July 28, 1931. J. W. CANNON 1,816,110

HEATER FOR BOILERS OF THE VERTICAL TYPE

Filed Nov. 22, 1928 4 Sheets-Sheet 1

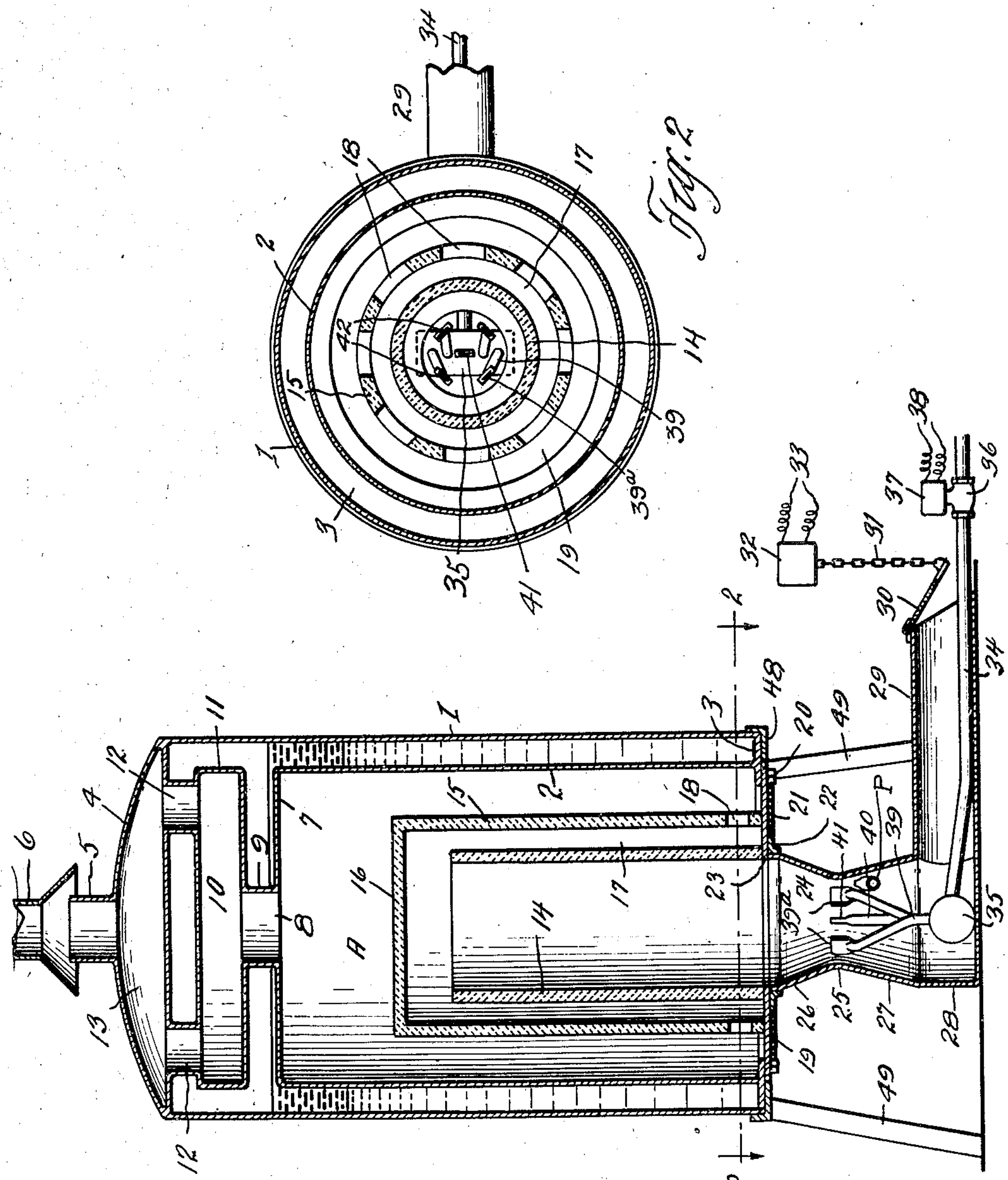

Fig. 1

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