulated by the heat generated in the burner which is placed under the radiator. They may be connected to an

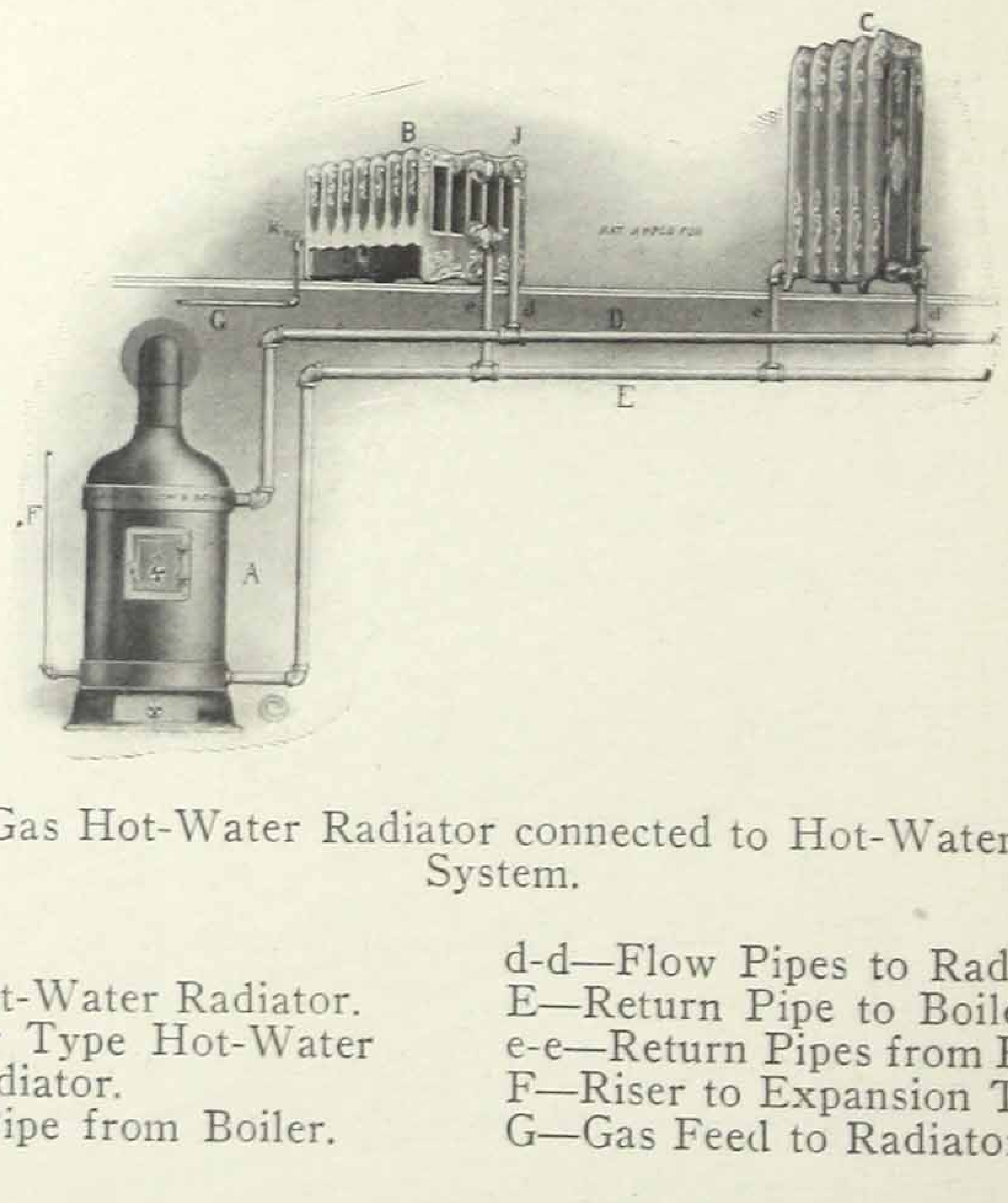

Fig. 8.—Gas Hot-Water Radiator connected to Hot-Water Heating System.

A—Boiler.
B—Gas Hot-Water Radiator.
C—Regular Type Hot-Water Radiator.
D—Flow Pipe from Boiler.
d-d—Flow Pipes to Radiators.
E—Return Pipe to Boiler.
e-e—Return Pipes from Radiators.
F—Riser to Expansion Tank.
G—Gas Feed to Radiator.

existing hot-water boiler (Fig. 8), water back (Fig. 9), or be operated independent of the boiler. They are equipped with thermostats which, actuated by the water temperature, control the gas supply and maintain the water at a uniform temperature. This type of heater uses a Bunsen burner.

Heaters of this kind can also be connected as part of a central house heating system, and can be operated either independent of the system or in connection with it.

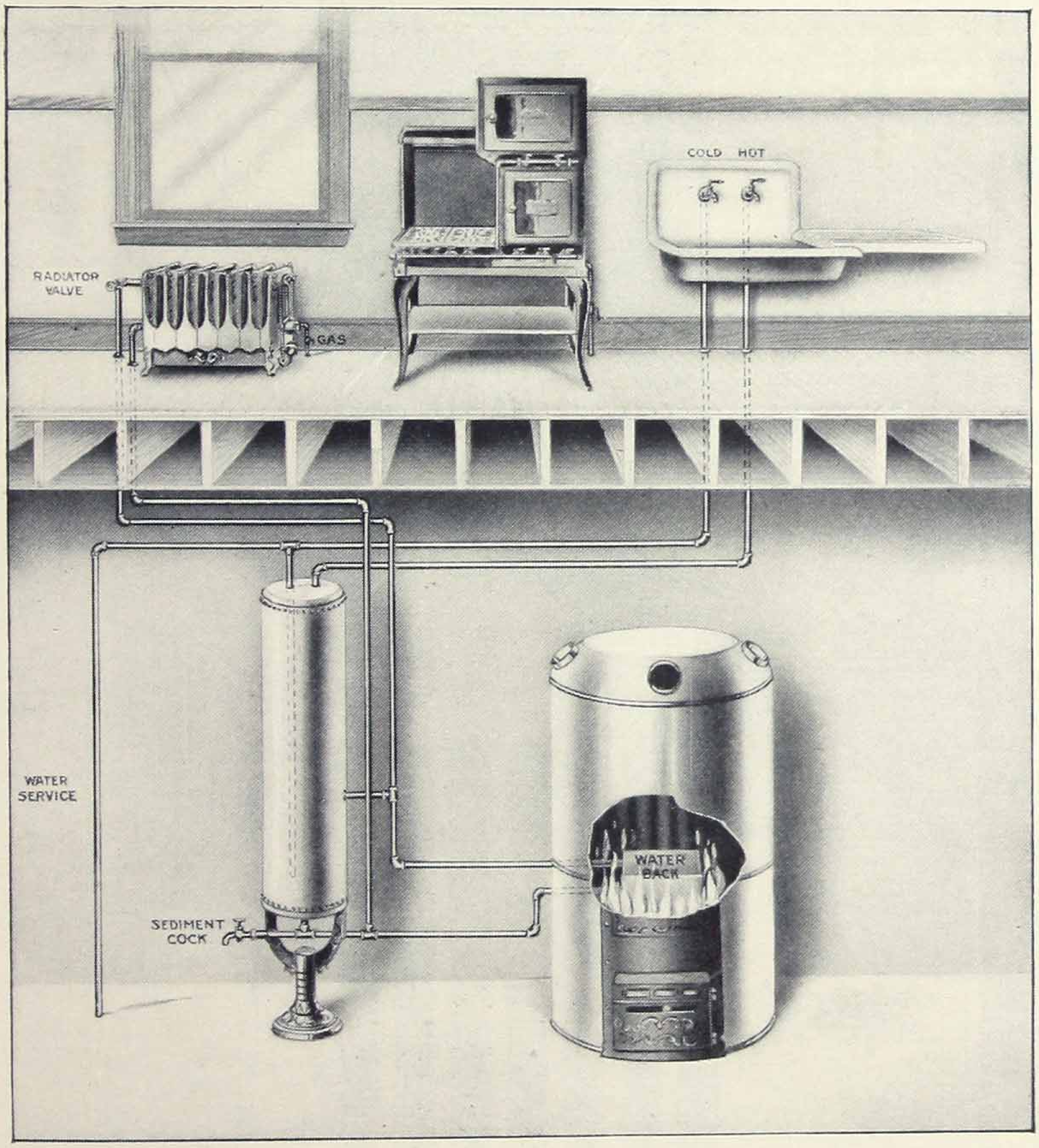

Fig. 9.—Gas Hot-Water Radiator connected to Furnace Hot-Water Back.

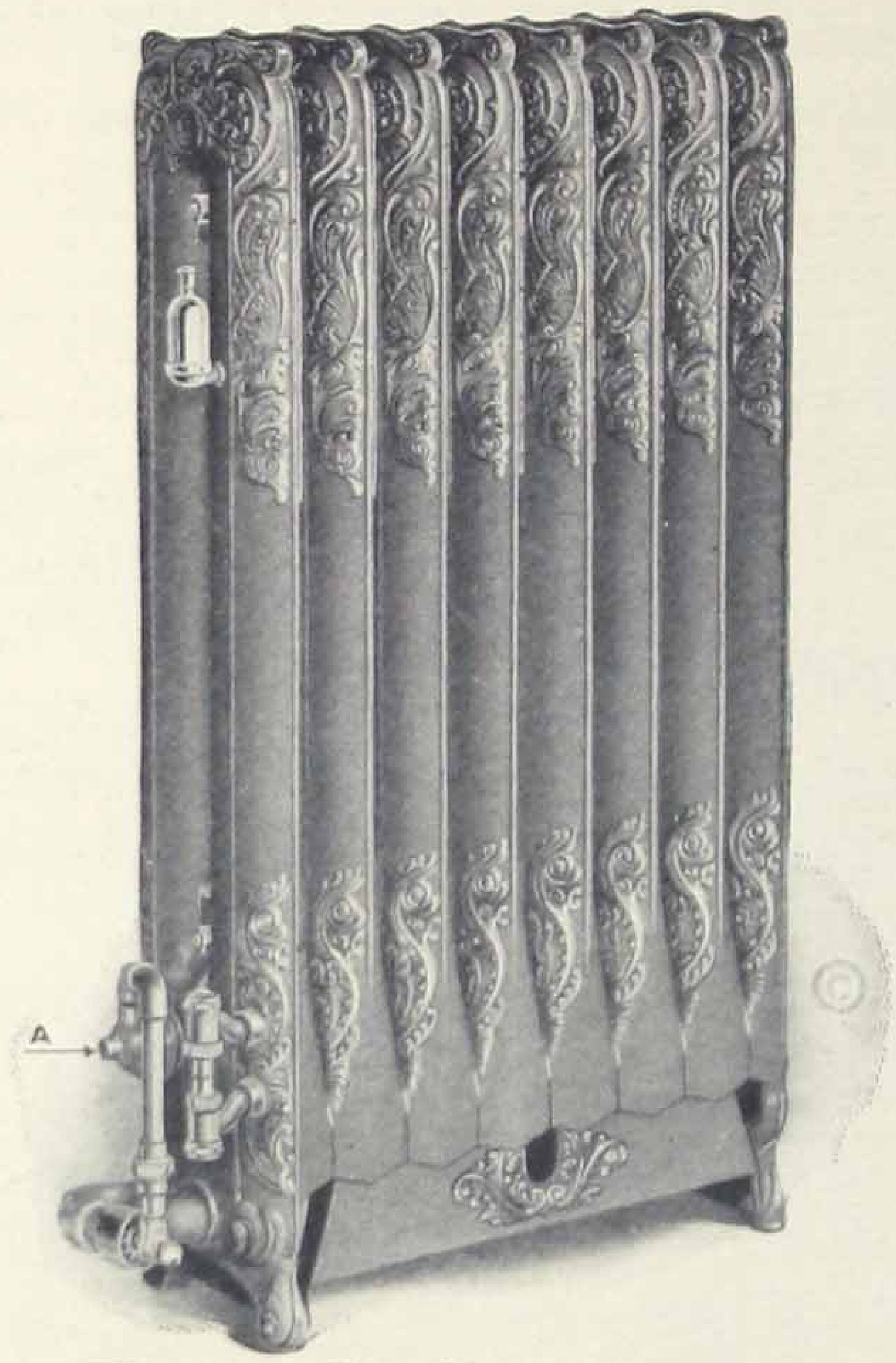

Fig. 10.—Gas Steam Radiator.
(Also made in form shown in Fig. 7.)

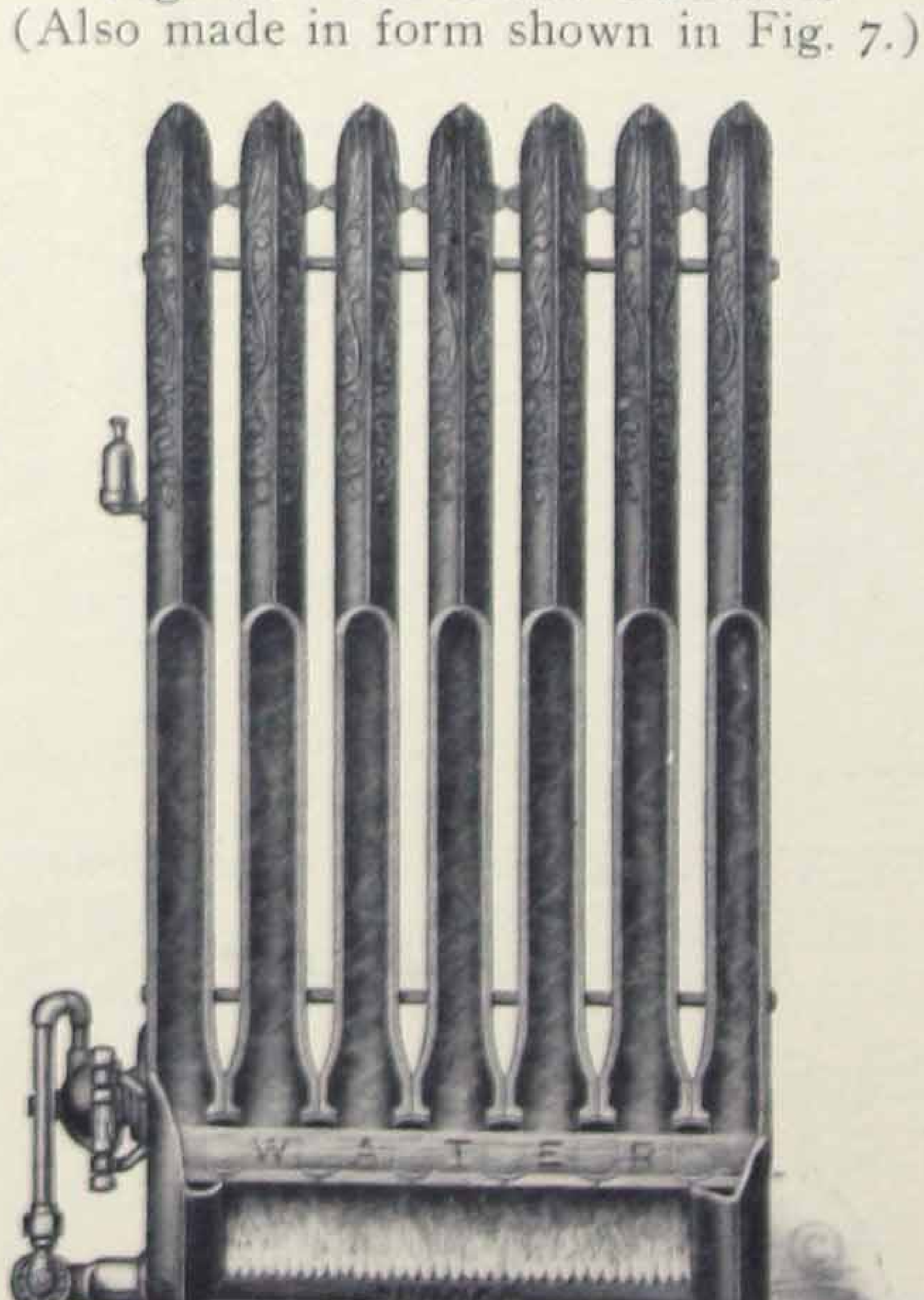

Fig. 10a.—Section of Fig. 10.