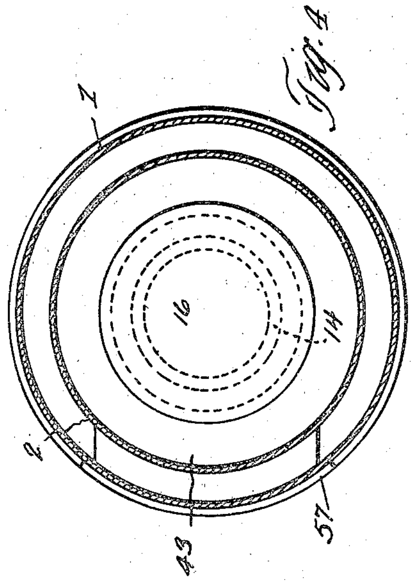

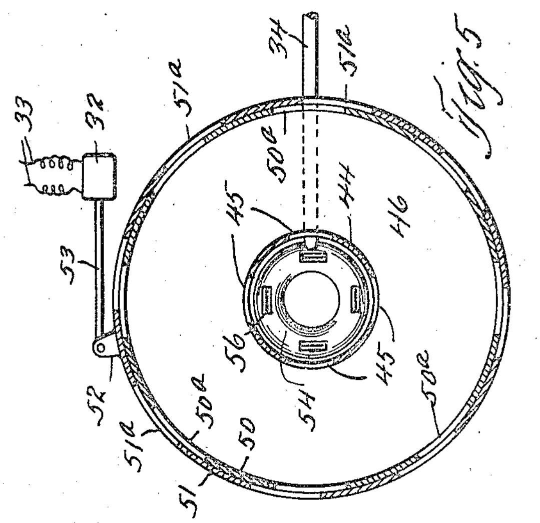

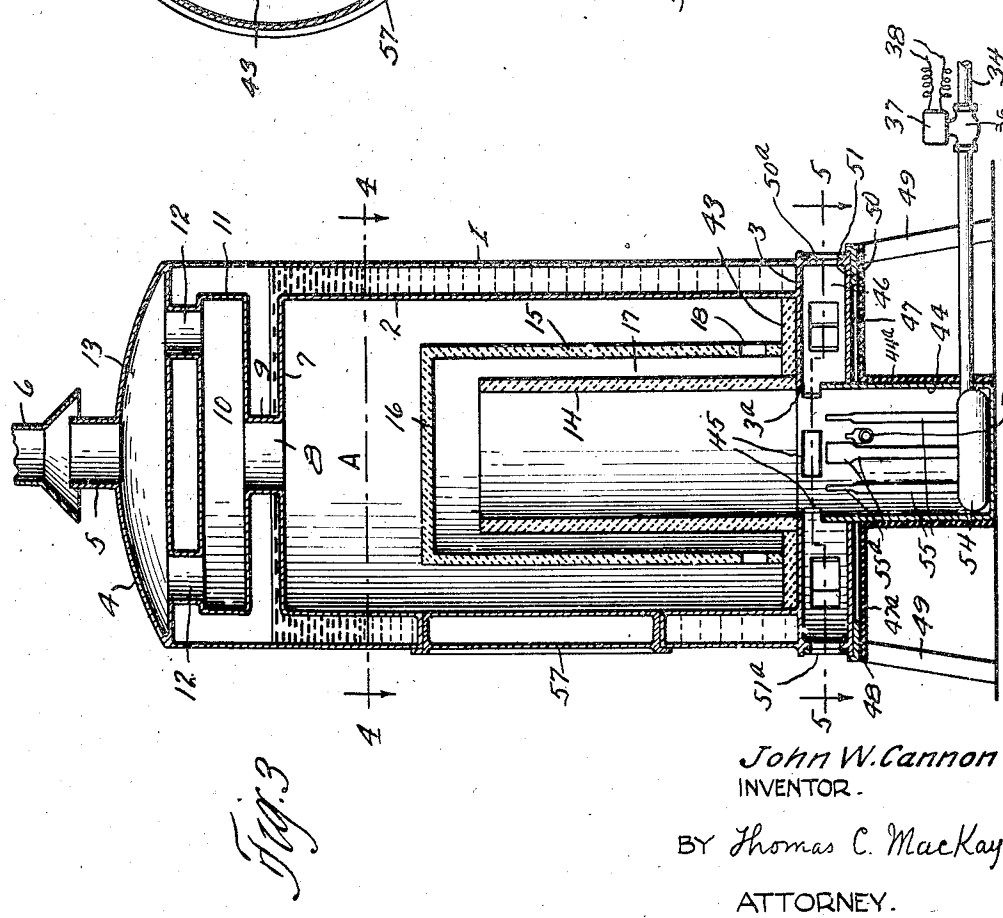

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Fig. 7.