GAS STEAM RADIATORS (Figs. 10 and 10a)

These differ from gas hot-water radiators in that only a small quantity of water is used in the radiator itself. Heat is supplied by burning gas in the base of the radiators, and the amount of gas is controlled by an automatic regulator. The pressure of steam on the diaphragm of the regulator reduces the flow of gas to the radiator when the steam pressure has been raised to that at which the regulator is set. There is also a gauge which indicates the amount of water in the

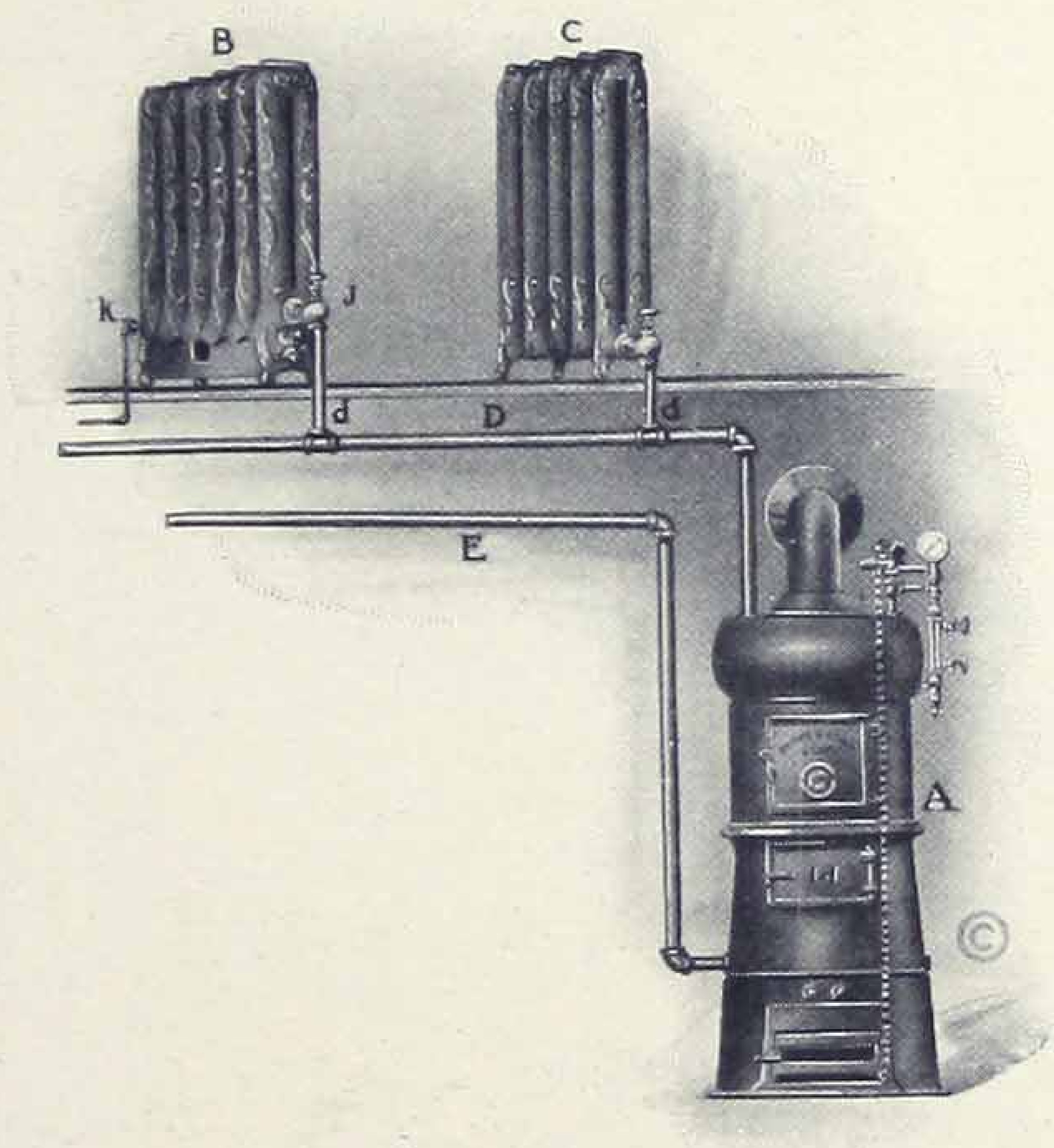

Fig. 11.—Gas Steam Radiator connected to Steam Heating System.

A—Boiler.
B—Gas Steam Radiator.
C—Regular Steam Radiator.
D—Supply Pipe from Boiler.
d-d—Supply Pipes to Radiators.
E—Return Pipe to Boiler.
G—Gas Feed to Radiator.

water chamber and, through this, water may be supplied to or drawn from the radiator. This appliance may also be connected to an existing boiler (Fig. 11).

An automatic air valve which closes as soon as the radiator is filled with steam prevents the system from becoming air bound, which condition is caused by the trapping of air in the radiator, occupying the spaces designed for steam. As air is a poor conductor of heat, an "air-bound" radiator does not perform its functions properly. This appliance is constructed so that 4 to 15 sections of 4 sq. ft. each of radiating surface may be assembled together. From 20 to 30 minutes is required to "get up steam," after which the automatic regulator

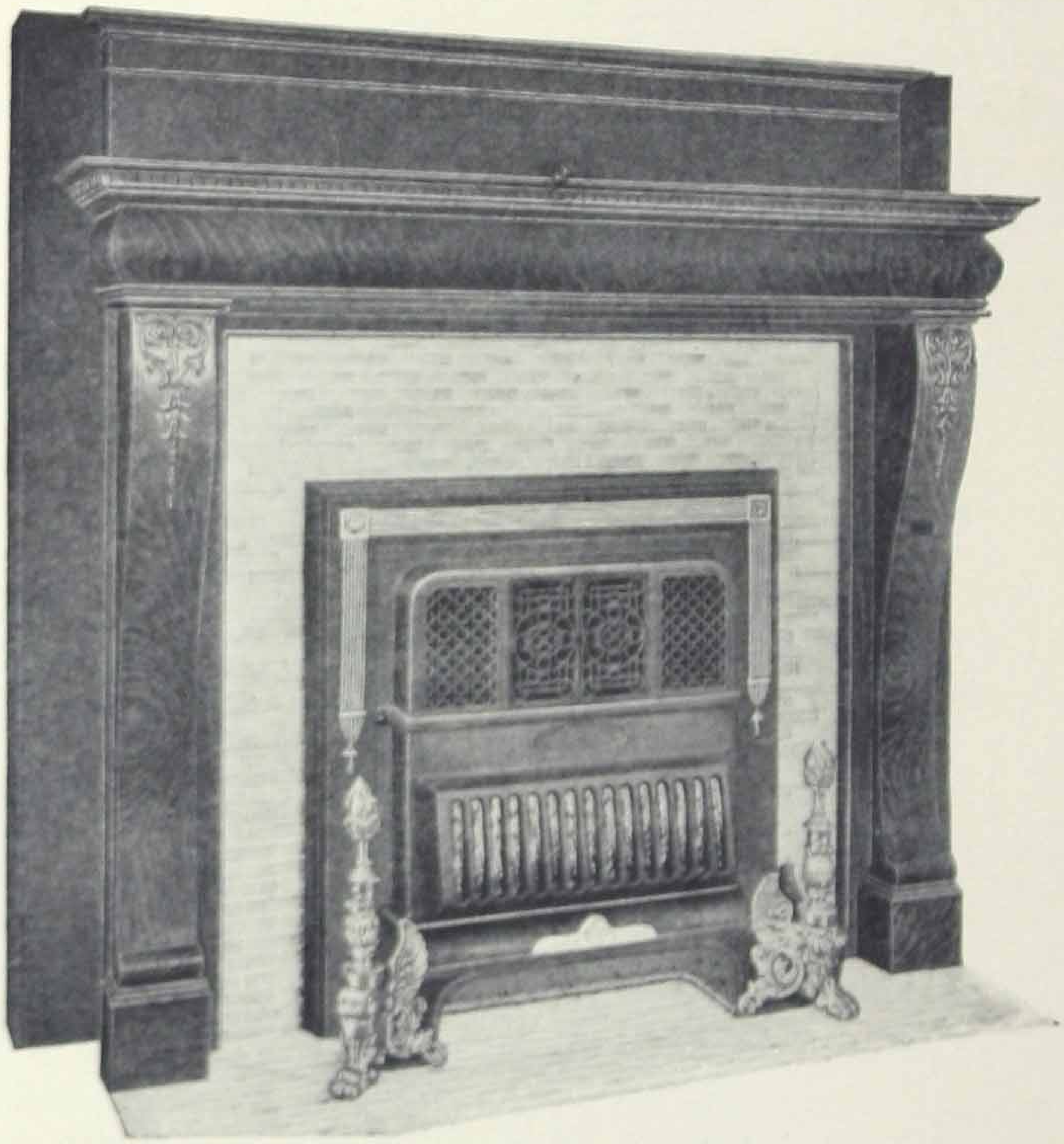

Fig. 12.—Yellow-Flame Incandescent Fireplace Radiator.

reduces the consumption to about 2 cu. ft. per hour per section.

Independent individual room heating appliances are designed for location at any convenient point in the room, are usually not fitted for flue connection and with the exception of the Gas Hot-Water and Gas Steam Radiators are usually designated as "portables"—that is, their locations may be altered by the user without inconvenience or the services of a pipe-fitter. Pipe connections are always advisable, however.

FIREPLACE HEATERS

Heaters designed for installation in fireplace openings and for flue connection utilize to a large extent the same principles of heating except that the convection currents arising

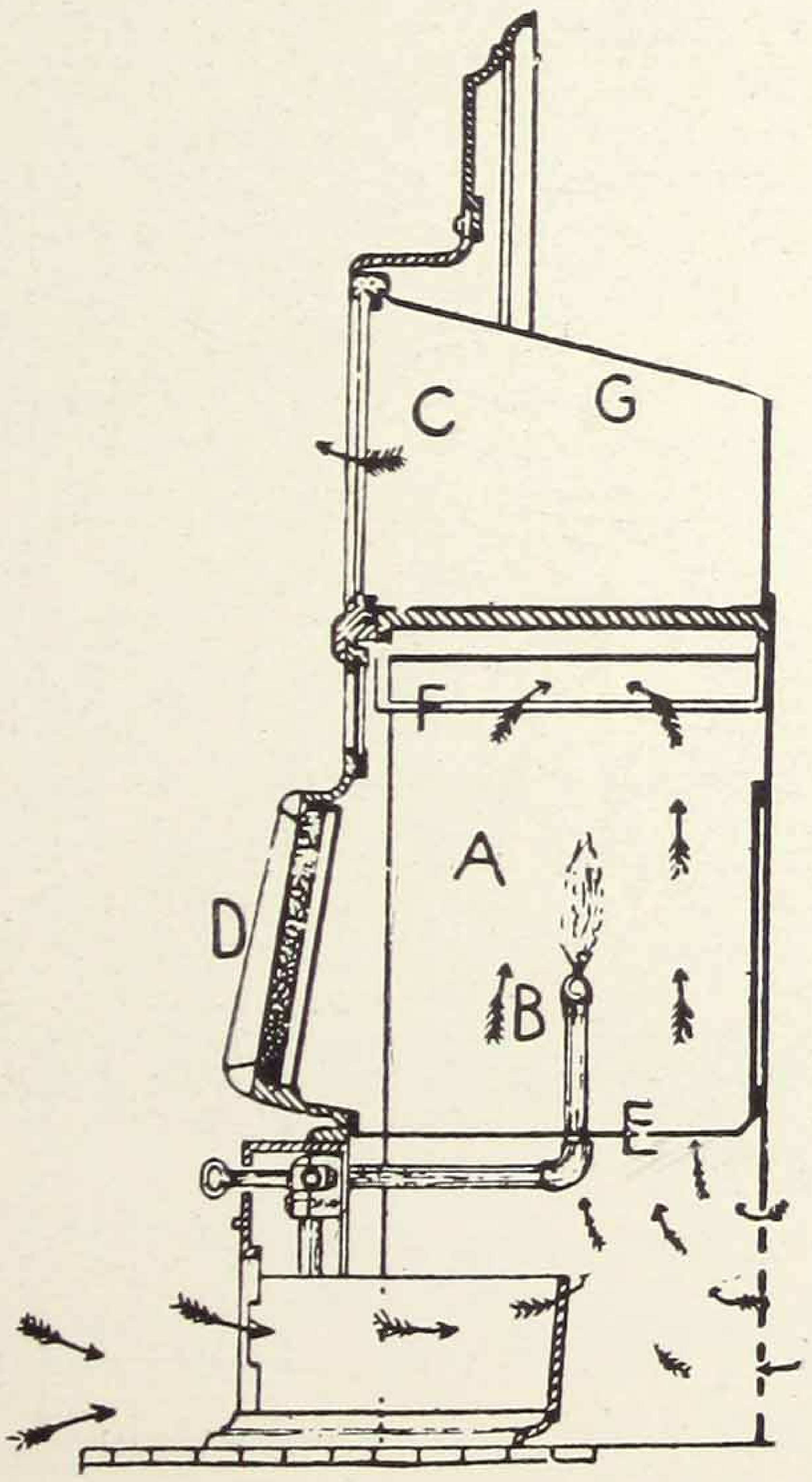

Fig. 12a.—Cross-section of Fig. 12.

from the apparatus are not available for heating to any great extent, most of the heat in combustion products being lost through the flue. They are usually of the Incandescent Radiator type, as the optical effect of a coal or wood fire is desired. Figs. 12 and 12a show a fireplace heater of the Incandescent

Yellow-Flame type, consuming 25 to 30 cu. ft. per hour. Radiation takes place through a transparent front, and is also reflected from a polished metal surface back of the burner, so that this heater partakes of the nature of the reflector type as well. This heater is *not* designed for flue connection.

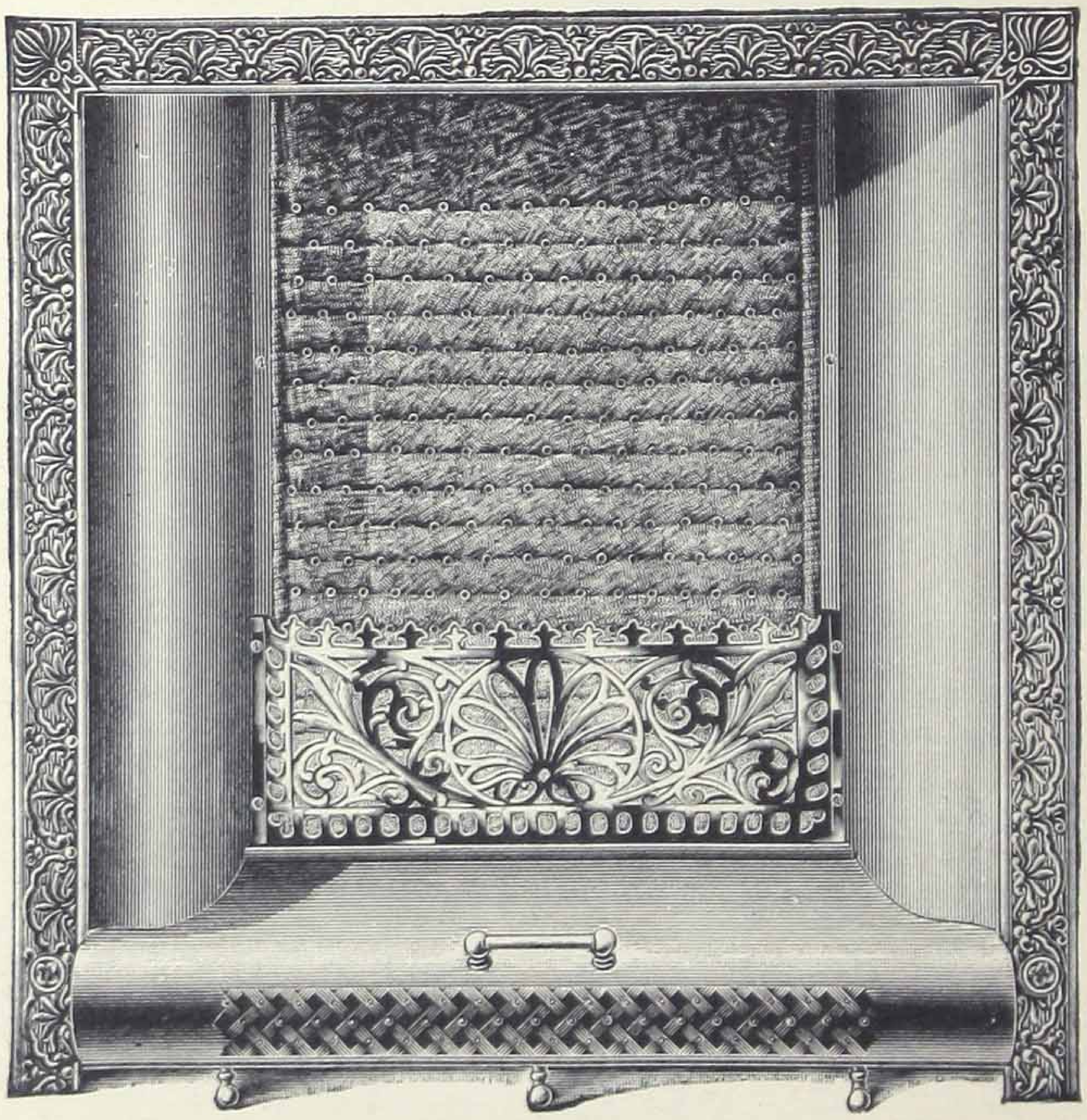

Fig. 13.—Blue-Flame Incandescent Fireplace Radiator.

Figs. 13 and 14 show fireplace heaters of the Incandescent Blue-Flame type, which are identical in principle with the independent room heaters described above. The reflector type is also manufactured for fireplace installation (Fig. 15).

Gas Log Fires

In an attempt to imitate the wood fire on an open hearth, many varieties of so-called gas logs (Fig. 16) have been constructed. Originally they were made entirely of "terra cotta" shaped to look like a log or logs of wood colored to imitate wood bark, with here and there a little loose asbestos fibre so that the burning gases will "liven up." In construction the terra cotta was made hollow with channels communicating from log to log, the front walls of the logs giving a very pleasing effect. Yellow or illuminating flames were used in this appliance.