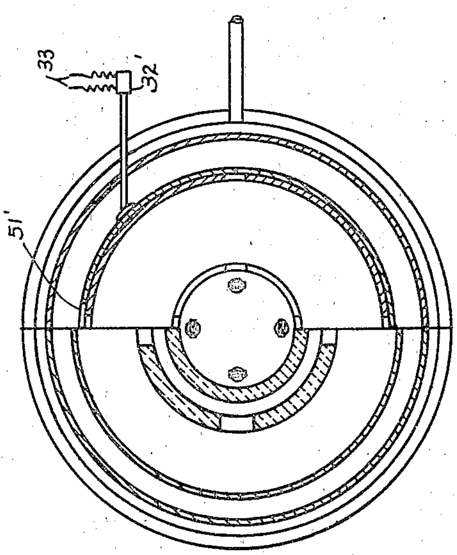
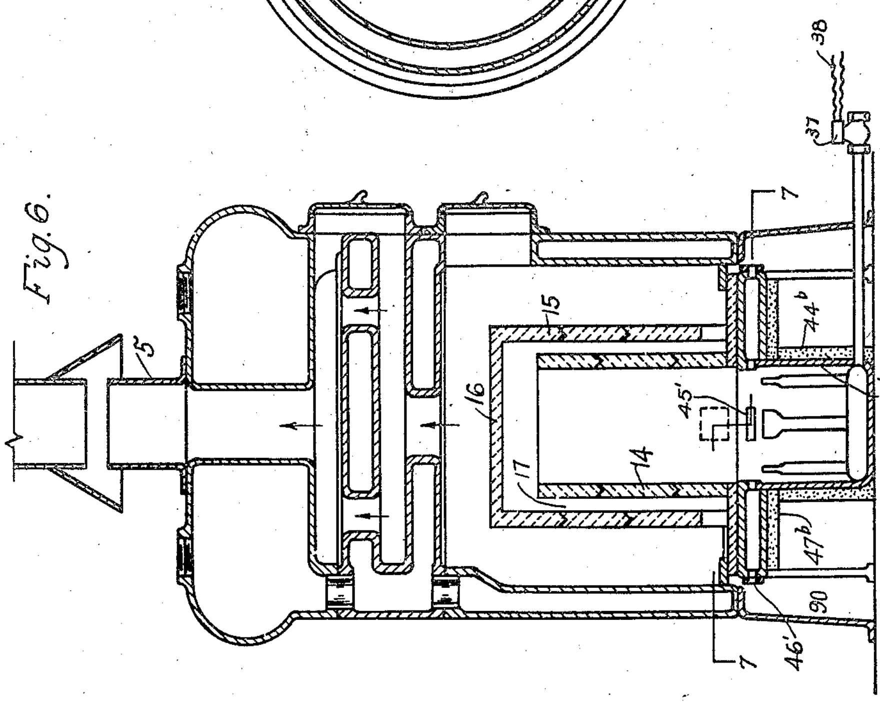


Fig. 6.



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HEATER FOR BOILERS OF THE VERTICAL TYPE

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Fig. 9.