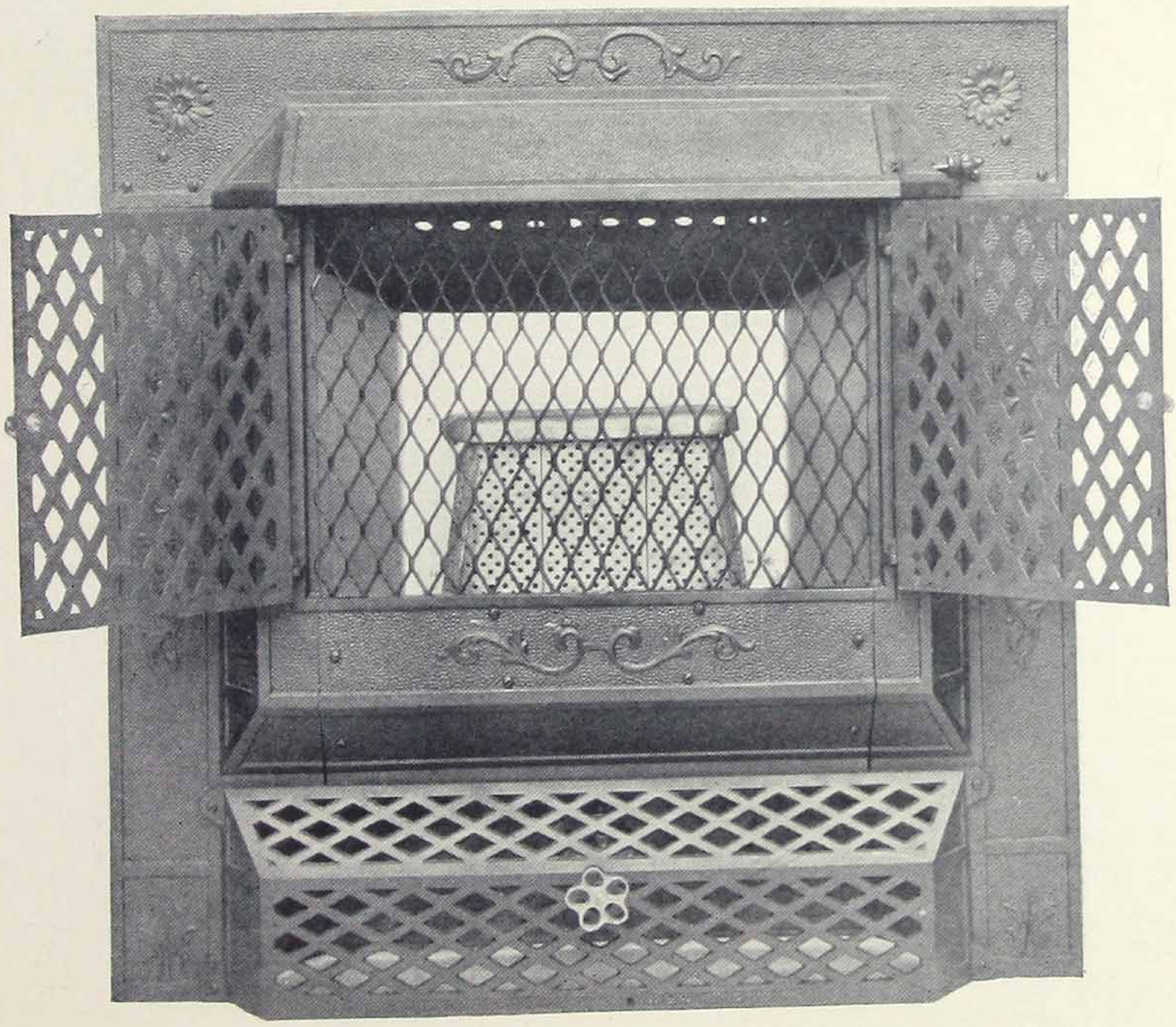

Fig. 14.—Blue-Flame Incandescent Fireplace Radiator.

This device was not entirely satisfactory, since the communicating channels between the logs very often closed up, causing a lack of gas supply. Furthermore, the flame would in time deposit carbon on the log, closing up exit holes, thus causing imperfect combustion and objectionable odor.

In an endeavor to overcome these faults the "semi-blue" flame was used. This was accomplished by equipping the logs with an air mixer that would admit only a small quantity of air, insufficient to create the full Bunsen effect, but no attention was paid to the top log. The secondary air supply

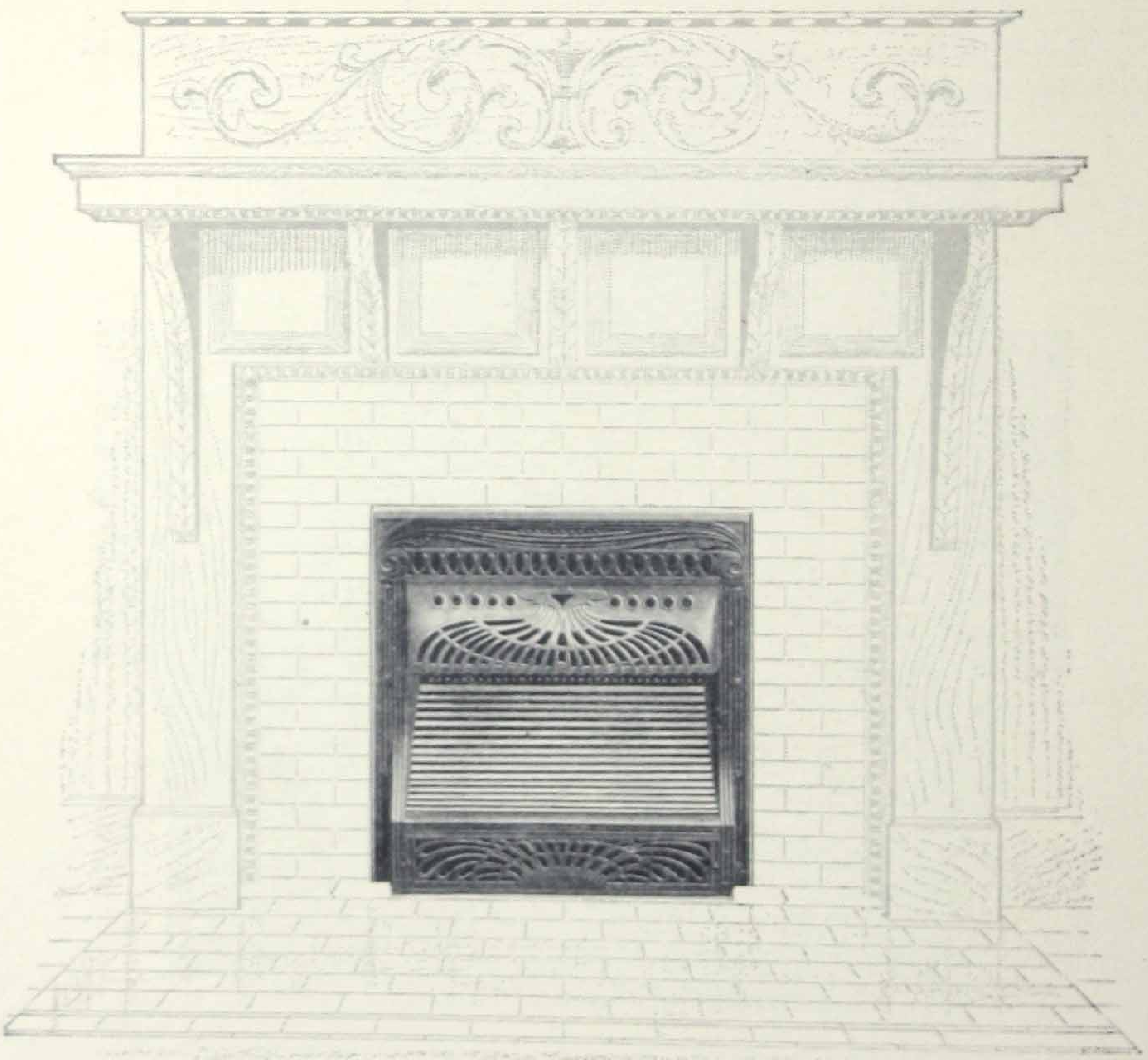

Fig- 15.—Reflector Type Fireplace Radiator.

to the top log was contaminated by the combustion products arising from the bottom log, resulting in incomplete combustion. Troubles and odors were just as frequent, and the manufacturers were forced to look into the construction more fully and to employ methods to bring the gas log to the same efficiency as other appliances.

As a result of this investigation, the interior of the logs was made of proper area to take care of the volume of gas to be consumed and methods employed so that the areas could not change and stoppages would not occur. The exit holes were properly proportioned and the appliances were equipped

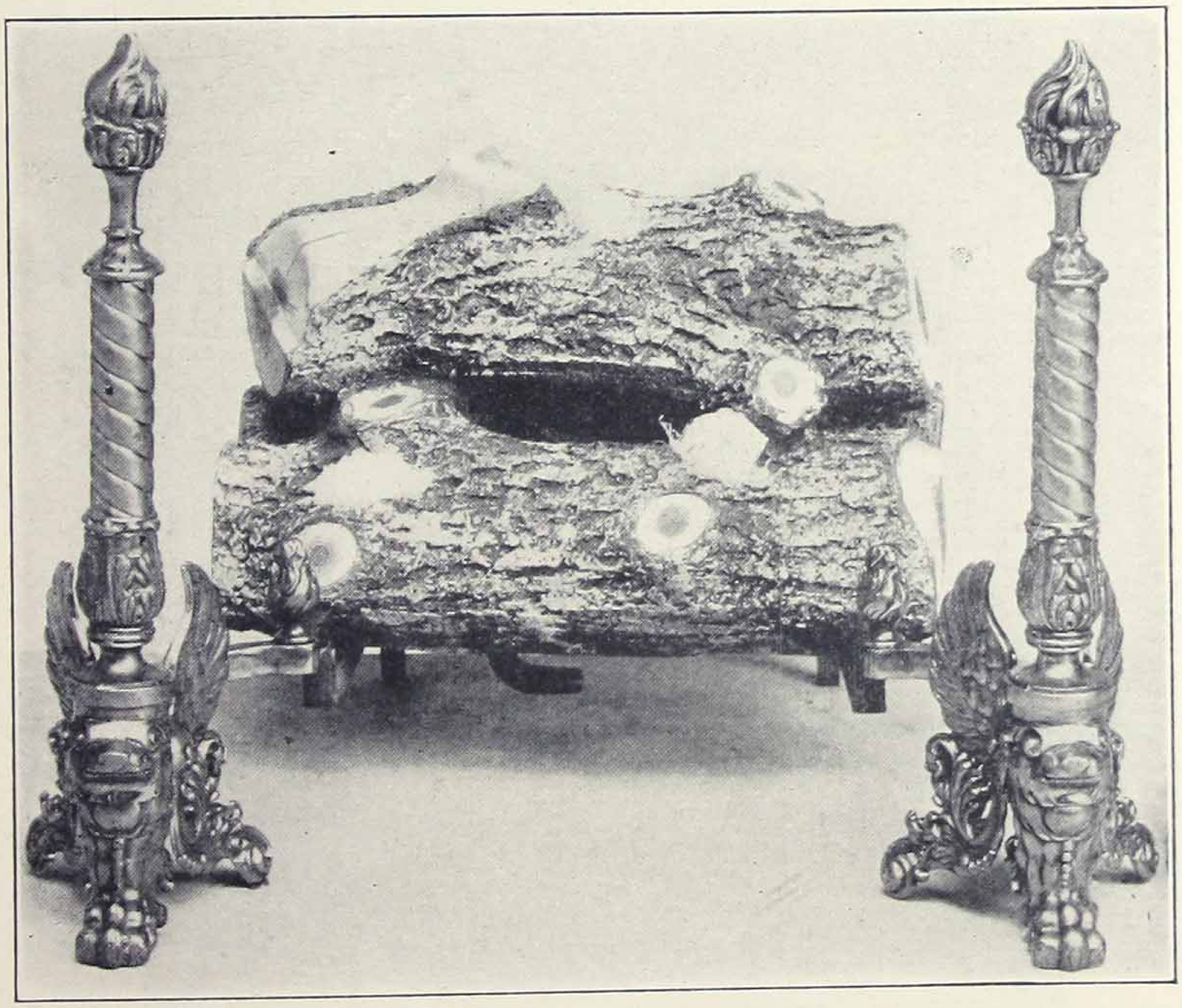

Fig. 16.—Gas Log.

with a regulating air mixer and adjustable gas supply, thus bringing the "gas logs" to the same degree of efficiency as any other gas burning appliance. A recently introduced type provides separate burners for the upper and lower logs. In this way the primary air to the top log may be increased to compensate for the lack of oxygen in the secondary air, which is diluted by products of combustion from the bottom log.

Fig. 16a shows a combination of Gas Log and Steam Radiator, the construction and operation of which is clearly indicated in Fig. 16b.

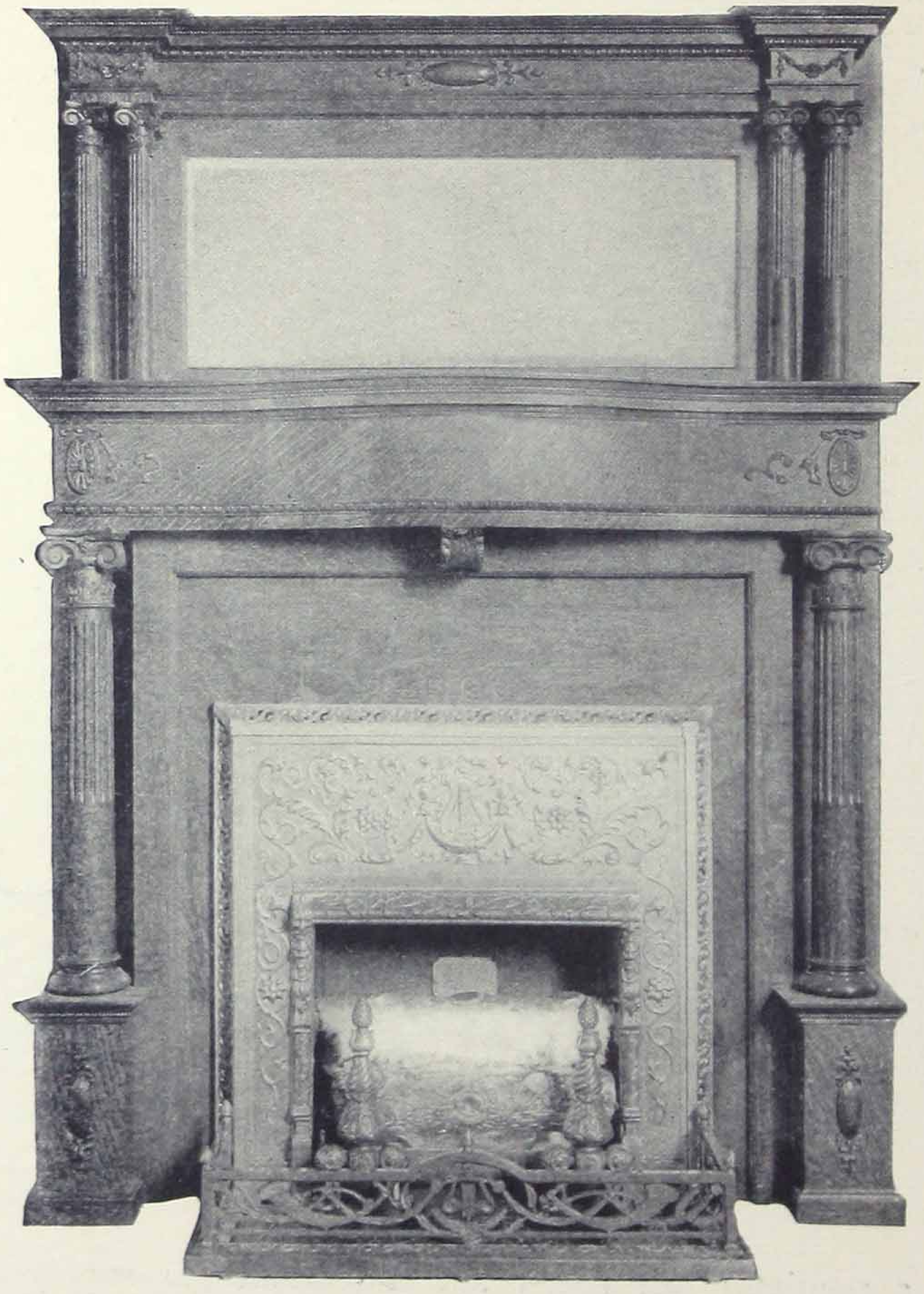

Fig. 16a.—Gas Log and Steam Radiator Combined.

The gas log is made in various sizes. An 18 in. gas log fire of one make consumes up to 74 cu. ft. per hour, according to adjustment, performing satisfactorily at each adjustment. The consumption depends upon the design, and in some makes does not exceed 24 cu. ft. per hour for an 18 in. fire.

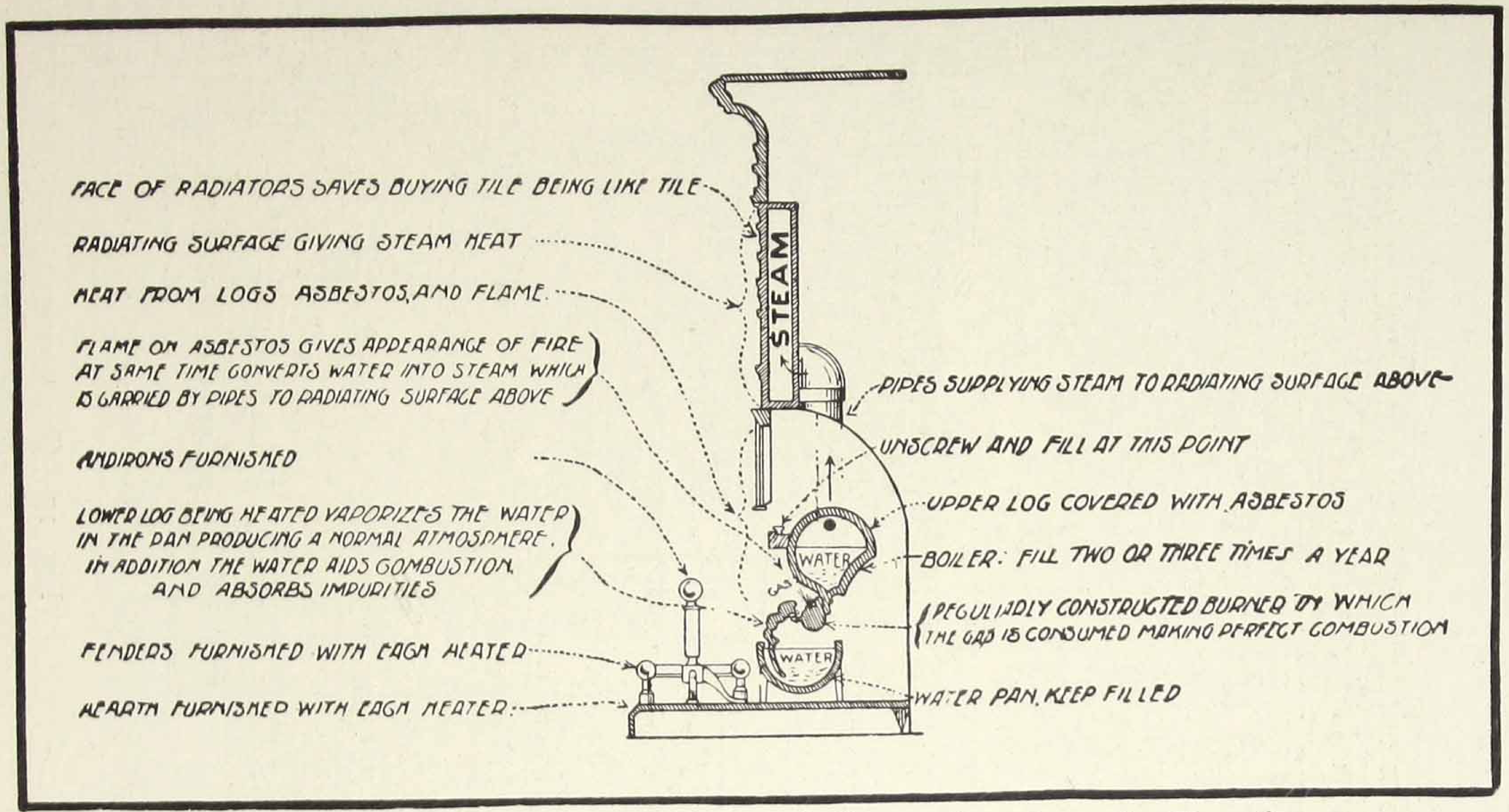

Fig. 16b.—Sectional view of Heater similar to that shown in Fig. 16a.

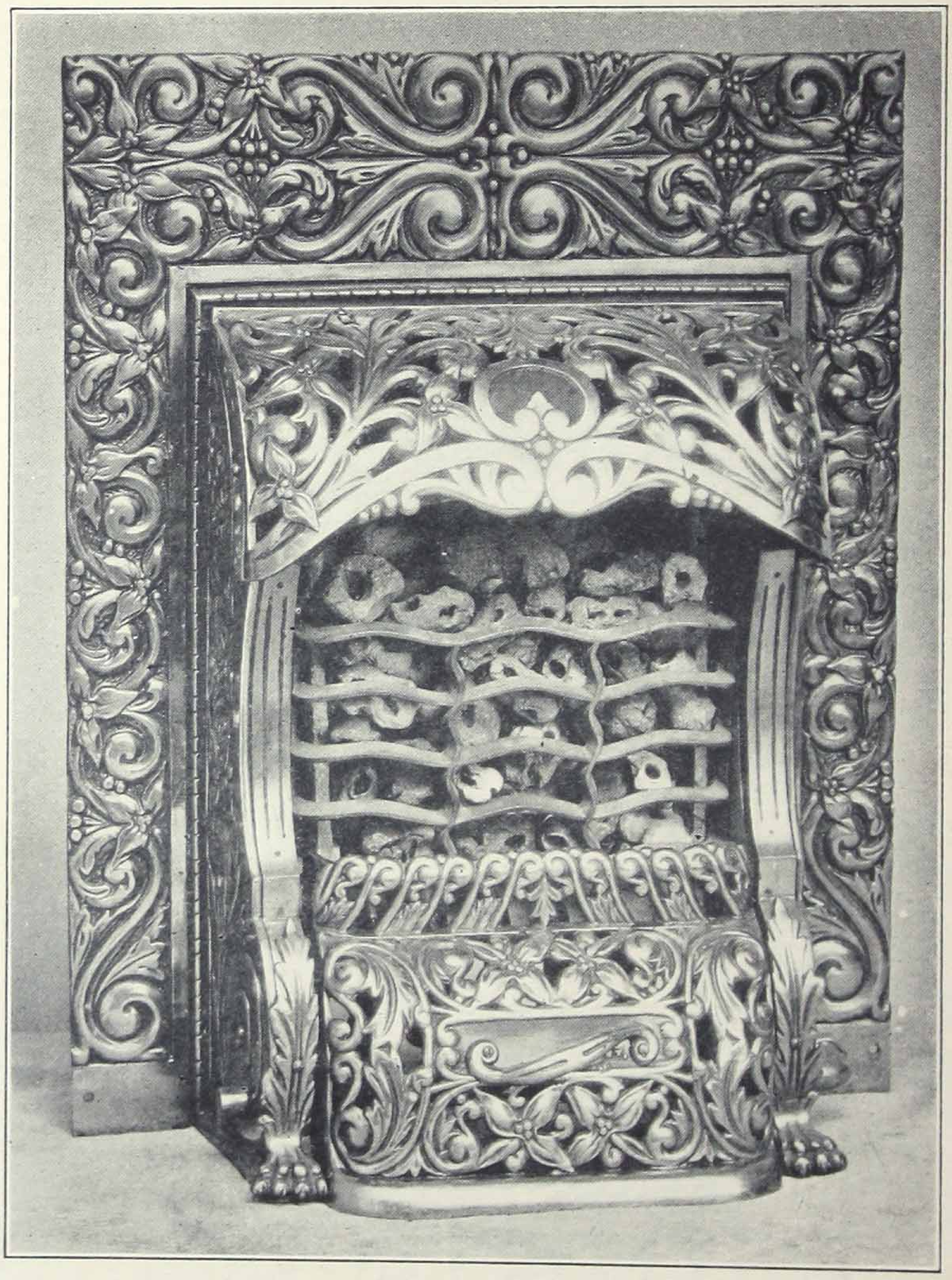

Fig. 17.—Gas Grate.

GAS GRATES

A type of gas grate (Fig. 17) which simulates closely the open coal fire is constructed in the shape of a coal burning grate and contains a number of pieces of refractory material perforated so that the flames may play through them and supply heat in addition to that radiated from the material which is rendered incandescent.

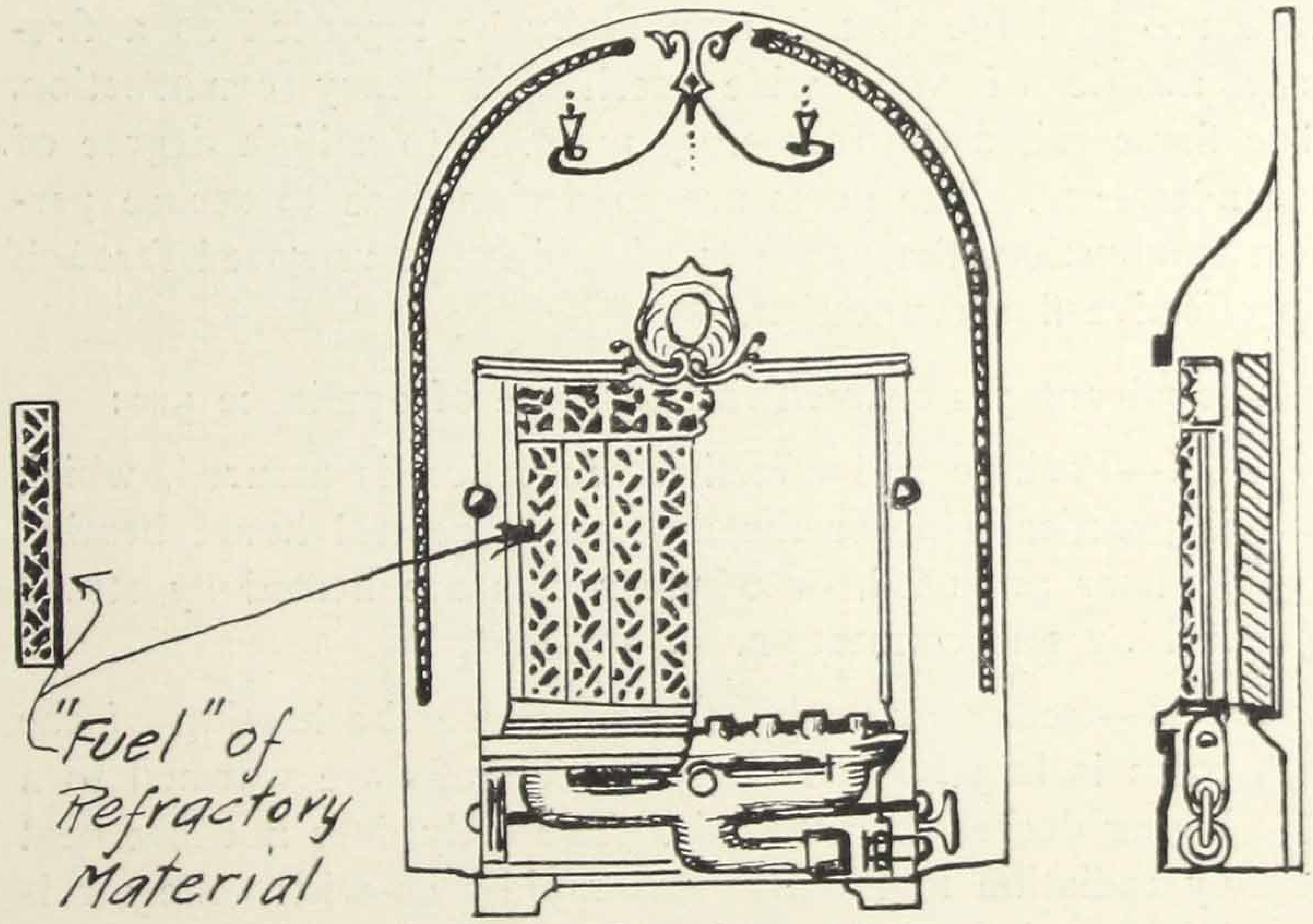

Fig. 18.—English Gas Fire.

Part of front cut away to show means of placing "fuel" over flame ports.

In these types of gas grate, a blue flame is used, and the products of combustion pass out of the chimney through the flue connection. It is made in various sizes for different fireplace openings.

GAS FIRES

House heating by artificial gas has reached its highest development and greatest success in England, where the 'Gas

Fire' is principally used for this purpose. Since this is the only appliance in which artificial gas has been successfully used in a large way to displace coal as the principal means of heating dwellings, it is entitled to detailed description, although it is not used in America.

The most common type of English 'Gas Fire' (Fig. 18) consists of a Bunsen burner having a large number of flame-ports or tips, over each of which is placed a long, narrow perforated tube of refractory material. The perforations in this tube are so large that it may really be regarded as a fire-clay mantle of very wide mesh and heavy construction. The flame raises the refractory material to a high degree of incandescence. The ports are so designed as to secure perfect combustion, the products of which are removed through an effective flue connection.

The advantages claimed for this type of appliance are:

I—Positive and effective ventilation is assured, which is practically never the case when central house heating systems are used, or where rooms are heated by stoves lacking flue connection.

II—Better hygienic effects. Since the heating of the room is largely by radiation, the walls are warmed to a higher degree than the air. The body does not lose heat by radiation to the walls as rapidly as where the air is warm and the walls cool. The lower temperature of the air decreases its capacity for absorbing moisture, hence, occupants of the room do not experience the sensation of dryness, encountered in rooms where the air is warm. Undoubtedly, it is preferable to keep the air at as low a temperature as is consistent with bodily comfort, and a greater degree of bodily warmth is experienced in a room with warm walls and cool air, than in one with warm air and cold walls.

From a hygienic standpoint the principles of heating by individual radiant heaters are far superior to the common American practice of heating by steam, hot water or hot air.

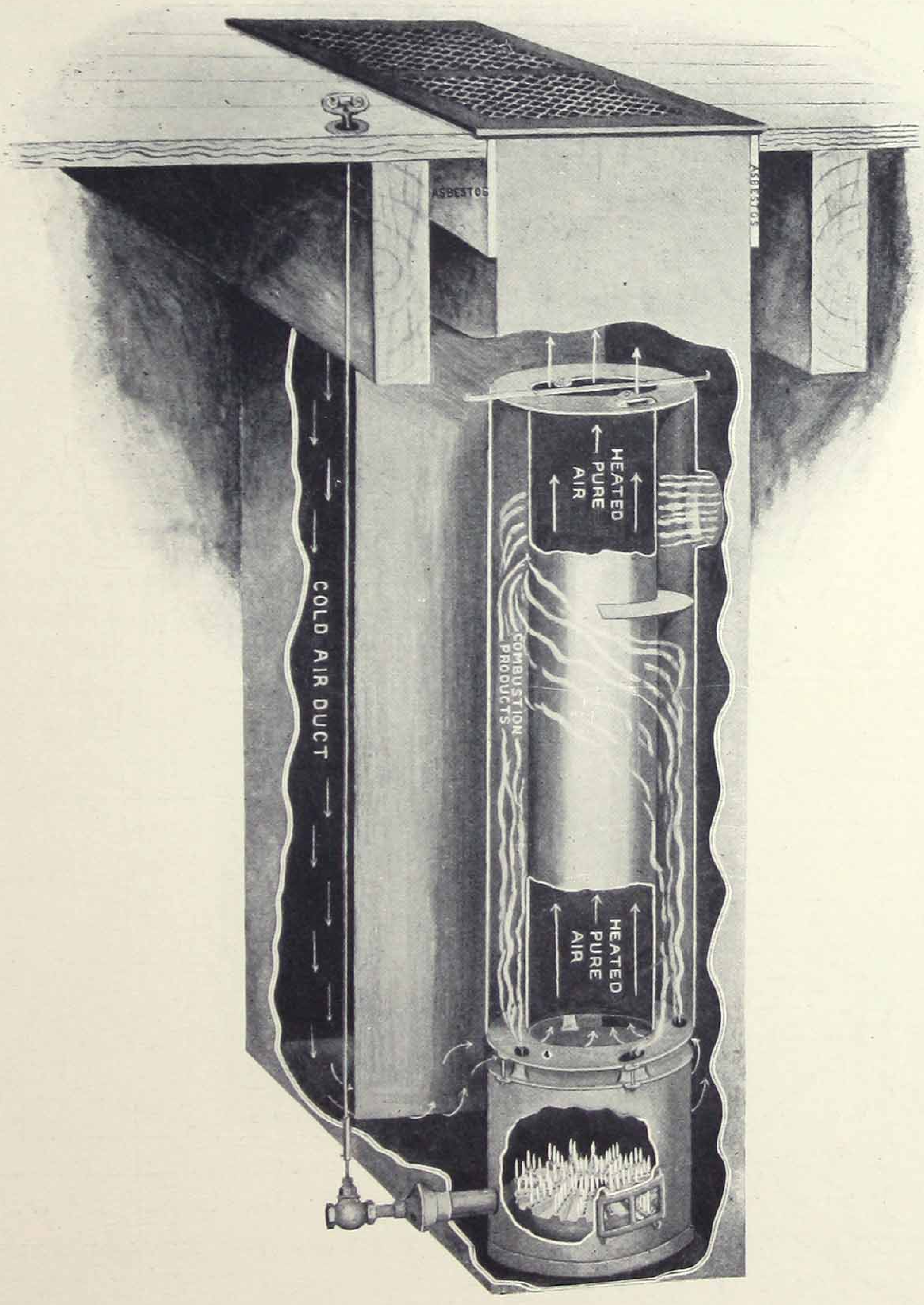

Fig. 19.—Floor Heater.

FLOOR HEATERS AND WALL HEATERS

In addition to the more common type of house heaters described above as portable heaters or fireplace heaters, there is still another type of individual room heater which is somewhat different in its application. This is the type known as the floor register heater (Fig. 19) or circulating floor furnace. This appliance consumes about 40 cu. ft. per hour on artificial gas or 25 cu. ft. per hour on natural gas.