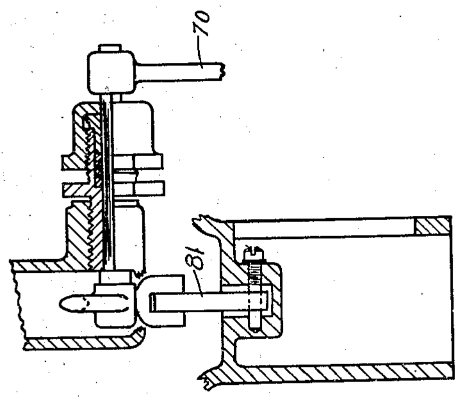
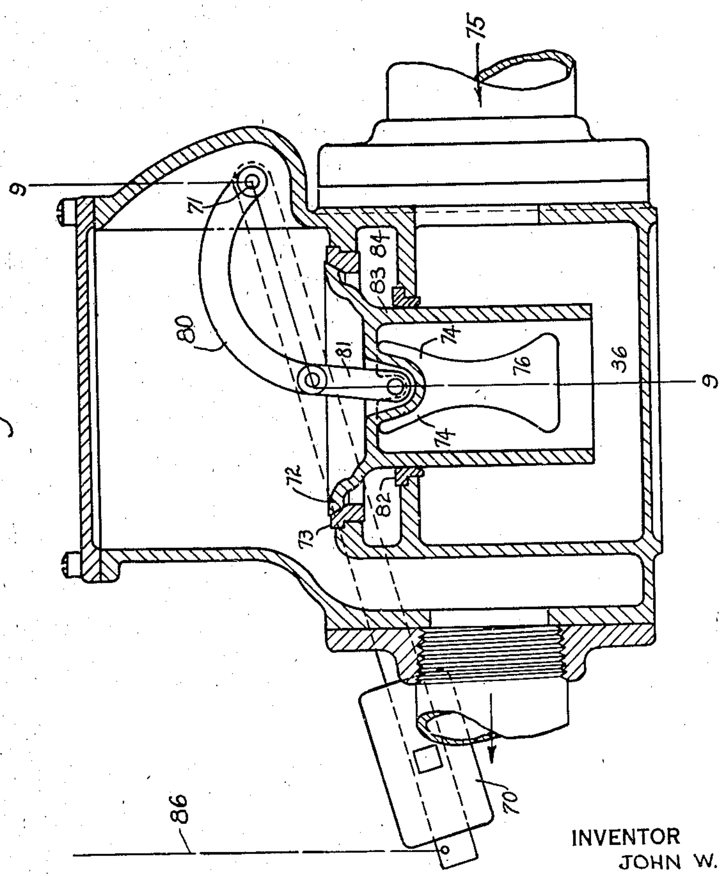


Fig. 8.



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Patented July 28, 1931 **1,816,110**

UNITED STATES PATENT OFFICE

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HEATER FOR BOILERS OF THE VERTICAL TYPE

Application filed November 22, 1928. Serial No. 321,254.

This invention relates to heaters, and more particularly to water heaters of the domestic house-heating boiler type wherein the water is contained within a vertical annular space, the interior of the said space constituting or being furnished with a combustion chamber for heating the water.

It is the general purpose and object of the invention to provide a heater of the character referred to which will secure a very high efficiency from the combustion fuel, thereby producing economy in operation. A further object of the invention is to provide a construction of heater which, while realizing such efficiency in operation, will be extremely simple of construction and economical of production.

Further objects of the invention will appear hereinafter and will be realized in and through the construction and arrangement of parts shown in the drawings, wherein Fig. 1 represents a central vertical sectional view through a heater constructed in accordance with and embodying my invention; Fig. 2 a transverse sectional view corresponding to the line 2—2 of Fig. 1 and looking in the direction of the arrows; Fig. 3 a view, similar to Fig. 1, of a modified form of heater embodying my invention; Figs. 4 and 5 are details in section corresponding respectively to the lines 4—4 and 5—5 of Fig. 3 and looking in the direction of the arrows; Figs. 6 and 7 illustrate the adaptability of our furnace arrangements to a coal-fired furnace, Fig. 7 being a transverse sectional view on the line 7—7 of Fig. 6; and Figs. 8 and 9 represent a fuel valve which is intended to open slowly, Fig. 9 being a vertical section on the line 9—9 of Fig. 8.

Referring first to Figs. 1 and 2, 1 denotes the outer vertical wall, and 2 the inner vertical wall of an annular water heater, the lower ends of the said walls being connected in any suitable manner to an annular bottom plate 3 which extends inwardly beyond the inner wall 2. 4 denotes a dome or cover for the top of the outer wall having a central outlet 5 adapted to discharge into a flue 6. The inner wall 2 is provided at its top with a cover wall 7 extending inwardly to a central opening 8 which is connected by a short flue 9 with a transversely extending chamber 10 having its outer wall 11 spaced from the wall 1 and connected by flues 12 with the chamber 13 provided below the dome 4. The inner wall 2 and its cover 7 provide a chamber A surrounding the combustion chamber.