These are made with either a series of tubes or a drum divided into compartments under which is placed a blue-flame burner. Cold air from the floor passes down through the

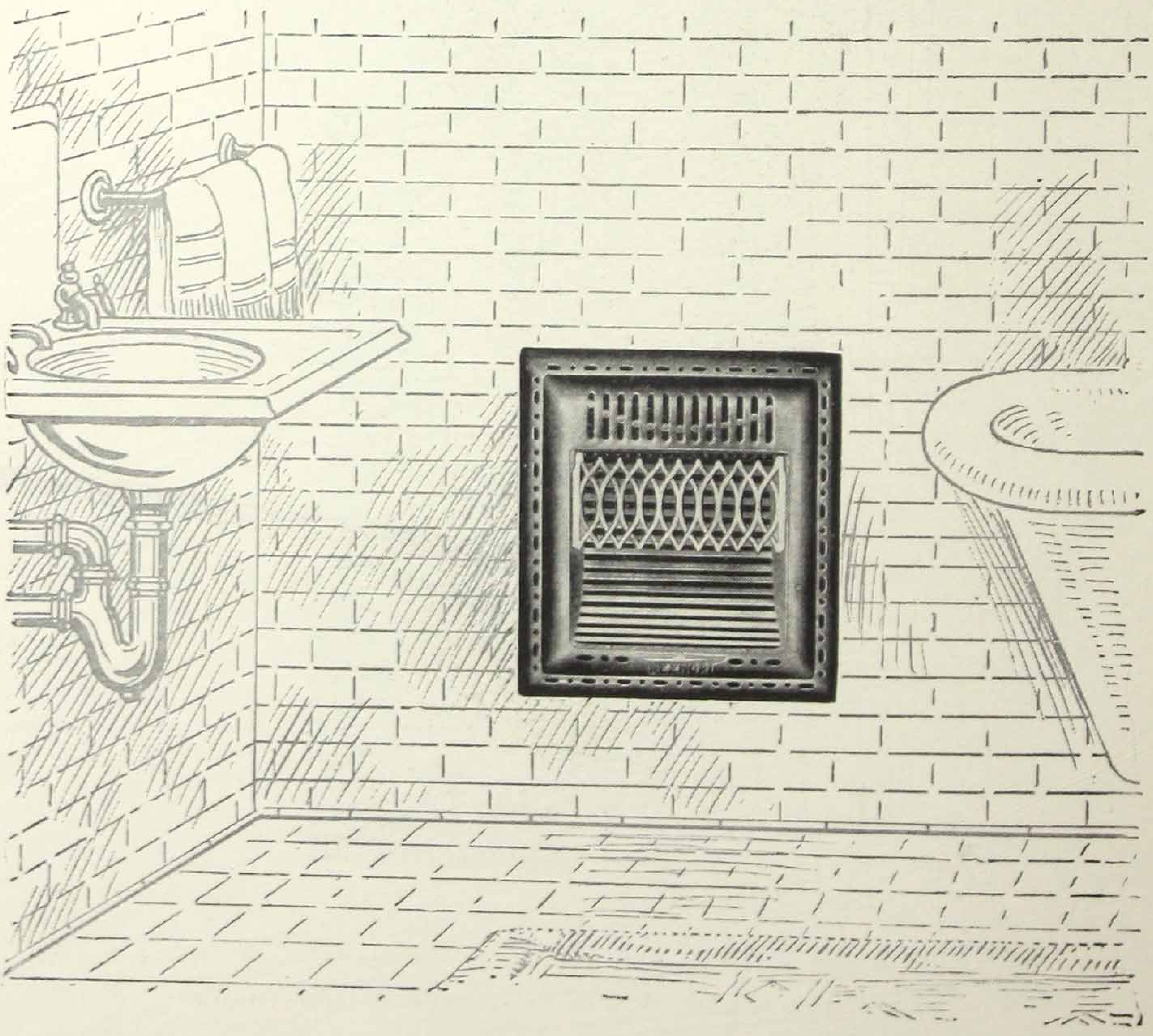

Fig. 20.—Yellow-Flame Reflector Radiator. (Wall Type.)

openings on the sides of the drum or tubes, becomes heated as it returns to the drum or tubes, and passes out through the register in a super-heated condition without coming in contact with the combustion products. The products of combustion are carried off through a flue pipe in the chimney. There is an opening at the bottom of the heater to permit the necessary air for combustion.

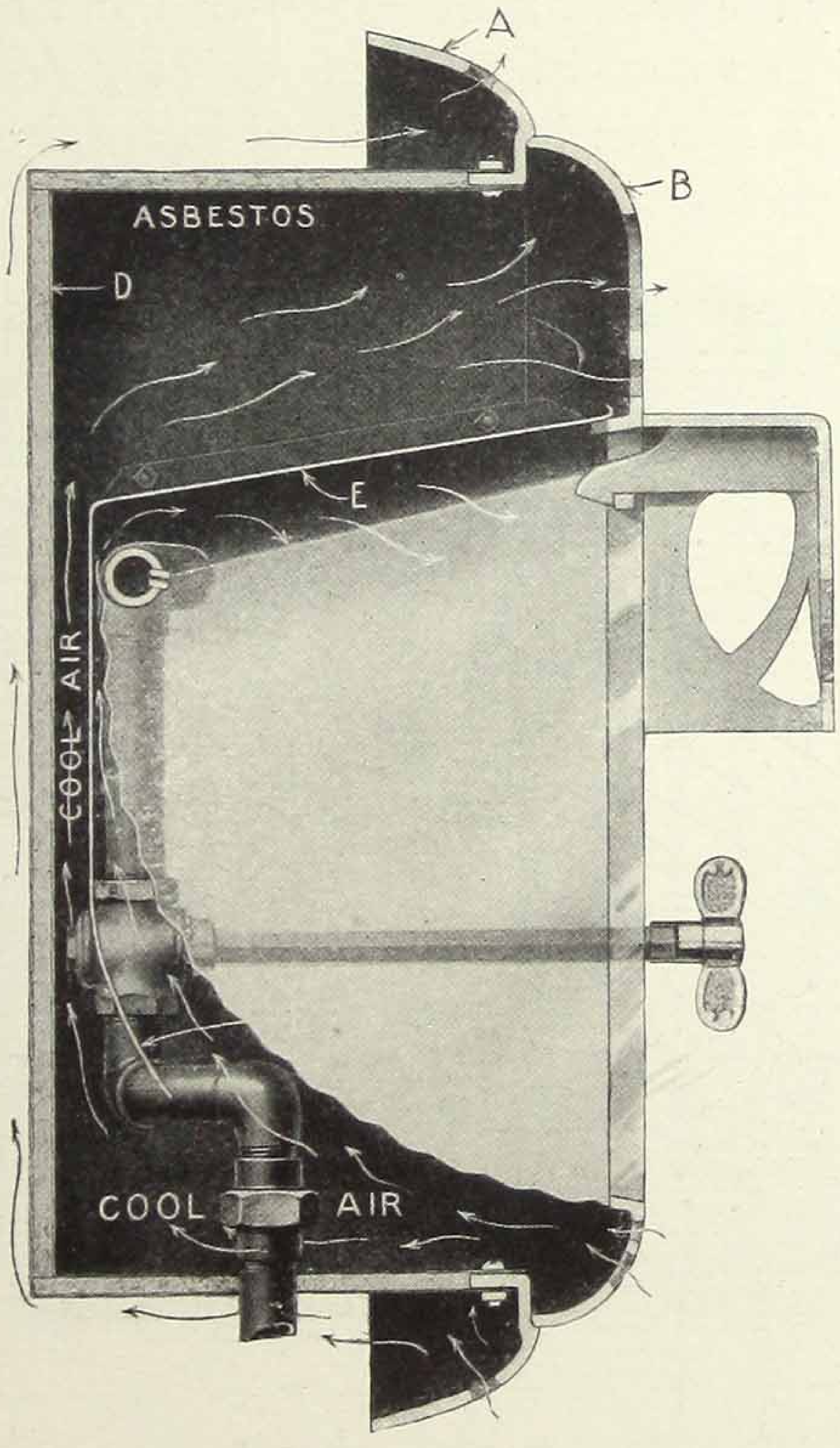

Fig. 20a.—Cross Section of Fig. 20.

This style of heater is especially adapted for stores, churches, or public places where cellar space is available.

Figs. 20 and 20a show a special modification of the yellow-flame reflector radiator for installation in the wall of a bath or similar room where space is limited.

INDIVIDUAL ROOM HEATING APPLIANCES EXHAUSTING INTO A CENTRAL VACUUM SYSTEM

A system of house heating by individual gas radiators supplying heat by the products of combustion, but requiring a new installation instead of utilizing an existing furnace, consists essentially of a Bunsen burner placed in an air-tight compartment located at the center of a set of pipes looking not unlike

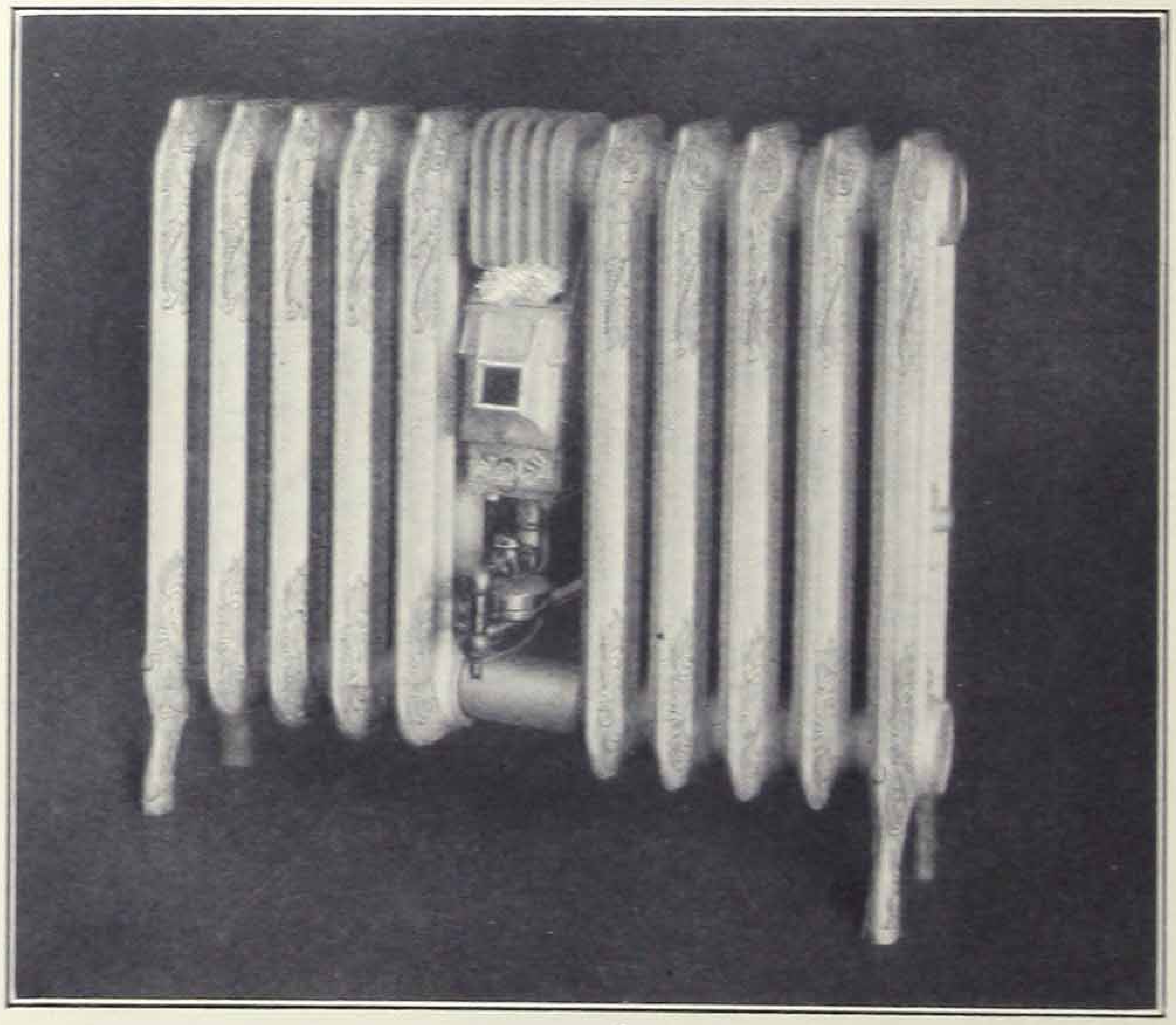

Fig. 21.

an ordinary steam radiator. (Fig. 21.) The pipes leading from this radiator instead of conveying steam or hot water as in the ordinary heating apparatus, convey the products of combustion and connect with a revolving fan placed in the basement, which exhausts the air in the pipe.

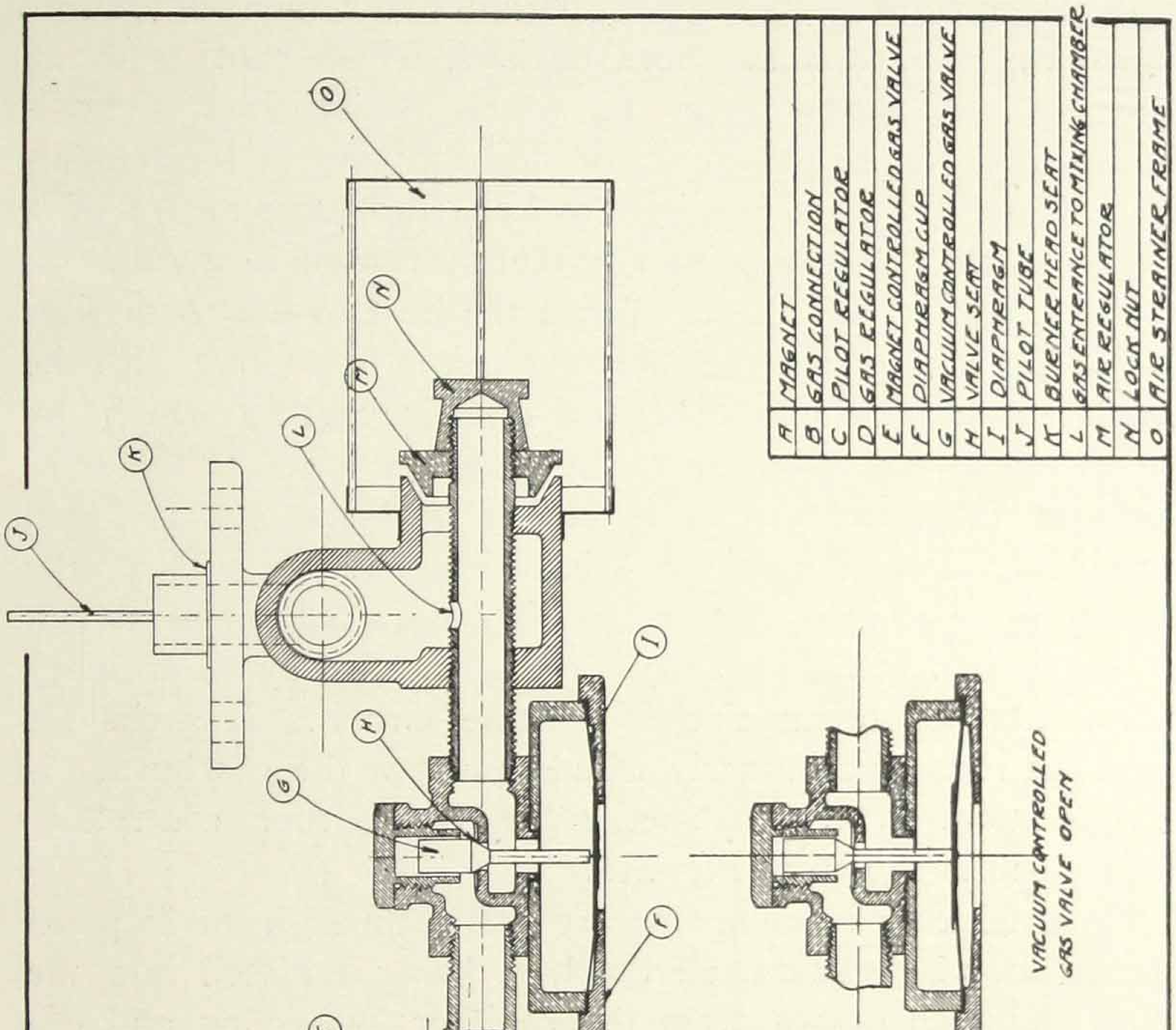
A MAGNET
B GAS CONNECTION
C PILOT REGULATOR
D GAS REGULATOR
E MAGNET CONTROLLED GAS VALVE
F DIAPHRAGM CUP
G VACUUM CONTROLLED GAS VALVE
H VALVE SEAT
I DIAPHRAGM
J PILOT TUBE
K BURNER HEAD SEAT
L GAS ENTRANCE TO MIXING CHAMBER
M AIR REGULATOR
N LOCK NUT
O AIR STRAINER FRAME
VACUUM CONTROLLED GAS VALVE OPEN

Fig. 21a.

In order to make the apparatus automatic in its action, an ingenious thermostat has been devised, which consists of an ordinary dial thermometer to which is adjusted a brass pointer that can be placed at any desired point of the temperature scale. If it is required to keep the temperature of a room at, say, 70°, the pointer is merely turned to number 70 of the scale and left there. When the heat in the room rises to 70° the hand of the thermometer comes in contact with the brass pointer and establishes an electric current which, by energizing an electro-magnet, shuts off the gas. If the temperature falls, the circuit is broken and the gas is again turned on, a small pilot light effecting ignition. Thus, the apparatus, once in operation, requires no attention whatever.

The suction fan is kept in continuous action by an ordinary motor attached to an electric lighting circuit. It sucks air from the room continuously whether or not the gas burner is in operation. The construction of the burner controlling mechanism is shown in Fig. 21a.

The products of combustion are drawn through the loops of the radiator by suction, all the heat being radiated into the room and then drawn from the radiator by suction and exhausted through a flue or outside the building. There are a number of individual gas radiators located in the various rooms of a building, all connected to the suction fan and exhaust motor.

The burner face is composed of alternate layers of corrugated and straight strips of brass; the burner is so constructed as to be easily taken apart and cleaned. The radiators are generally regulated to pass 20 cu. ft. of gas per hour. However, as the thermostat keeps the radiator shut off practically three-fourths of the time in average weather, the gas consumption per radiator per hour averages only about 5 or 6 cu. ft. A Bunsen pilot is used with this burner.

The thermostat may also be wired to the motor, thus controlling the system by cutting off the suction when the desired temperature has been reached. A clock also may be wired to the radiator or motor to start either the individual radiator or the whole system, as the case may be, at a certain hour. This clock operates in a manner similar to the thermostat.

By placing thermostats in the various rooms or parts of the house it is possible to control the temperature at any desired degree uniformly through the house or it may vary in each room. For instance, the living-room may be set at 70° F. and the bedrooms at 50° F. or 60° F., while the basement is kept at 35° F. or 40° F. or just warm enough to prevent water freezing in the pipes.

With a system of this character, the entire house heating plant may be started and stopped at a moment's notice by simply pushing a button. This button controls the exhaust fan, which maintains the suction throughout the entire system. This suction holds open the gas valve in each radiator. The instant the suction is stopped by the push button, or for any other cause, the valves automatically close in each radiator, shutting off the gas. The instant the button is pushed, turning on the suction, the gas is automatically turned on again in each radiator, is lighted by the pilot, and then continues to burn until turned off again by the thermostat or push button. Not only is this true for the entire house, but also for each room in the house. In the latter case, however, the individual radiators are turned off and on by turning the thermostat hand backward or forward. The advantages of this system are:

Vigorous and positive mechanical. Each radiator exhausts about 200 cu. ft. of air per hour.

Economy of fuel due to close adaptation to varying requirements. It is said that the waste of coal due to the lack of this feature is at least 25 per cent. of the total amount burned during a season.

The release, for useful purposes, of the basement space required for the steam or hot-water boiler, coal storage, janitor's quarters, etc.

High efficiency due to low temperature of flue gases.

A sectional view of a typical installation is shown in Fig. 22.

HEATING FROM A CENTRAL PLANT

House heating by artificial gas offers a number of advantages that readily appeal to the consumer. Briefly stated, these advantages consist of absolute cleanliness in the house and atmosphere, a uniform even temperature, automatic control, heat in any quantity and at any time and freedom from janitor troubles.

Referring to the possibilities of heating houses exclusively with artificial gas, this subject has been the cause of much investigation and experiment in all parts of the country. Aside

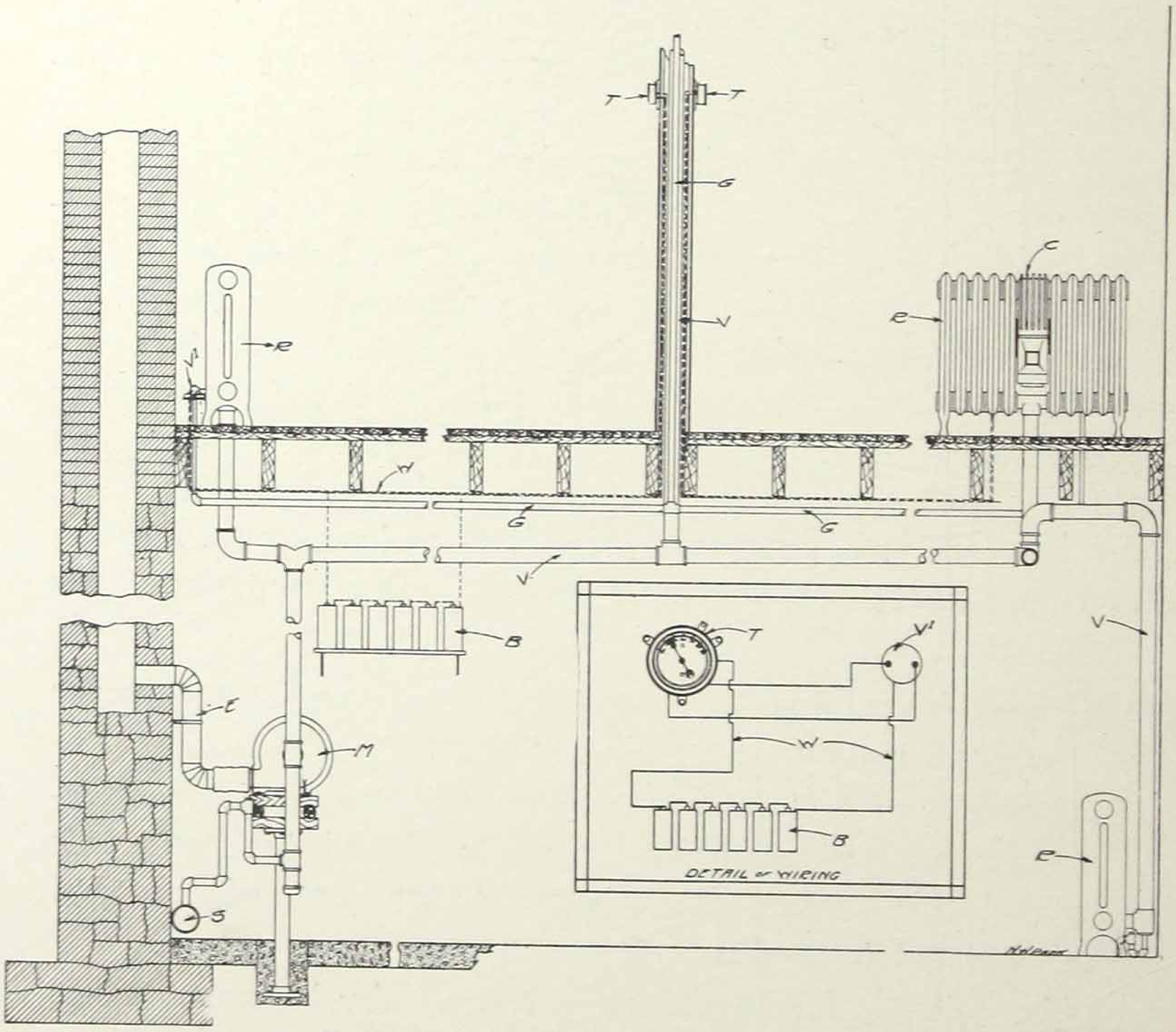

Fig. 22.

B—Dry Battery.
C—Combustion Chamber.
E—Exhaust Pipe to Flue.
G—Gas Supply.
M—Motor-driven Exhaust Fan.
R—Radiator.
S—Sewer.
T—Thermostat.
V—Vent to Exhaust Fan.
V¹—Electrically Controlled Gas Valve.
W—Electric Circuits.

from the many advantages in the house itself, there is the important feature of smoke abatement and the handling of coal and ashes into and from the cellar.

It is fully conceded that gas at 50 cents per 1,000 cu. ft. will cost in excess of coal at $8.00 per ton from 85% to 100%. This may appear rather unfavorable to the use of gas, but it should be remembered that this figure does not take into consideration any of the costs incident to janitor service, handling coal and ashes, the value of cleanliness and personal comfort about the home and other advantages, all of which can reasonably be reduced to a monetary value. Not so many years ago, illumination by gas, as compared with the cost of coal oil, appeared beyond reason, while those advocating gas for cooking and for domestic water heating at first met with considerable opposition. In all the instances just mentioned, the cost of operation by using gas was equally as much, and often more, in excess of that with the old fuel, as gas fuel is in excess of hard coal. It must be remembered that gas house heating is not expected to become, in the near future, as universal in its application as that of gas for other domestic purposes, but in a great many cities in the United States the climatic conditions are favorable to the use of gas fuel, and therefore the subject deserves the most rigid investigation and the most liberal chance for development.

HOT-AIR SYSTEMS

The hot-air house heating system consists of a furnace and hot-air ducts leading from the furnace to the various rooms, into which they discharge through registers placed in the floor or walls.

The furnace consists of a fire-box and combustion chamber, enclosed in a shell forming a hot-air chamber. The latter receives air from the room in which the furnace is placed or from out of doors through a cold air duct, and discharges the heated air through the hot-air ducts.

In St. Louis, where probably more extensive work is being done in supplying heat from a central plant by means of artificial gas, than perhaps in any other locality, a hot-air furnace was used in one residence with the following result:

"A number of difficulties were experienced in the beginning of the season. These troubles consisted chiefly in matters of mechanical detail relative to the proper operation of cut-off valves actuated by the thermostat motor, and the correct drilling, adjusting and proportioning of burners used in the heaters. Some little experimental work eliminated these obstacles in a very satisfactory manner. The hot-air furnace, however, proved so highly inefficient that some changes were necessary for a proper conservation of heat, and it may be of interest here to go more into details of the changes and resultant operation of this particular system. The installation consisted of two 28-inch furnaces connected as a single unit, in a new home built during the summer of 1911. Two concentric ring burners, with mixers on the outside, controlled by a thermostat and lighted by a pilot, were placed in the fire box of each furnace. Due to the inefficiency of the heating plant, as constructed by the manufacturer, it was fully demonstrated in a couple of months that the heating capacity was quite inadequate, while the cost of operation would go far beyond reasonable limits. An economizing device was then installed in an effort to utilize heat that was otherwise lost in the flue gases. This economizer consisted of fifty 2" x 2" x 66" tubes made of galvanized sheet metal, sealed into a header at each end, and then placed transversely into the cold air duct leading from out-of-doors into the furnace. The flue gas was then conducted from the furnace through the economizer, on the inside of the square tubes, and on to the stack. The ventilation was controlled by a damper placed in the flue pipe on the chimney side of the economizer. The fuel economy was at once apparent, the consumption in days of equal temperature showing a decrease of from 35% to 40%, and it was possible to supply sufficient heat to the residence throughout the unusually severe season without providing additional burner capacity. Temperatures taken at various points of the system showed the following results:

Temperature of outside air .... 26° F.
Temperature of flue gases leaving furnace..........460° F.
Temperature of flue gases after passing economizer..160° F.
Temperature of fresh air between economizer and furnace ....100° F.
Temperature of heated air going to room ....190° F.

"This indicates a drop of 300° F. in the flue gases and an increase of 74° F. in the incoming fresh air. It shows, also, that the heated air ready to go to the various rooms was 30° F. higher in temperature than the flue gases after leaving the economizer. Inasmuch as the products of combustion are cooled to a point considerably below 212° F., it is possible, by this method, to utilize the gross heating value of the gas due to the condensation of the moisture contained in the burned products. To provide for this condensation a small pipe was placed in one end of the economizer and extended to a sewer opening in the floor. In this residence the more distant rooms were heated by a hot-water system, the heating coils of which were placed inside the hot-air furnace. Because of the intermittent application of heat in the furnace, these coils proved inadequate and an auxiliary gas heater, built locally and automatic in its operation, was connected to the hot-water portion of the heating system. This arrangement proved very satisfactory in that all distant rooms were kept comfortably heated, independent of the hot-air furnaces. It should be borne in mind, however, that the hot-air furnace, though rendered comparatively efficient by the introduction of the economizing device mentioned, offers a rather limited field, due principally to the manner in which it is constructed. It is highly probable that few furnaces, after some years of operation on coal fuel, will maintain sufficient mechanical perfection to prevent the communication of the products of combustion into the fresh air chamber. It is true, to be sure,

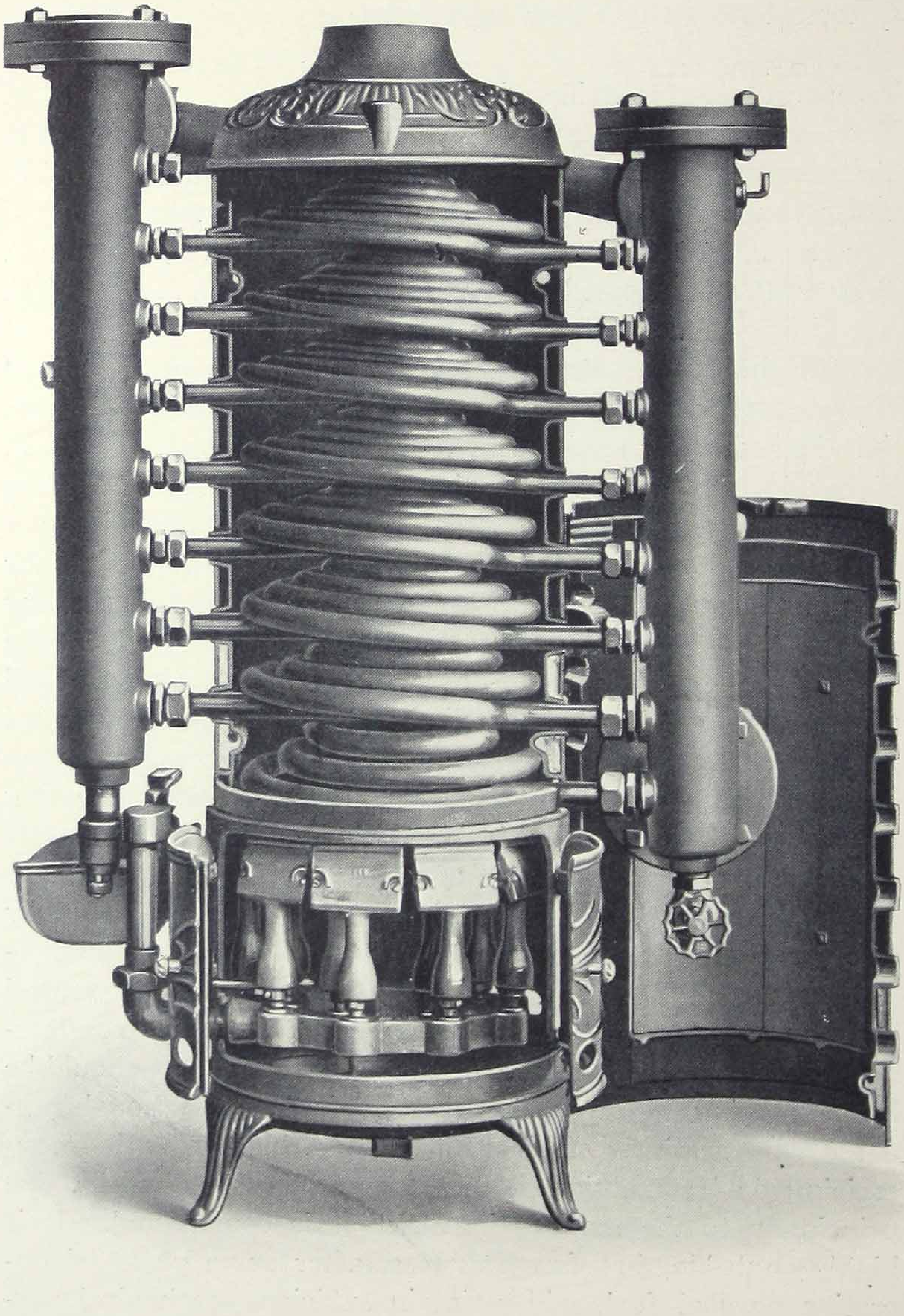

Fig. 23.—Gas-Fired Hot-Water Boiler.
Front Jacket Removed.

that a condition as just mentioned would be more obnoxious with coal fuel than with gas fuel, but inasmuch as it is the purpose of the gas company to render as near as possible perfect heating service, every care should be exercised to remove from the building all of the burned products. It is essential, therefore, to obtain fullest assurance that the furnace is in first-class condition, and when found so, the method of conversion as described can be utilized, and with satisfactory results."

HOT-WATER SYSTEMS

These consist of a gas-fired boiler located in the basement and pipes for conveying the water from the boiler to the *radiators* and back again. Since the entire system is filled with water which is non-compressible and expands with temperature, an *expansion tank* is necessary. Such a system is shown in Fig. 8 together with an individual gas hot-water radiator connected to the same system.

The boiler in the best types consists of a combustion chamber in which are placed coils or tubes containing water (see Fig. 23) or as in the cheaper types the water chamber may surround the combustion chamber and flues leading from it. In Fig. 24 is shown a boiler combining both methods of heating. The hot products of combustion pass around the water tubes and out through the flues in the hot-water drum. In the better boilers the tubes are of steel or copper—in the cheaper types the entire structure is of cast iron.

STEAM SYSTEMS

These are similar to the above but operated at a temperature at which evaporation into steam takes place in the boiler. The steam is conveyed to the radiators, and cooled therein, condenses to water and is returned to the boiler. Steam being compressible, no expansion tank is required.

The boiler shown in Fig. 24 is designed so as to be operated as a steam boiler as well. Fig. 24a shows the same boiler in suitable housing, as installed. Steam boilers are similar in construction to hot-water boilers and the systems are similar in operation.