14 denotes the inner vertical wall and 15 the outer vertical wall of a combustion chamber, the wall 15 being provided with a closed top 16 spaced from the top of the wall 14, the parts 14 and 15 being so arranged that an annular space 17 is provided therebetween and the wall 15 being provided at the bottom with a plurality of outlet openings 18. The parts 14, 15 and 16 of the combustion chamber are mounted upon an annular plate 19, preferably of metal, the outer portion of the plate being secured to the inner portion of the bottom plate 3, as by means of bolts 20.

To the bottom of the plate 19, insulating material is applied, as indicated at 21; and an angular ring 22 is secured to the inner edge of the bottom of the plate 19, the said ring being of somewhat greater diameter than the central opening in the said plate, thereby providing within the ring a seat 23 for the upper end of a casing, indicated generally at 24.

This casing is shown as substantially circular in section and comprises an intermediate contracted portion 25, with an upwardly flaring or inverted frusto-conical portion 26 extending therefrom and having its upper edge seated within the ring 22; also with a lower frusto-conical portion 27 which merges with a bottom cylindrical portion 28 from which there extends an air supply duct 29, the outer end of which is provided with a damper 30 operated by a flexible connection, such as a chain 31, which in turn is connected with and operated by any suitable temperature-controlled mechanism of the thermostatic order. The damper-operating portion of the said mechanism is indicated conventionally at 32 and is operated by wires 33 leading to the thermostatic device installed in the particular place the temperature whereof is to operate the damper. Instances of thermostatically-controlled mechanism such as indicated herein are the "Honeywell" control, and the control known to the trade as the "Regitherm".

Projecting into the duct 29 is a gas supply pipe 34 discharging into a header 35 located in the part 28 of the casing 24. This pipe is provided with a valve 36 equipped with a thermostatically-operated control 37 similar to the control 32 and provided with the wires 38. The showing of the valve 36 in Figures 1 and 3 is conventional. It is understood that the thermostatic control 37 may be applied to any slow-opening valve such as that which is illustrated in Figures 8 and 9. Control member 37 may be identical with member 32, but is shown separately for convenience in drawing.

Projecting upwardly from and communicating at their lower ends with the header 35 are burner tubes 39, 40. Five such tubes are shown, but it will be understood that the number may be varied if desirable or necessary. Each of the tubes 39 is bent outwardly in such manner that their flattened delivery ends 39ª are arranged within the contracted portion 25 of the casing 24 and are preferably spaced equidistantly therefrom and approximately equidistantly apart. The burner tube 40 is arranged centrally with respect to the tubes 39 and is provided with a flattened delivery end 41. The flattened ends 40 and 41 of the burner tubes provide elongated slots 42.

Within the parts constructed and arranged as described, the operation will be as follows:—Gas will be supplied through the pipe 34 in the usual manner to the header 35 and will be ignited as it issues from the slots 42. A pilot burner P which is to be lighted before the furnace is started is shown at P in Figure 1 and in Figure 3. The streams of gas, being delivered at the contracted portion of the Venturi tube constituted by the parts 26 and 27, will entrain in a most efficient manner the air supplied to the said tube through the duct 29, and the ignited mixture will be burned in the combustion chamber provided by the parts 14 and 17 inclusive. The parts will be so constructed and proportioned that complete combustion will be secured within the chamber, the best results being accomplished when the end of the flame reaches the ports 18; and the aggregate area of the said ports should be preferably as great as the cross sectional area of the annular space 17.

The parts 14, 15 and 16 are made of material having a thermal conductivity greater than 0.006 calorie/cm^3/°C./sec. such as silicon carbide. This material also has a high emissivity, which has been found in some cases to be about 97 percent of that of a black body. Fused alumina is another material which has a comparatively high thermal conductivity and which I might also use in constructing the combustion chamber. It is particularly desirable that the outer cylinder 15 be constructed of good conducting material such as mentioned. This is not so much the case with the inner cylinder 14. This may be constructed of any refractory which will withstand high flame temperatures. It is essential that the inner surface of 14 should be heated to incandescence to insure complete combustion of the fuel and to reduce the amount of soot which is formed as a result of incomplete combustion.