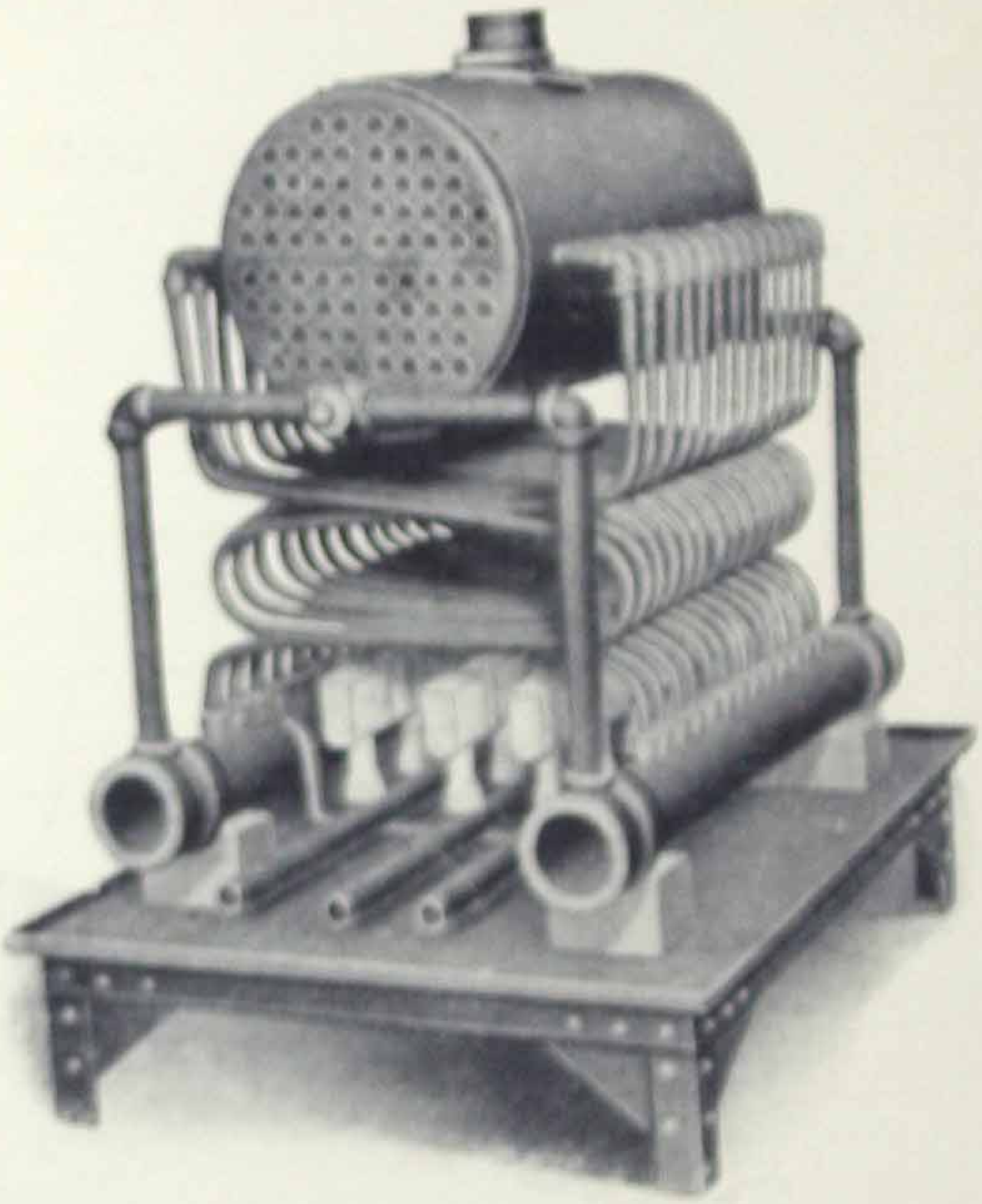

Fig. 24.

Steam radiators operate at a somewhat higher temperature than hot-water radiators and less radiating surface is required.

The design of central house heating systems—hot-air, hot-water or steam—should always be entrusted to a competent heating engineer.

CONNECTIONS

From the viewpoint of safety, the method of connecting room heaters is more important than the construction of the room heaters themselves.

FLUE CONNECTIONS

Yellow-flame room heaters may be operated continuously without an effective flue, provided the gas consumption is at the rate of less than 25 cubic feet per hour. In rooms of considerable size with properly constructed heaters, a flue is not necessary for intermittent operation, but in small rooms, such as bathrooms and sleeping rooms, in which during cold weather there is likely to be inadequate ventilation, great care

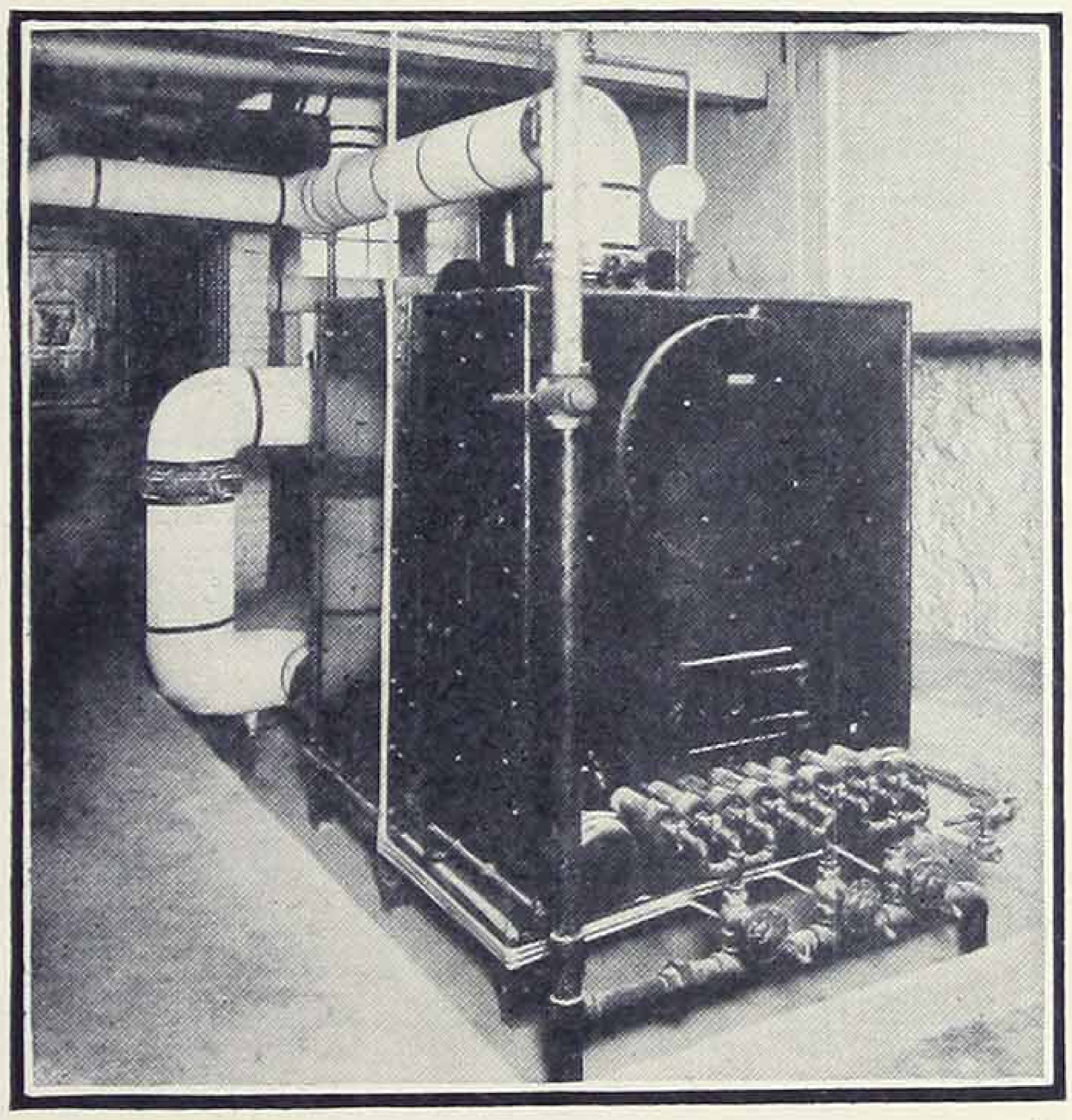

Fig. 24a.—Boiler shown in Fig. 24 encased in housing.

should be exercised in the selection of gas heaters to which a flue is not attached.

Room heaters of a portable type that are heated with blue-flame burners are not approved in certain situations, principally because no provision is made for a flue connection. This is a matter of local practice and its decision or advisability is not within the province of this lesson.

Generally speaking, fireplace heaters are provided with a flue and the products of combustion are discharged into the chimney. In that class of fireplace heaters which are constructed like portable heaters and are merely set in the fireplace for the sake of effect, the same conditions would apply as when they are placed in any other part of the room.

GAS CONNECTIONS

Portable type heaters, irrespective of their method of burning gas, should be connected when possible with iron pipe. A union connection at the heater will permit of convenient disconnection for the purpose of changing the appliance from one room to another.

The question of whether tubing with slip-ends or with so-called safety-end connection is used is also a matter of local policy. In any event, it is necessary to have a cock at the outlet from which the tubing is run to the heater so that the gas can be shut off at that point and not allowed to exert its pressure in the tubing while the heater is not in use.

It is possible to connect a room heater from a floor or baseboard connection and thus have the piping or tubing as inconspicuous as possible in the room.

Referring to the conservative stand which has been taken in one large situation in regard to the question of approving for connection certain classes of heating stoves and also to the method of connecting those that are approved, a prominent engineer has set forth his views as follows:

"When we consider the great extent to which gas burning appliances are used in this country, the number of fatal accidents resulting from their use is surprisingly small. Because there is an occasional fatal asphyxiation case, it would be unwise to argue that the use of such appliances should be prohibited. The rules we have enforced have not been adopted because we think there would be any extreme degree of danger in a contrary practice, but because we believe it to be good gas engineering practice to render the use of gas appliances as safe as the limits of commercial considerations permit.

"Whenever there is a real economic or commercial demand for the use of a certain type of gas appliance or for the application of gas for some specific purpose to the arts and sciences, we consider it to be the duty of the gas engineer not to prohibit such practice because there is some degree of risk connected with it, but to permit the practice, taking care to surround it with such safeguards as are commercially feasible."

ADAPTATION TO CONDITIONS

COMPUTATION OF RADIATION

To be in a position to recommend with a fair degree of accuracy the proper heater for the proper place requires a knowledge of how to compute radiation. It is impossible to adopt any hard and fast rule which would cover the thousand and one problems which are continually arising. There is such a wide variation in the ranges of temperature encountered, the quality of construction in buildings, the effects of different exposures, wind velocities, etc., in different situations, that all rules must be regarded as requiring much judgment in their application.

* "In determining the size of apparatus required to heat any given apartment, it is known from practical experience that every class of building material loses, by absorption and conduction, a given quantity of heat per hour for each degree of difference in temperature between the outside and the inside. With these figures, which are called the "coefficients of heat loss," and knowing the outside temperature and the temperature to which it is desired to raise the apartment, it is a simple matter to calculate the number of cubic feet of gas necessary to do the work.

"Loss in B. T. U.'s per square foot of surface for every 1° F. temperature difference between inside and outside temperatures:

8 inch brick wall	0.48
12 inch brick wall	0.35

* Arthur Forshaw, *Gas World*, March 9, 1912, page 319.

18 inch brick wall	0.26
Single windows	1.0
Double windows	0.5
Ceilings with good air space	0.1
Floor	0.2

"It is usual to allow for not more than three changes per hour in the apartment, knowing the cubical contents and the number of air changes, and allowing 0.019 B. T. U. to raise the temperature of 1 cu. ft. through 1° F., it is possible to calculate the number of B. T. U.'s required to heat the air. This is added to the former number, representing the heat loss through the walls, etc., and the total loss thus obtained gives the heat which has to be supplied per hour by the heating apparatus.

"Regard must be paid to the heat which is allowed to go up the flue for ventilation. It must also be remembered that the result obtained by calculation refers to maintaining the heat of the room when once the desired temperature has been obtained."

The consumption per hour of the various heating stoves on the market is listed by the appliance manufacturers according to the various sizes of the heaters, and it is not difficult to determine their consumption in any particular situation or town according to the average pressure conditions in that place. Therefore, the size of the heater required or the number of heaters of a given size necessary to heat a specific room can be determined with a fair degree of accuracy from any of the methods of figuring radiation.

A satisfactory formula for rooms of south exposure in well-constructed buildings is as follows:

$$H = 0.04\ V + 0.25\ W + G,$$

where H = B. T. U.'s lost per hour per degree difference in temperature between inside and outside of room,

V = volume of room in cu. ft.

W = *exposed* wall surface in cu. ft.,

G = *exposed* glass surface in cu. ft.

The result must be multiplied by the difference in temperature between inside and outside of room. Thus, if it is desired to heat the room to 70° F. during zero weather, the formula becomes:

Total B. T. U.'s per hr. required = 2.8 V + 17.5 W + 70 G.

The result thus obtained must be further multiplied by one or more of the following factors, if the corresponding conditions are present:

Northern exposure	1.30
East or West exposure	1.20
Good frame construction (or 12″ brick)	1.20
Fair construction	1.20
Poor construction	1.30
Fair frame construction	2.00
Poor frame construction	2.50
Room heated in day-time only	1.10
Room heated occasionally	1.30 to 1.40
Cold cellar below or attic above	1.10

To obtain the number of square feet of radiating surface required, divide the total B. T. U.'s lost per hour (*after all allowances*) by:

225 to obtain number of sq. ft. of steam radiator surface required.

150 to obtain number of sq. ft. of hot-water radiator surface required.

To obtain the number of cubic feet of gas required per hour, divide the total B. T. U.'s lost per hour (*after all allowances*) by:

Calorific value of gas for heaters without effective flue connection.

One-third to two-thirds of calorific value of gas, depending upon radiant efficiency of heater, for heaters with effective flue connection, except in cases where products are first carried through radiators and cooled down to approximately room temperature, in which case the full calorific value of the gas may be used.

The above formula may be expressed in sq. ft. of radiating surface instead of B. T. U.'s thus:

FOR STEAM RADIATION

The number of sq. ft. of radiation required to supply the losses from any source will be the amount of the total losses in B. T. U.'s per hour divided by the B. T. U.'s per hour furnished by each square foot of "radiation." The formula becomes:

$$\text{Sq. ft. of ``radiation'' required} = \frac{2.8}{225} V + \frac{17.5}{225} W + \frac{70}{225} G$$

$$= 0.0124\,V + 0.077\,W + 0.31\,G.$$

The number of sq. ft. of hot-water radiation required will be 50% greater or $1\frac{1}{2}$ times as much, since the B. T. U.'s per sq. ft. are but $\frac{2}{3}$ as great ($\frac{150}{225} = \frac{2}{3}$).

It is sometimes convenient to make calculations on the basis of the number of sq. ft. of wall and of window exposure and of room volume that one sq. ft. of radiation will provide for. That is, instead of "radiation" per sq. ft. of wall area exposed, etc., the wall area per sq. ft. of "radiation" is calculated. In this case the reciprocal of the figures in the above formula are taken, thus:

$$\text{Sq. ft. of radiation required} = \cfrac{V}{\frac{1}{0.0124} = 80} + \cfrac{W}{\frac{1}{0.077} = 13} + \cfrac{G}{\frac{1}{0.31} = 3.2}$$

This may also be expressed as follows:

	Steam	Hot water	
Allow 1 sq. ft. of "radiation" for each:	80	53	Cu. ft. of room volume
	13	8	Sq. ft. of exposed wall
	3	2	Sq. ft. of exposed glass (single window)
	6	4	Sq. ft of exposed glass (double window

Example of calculation for steam heating:

Room 15′-0″ x 10′-0″ x 8′-0″.

2 windows each 3′-0″ x 5′-0″.

2 exposed walls 8′-0″ x 10′-0″ and 8′-0″ x 15′-0″.

Volume or cubical contents =

$15 \times 10 \times 8 = 1200$ cu. ft. and requires $\frac{1200}{80} = 15$ sq. ft. radiation

Exposed wall =

$8 \times 10 = 80$

$8 \times 15 = 120$

200 sq. ft. requires $\frac{200}{13} = 15$ sq. ft. radiation

Glass =

$2 \times 3 \times 5 = 30$ requires $\frac{30}{3} =$ 10 sq. ft. radiation

Total "radiation" required = 40 sq. ft.

Various methods of calculation are furnished by manufacturers for use in the application of their products. There may be and usually are considerable differences among them, due to the fact that the allowances to be made for the frequency with which the air in the room changes, the character of construction, "factors of safety," etc., depend upon the judgment of the individual authority and the nature of his experience. In many cases extreme and inexcusable liberties have been taken in order to make the figure come in a simple and easily remembered arrangement. The foregoing methods have been derived from the formulæ accepted by leading architects and engineers and are believed to be as accurate and conservative as good engineering practice will permit.

A method of determining the cubic feet of gas per hour required may be derived in a similar manner by using the heating value of the gas instead of the B. T. U.'s per sq. ft. of radiating surface.

The following method may be used with gas of 600 B. t. u.'s per cu. ft. where the heater has no flue connection or where practically all the heat is extracted from the products of combustion before they are taken from the room:

Allow one cu. ft. of gas per hour for each:

- 215 cu. ft. of cubical contents
- 35 sq. ft. of wall exposure
- 9 sq. ft. of window surface (single window)
- 18 sq. ft. of window surface (double window)

If there is an effective flue connection through which the combustion products are discharged at a temperature above that of the room, the result obtained must be increased according to the radiant efficiency of heater, say about 40% to 50% for the English gas fire, and from 100% to 200% for gas logs, gas grates, etc.

Since gas, in most localities, is a rather expensive fuel compared to coal, it is advisable to make calculations to a high degree of accuracy in order that no considerable excess of heat may be furnished and waste thereby ensue.

The following formula, contributed by the American Society of Heating and Ventilation Engineers, in response to a request from the National Commercial Gas Association through Mr. George S. Barrows, chairman of the Committee on Heating, Ventilation and Refrigeration, is especially designed for use in connection with All-Gas Kitchens.

TO OBTAIN THE SQUARE FEET OF RADIATION REQUIRED FOR HOT WATER HEATING BY A FURNACE CONNECTION OR GAS HOT WATER RADIATOR

Add together the following:

A. Square feet of window surface (if storm windows are used multiply by 0.5).

B. Multiply 0.3 by the square feet of the exposed walls (exclusive of windows or doors, except where there is a storm door or the door opens to an enclosed porch).

C. Multiply 0.1 by the square feet of floor, if the room is over an unheated space, the temperature of which is taken as 30 degrees.

D. Multiply 0.3 by the sq. ft. of the ceiling if the room is under an unheated space, the temperature of which is taken as 30 degrees.

E. Ordinary outside doors, on account of their leakage and because of the fact that they usually have a considerable proportion of glass, are considered as glass surface. Where there is a double door or an enclosed porch they are considered the same as wall surface.

F. Multiply 0.02 by the contents of the room in cubic feet. (This allows for one change of air per hour by leakage.)

G. Sum of A, B, E and F.

H. 1—Multiply this sum, G, by the difference between the lowest outside temperature and the desired room temperature, in degrees Fahrenheit.

H. 2—Take the sum of C and D and multiply it by the difference between 30 degrees and the desired room temperature, in degrees Fahrenhit.

I. Add together H -1 and H -2.

J. Increase this (I) by 10 per cent *if the room is exposed to the north or west.*

K. This product, J, divided by 150 will give the number of square feet of radiation required.

B. T. U.'s Required for Heating Air

("The Ideal Fitter"—American Radiator Company.)

This table specifies the quantity of heat in British thermal units required to raise one cubic foot of air through any given temperature interval.

External Temperature	Temperature of Air in Room									
	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°
−40 Degrees........	1.802	2.027	2.252	2.479	2.703	2.928	3.154	3.379	3.604	3.829
−30 "	1.540	1.760	1.980	2.200	2.420	2.640	2.860	3.080	3.300	3.520
−20 "	1.290	1.505	1.720	1.935	2.150	2.365	2.580	2.795	3.010	3.225
−10 "	1.051	1.262	1.473	1.684	1.892	2.102	2.311	2.522	2.732	2.943
0 "	0.822	1.028	1.234	1.439	1.645	1.851	2.056	2.262	2.467	2.673
10 "	0.604	0.805	1.007	1.208	1.409	1.611	1.812	2.013	2.215	2.416
20 "	0.393	0.590	0.787	0.984	1.181	1.378	1.575	1.771	1.968	2.165
30 "	0.192	0.385	0.578	0.770	0.963	1.155	1.345	1.540	1.733	1.925
40 "		0.188	1.376	0.564	0.752	0.940	1.128	1.316	1.504	1.692
50 "			0.184	0.367	0.551	0.735	0.918	1.102	1.286	1.470
60 "				0.179	0.359	0.538	0.718	0.897	1.077	1.256
70 "					0.175	0.350	0.525	0.700	0.875	1.049

(Above table from F. Schuman's "Manual of Heating and Ventilation," pages 41 and 64.)

Constants for Heat Transmission

(See p. 69 Supplementary Pamphlet)

B. t. u. transmitted per square foot per hour per degree difference in temperature between inside and outside air are as follows:

Constants for Brick Work

4 in. thick = 0.68	24 in. thick = 0.20
8 in. thick = 0.46	28 in. thick = 0.18
12 in. thick = 0.33	32 in. thick = 0.16
16 in. thick = 0.27	36 in. thick = 0.15
20 in. thick = 0.23	

Miscellaneous Constants

Reinforced concrete, 20% more than brick. Add one-third more for stone. Add one-half more for cement or concrete walls.

Wood as flooring	0.083
Wood as ceiling	0.104
Wood as wall	0.220
Fireproof flooring	0.124
Fireproof ceiling	0.145
Cement as flooring	0.310
Dirt as flooring	0.230
Wood, under slate or composition roof	0.300
Under iron	0.170
Tile (no boards underneath)	1.250
Cement roof	0.600
Single window	1.090
Single skylight	1.118
Double window	0.560
Double skylight	0.621
Door	0.420
Corrugated iron wall	0.840
Wood wall	0.280
Copper, silver plated and polished	0.02657
Copper, polished	0.04906
Zinc and brass, polished	0.04906
Cast iron, new	0.6480
Cast iron, rusted	0.6868
Oil or varnish	1.4800

COMMERCIAL CONSIDERATIONS

On the basis of heating value alone, one cubic foot of artificial gas (650 B. T. U.'s per cu. ft.) is equal to about $\frac{2}{3}$ cu. ft. natural gas (1,000 B. T. U.'s per cu. ft.) or to $\frac{1}{20}$ lb. of anthracite coal (13,000 B. T. U.'s per lb.). With artificial gas at 50 cents per 1,000 cu. ft., natural gas at 25 cents per 1,000 cu. ft., and anthracite coal at $8 per ton, the number of heat units obtainable for one dollar are:

Artificial gas	1,300,000
Natural gas	4,000,000
Coal (2,000 lbs. per ton)	3,250,000

These figures would represent the relative heating-service purchasing capacities of one dollar expended in the different fuels if each performed the same service, and if the same proportion of the total heat (efficiency) were obtained in each case.

As a matter of fact the service rendered by the various fuels is not the same nor are the efficiencies even approximately equal.

The essentials of service are:

Convenience.
Cleanliness and Hygiene.
Permanence.
Reliability.
Economy.

CONVENIENCE

In this regard gaseous fuel is in a class by itself. It is always ready for duty at the touch of a match, or if equipped with pilot light, even this trouble is avoided, the control being either automatic or at most involving the turning of a cock. There are no fires to kindle, watch, or bank for the night. No coal nor ashes to carry. It is not necessary to run up and down stairs to give constant attention to a fire that is apparently always bent on doing the opposite of the thing desired.

Tending the furnace is one of the most disagreeable and annoying of domestic duties, and is a serious obstacle in the way of satisfactory solutions of the servant problem. If a man is employed to do the work, an additional expense of from $1 to $2 per week during the winter is incurred, or from $25 to $50 per year.

CLEANLINESS AND HYGIENE

From the standpoint of both personal cleanliness and hygiene, the use of coal is to be deplored. Coal dust and ashes from the basement are distributed throughout the house, either through hot-air ducts or through casually opened doors. Room furnishings rapidly become grimy, the air is contaminated with sharp dust particles which lacerate the lungs and cause a predisposition toward tuberculosis and other lung diseases. The resulting condition is highly inimical to personal comfort, health and cleanliness. The lack of ventilating effect favors "stuffiness" and air-stagnation in the rooms. Since the abandonment of open fires which had this ventilating effect, the necessity of proper ventilation is coming to be realized, and there is even developing a market for electric "ozonizers" to compensate for the lack of ventilating effect with central house heating systems.

While the central system of house heating is undoubtedly inferior as regards hygiene, to a properly designed individual room heating system, the latter is quite expensive to install and not readily adapted to existing buildings. If conditions indicate the desirability of the central heating system from considerations of first cost, the gas-fired systems available possess every advantage except ventilating effect.

PERMANENCE

Owing to the rapid deterioration of coal burning furnaces, the results obtained with the new installation are never duplicated after a few months of use. In hot-air systems cracks appear in the fire-box and combustion chamber, interfering with draft and permitting products of combustion to enter the air ducts.

In hot water and steam systems a scale is formed on the interior of water carrying parts and soot is deposited on their exteriors, both interfering greatly with heat transmission. Gas-fired boilers are free from the latter trouble, and the distribution of heat may be so controlled as to minimize the former.

Since gas contains a negligible amount of sulphur, an active corrosive agent usually present in coal in large quantities, all initial parts of furnaces deteriorate much less rapidly with gas fuel than with coal.

RELIABILITY

Artificial gas is not subject except in *extremely* rare cases to interruptions of supply from strikes or weather conditions.

ECONOMY

While approximately 2½ times as many heating units are obtainable for one dollar in coal at $8 per ton as in artificial gas at 50 cents per 1,000 cu. ft., it does not follow that 2½ times as much available heat may be obtained. Gas-fired heating appliances are highly efficient, whereas coal-fired furnaces are quite the reverse.

Comparing a gas-fired hot-water boiler with a coal-fired boiler upon the basis of heat delivered to the water, the following figures are obtained:

	B. T. U.'s for $1.00 as above	Efficiency in per cent. of heat delivered to water	Heat delivered to water for each dollar expended for fuel
Gas	1,300,000	‡70 to 80	910,000 to 1,040,000
Coal	3,250,000	*New 44 to 66 average 55	1,787,500
		†Old about 40	1,300,000

* Test made in laboratory, very careful firing.
† Probable results under average conditions of actual service.
‡ It is said that as high as 94% has been obtained during experiments upon a new Type now in process of development.

Furthermore the price of gas is extremely unlikely to advance, whereas the price of coal is being advanced yearly. The economical operation of coal-fired furnaces and boilers demands continuous operation at or near full capacity for considerable periods. Where the requirements for heat occur intermittently, gas may be used with economy, and even where it is the more expensive fuel, its cleanliness and convenience will offset to a large degree the disadvantage of high cost.

In certain localities where electricity is sold for heating purposes at 5 cents per k. w. hour or less, the electric luminous radiator (Fig. 25) is quite largely used, under the impression that it is a particularly efficient and hygienic appliance. As a matter of fact, even with electricity at 2 cents per k. w. hour, heating by the electric luminous radiator is more than twice as expensive as with $1.00 gas used in the English gas-fire, or similar appliance, while the hygienic advantages are all in the side of the gas heater. The stagnant condition of the air resulting from the use of flameless radiators is a far greater menace to health than the products of gas combustion (see Hygienic Value of Gas-Lighting), and even these comparatively innocuous products are thoroughly removed by proper flue connections.

While the general and extensive use of artificial gas as an exclusive means of house heating will probably be of slow development, it is certain to come ultimately. The increasing appreciation of the necessity of abating the smoke nuisance will undoubtedly hasten the day.

In many localities where climatic conditions and the price of coal are particularly favorable, the exclusive heating of houses by gas is already practicable and commercially feasible. Where conditions are not sufficiently favorable to justify the use of gas as the sole heating agent, it has a wide and profitable field for auxiliary heating in rooms not in constant use and in the late spring and early fall.

In many old buildings, furnace heating systems have been installed, but there are rooms in which the required registers could not be conveniently provided. In these, obsolete types of coal or gas grates—uneconomical, unsightly and unhygienic—perform a more or less intermittent duty, being infrequently used on account of the poor service rendered. Such houses afford excellent opportunities for the installation of modern gas heating appliances.

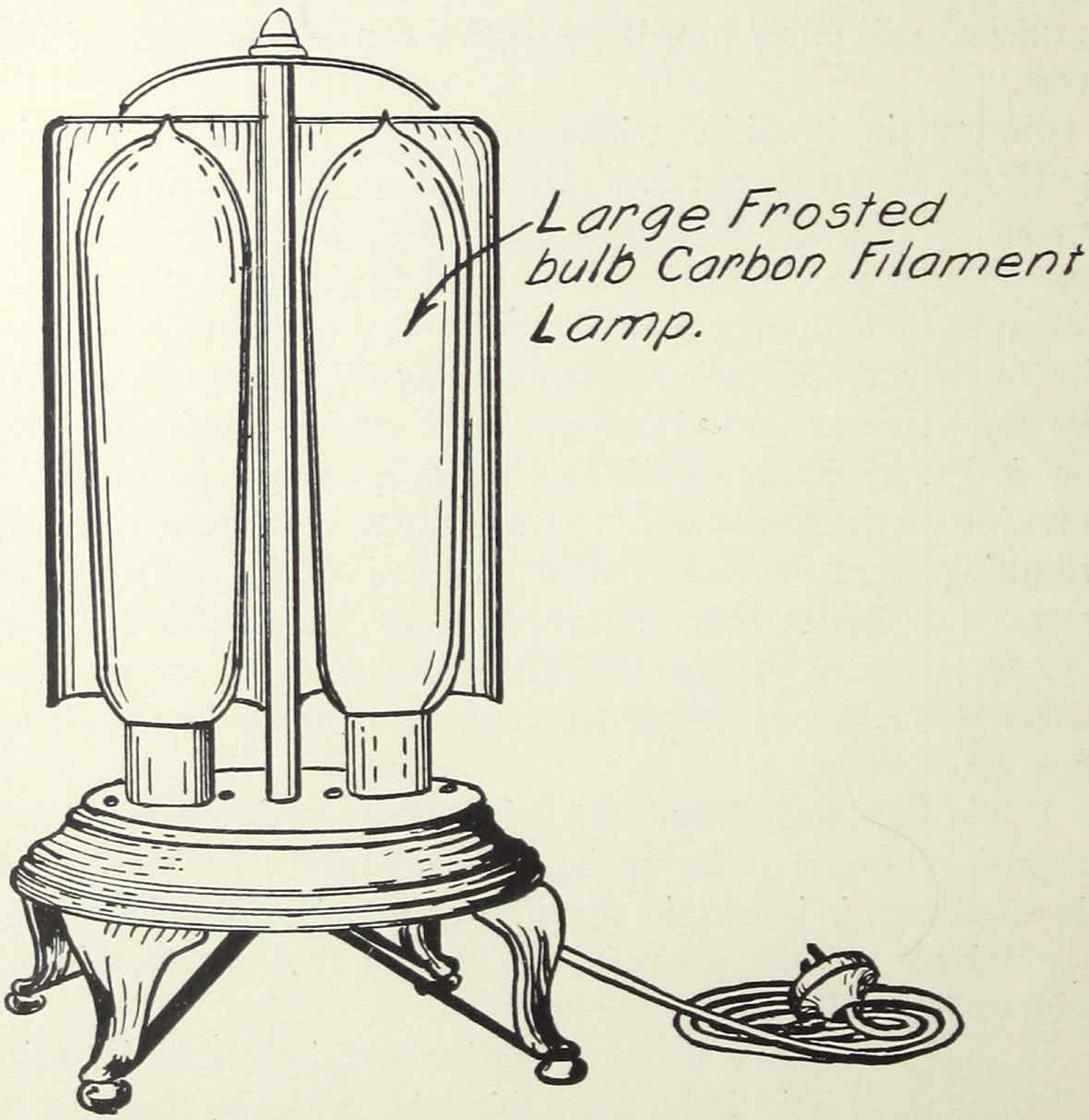

Fig. 25.—500-Watt Electric Luminous Radiator.

In one locality an inspection of 50 houses in one block disclosed one hundred fireplace openings were found of which 27 contained no heating equipment, 16 coal grates, 10 wood fires, 2 electric heaters and 12 gas heating appliances, the latter being mostly of obsolete types.

The sale of modern and satisfactory gas heating appliances in such buildings should be easily accomplished.

In all cases the salesman should carefully consider all the conditions surrounding each individual installation in order that the particular appliance which will perform the service most satisfactorily and economically may be recommended.

Each type of appliance has its place, and no one type or size will meet the requirements of every condition.

QUESTIONS

HOUSE HEATING APPLIANCES

1. Describe briefly the three (3) methods of heat transference and show their relation to room-heating problems.

2. Specify the various types of individual room-heating appliances and their distinguishing features.

3. Can a gas hot-water radiator be connected to the central house-heating system so as to be operated either independently of the system or in connection with it? Illustrate by diagram and explain.

4. How does the gas hot-water system of central-plant house heating differ from the gas steam system?

5. What conditions have prevented the successful operation of gas logs and how have these been overcome?

6. Under what circumstances would you advise a flue connection for fireplace heaters?

7. If you were asked to compute radiation (steam, hot water or gas) what information would you require? Give an example of such a calculation from data selected by yourself.

8. In estimating costs of operation for comparison of gas and coal, what factors would enter into the consideration of a total coal cost? (Review Lesson VI from p. 71 in this connection.)

9. Give five (5) good talking points for the use of a gas-heating appliance, specifying the kind of appliance and particular application; that is, store, office, church or dwelling.

10. (a) How would you answer the objection that " gas heating stoves burn up the oxygen in the air and make the room stuffy? " (Read " Hygienic Value of Gas Lighting " in this connection.)

(b) It is said that " a gas heating stove makes the walls sweat and ruins the wall paper." What is the reason and how can such a condition be avoided? (See above.)

(c) Would you recommend gas for entire house heating to a customer willing to pay well for the advantages, in a locality where the average outside temperature is 42° during the entire winter season of 210 days? Make a comparison of cost with hard coal at $7.50 per ton (2,240 lbs.) and artificial gas at $1.00 per 1,000 cu. ft., and state how you would justify the increased expense.

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