The thermal conductivity of fire clay may be given as 0.004 calorie/cm^3/°C./sec. while that of silicon carbide is said to attain a value about eight times as great or 0.034 in the same units at certain high temperatures.

The water and vapor between the shells or casings 1 and 2 will be heated mainly by radiation from the walls 15 and 16 of the outer member of the combustion chamber and will also be heated by the products of combustion delivered through the ports 18 and passing through the chamber A, flue 8, transverse chamber 10, flues 12, and chamber 13. The vapors thus generated will be conducted to the point or points of use by means of any suitable pipe installation (not shown).

The particular construction and arrangement of the burner parts 35—42 with reference to the Venturi tube 25, 26 and 27 insures the entraining of a large quantity of air by the gas issuing from the burner slots, with a corresponding quick commingling of adequate proportions of air and gas and a corresponding quick combustion of the mixture thus enabling me to reduce the length of the combustion chamber and of the members constituting the same. Furthermore, the burners 39ª, 41 and the header 35 are located where they are exposed to the inner combustion chamber member 14 and are therefore subjected to the radiant heat of the said chamber.

By the use of the enlarged header 35, the gas from the pipe 34 on its way to the burner tubes is retained for a while in a heated zone whereby the gas is preheated before delivery to the burner tips. The air supplied through the Venturi casing or tube is also preheated by contact with the walls of the casing, which are themselves heated by radiation as above described. The result is that I am enabled to produce a higher temperature in the combustion chamber and to improve the efficiency of the heater as a whole. In fact, I have been able, with a heater of the type shown herein, to convert fifty per cent or more of the total heat of combustion into the form of radiant energy and to secure a very high rate of vapor or steam generation with a comparatively small rate of combustion of the gaseous fuel.

The damper 30 and the valve 36 will be operated by thermostatic means. Figures 8 and 9 show one type of slow opening valve suitable for my purpose, altho other forms are within the scope of my invention, the essential feature of the valve being to provide that the rate of fuel feed to the burner shall be slow at first and progressively increase until the normal firing rate is reached, as the combustion chamber becomes heated. In Figures 8 and 9, 36 indicates the valve as a whole. The valve is opened by raising the lever 70 which is shown in Figure 8 as pivoted at 71. Lever 70 operates the curved arm 80 and connecting link 81 to raise the cylinder designated generally as 83. At the start, the passage of fuel is entirely prevented by the seating of portion 72 of the cylinder on portion 73 of the valve casing. As soon as the cylinder is raised slightly, free flow of fuel takes place past this seat however, and in order to restrict the flow I provide a secondary seat of portion 83 of the cylinder against portion 82 of the casing. This seat is maintained at all times. The cylinder is cut away as shown at 74, however, thus providing a passage up thru the hollow center 76 of the cylinder into the annular chamber 84 and as the cylinder is raised the proportion of the aperture 74 above the ring 82 is increased, thus permitting increased flow of fuel.

In Figs. 3–5 inclusive I have shown a modification of my invention in which the parts 3—18 are identical, or substantially identical, with the like-numbered parts in the preceding views. Instead of placing insulating material below the annular plate which supports the combustion chamber sections, I support the lower end of the section 15, 16 upon an annular slab 43 of silicon carbide or other material having high heat-radiating qualities and a thermal conductivity greater than 0.006 calorie/cm^3/°C./sec. and extend the plate 3 inwardly to form a support for the inner section 14 of the combustion chamber as indicated at 3^a.

Instead of using a Venturi tube for the casing which receives the burner and its header, a cylindrical casing 44 is provided, the upper portion of said casing having slots 45 which receive heated air from an annular chamber 46 which is provided below the plate 3, 3^a and above an annular plate 47, the central aperture of which plate 47 receives the upper portion of the casing 44. In both forms of my invention, the heater is supported by a flanged annular base 48 and legs 49. The bottom of the plate 47 and the outside of the casing 44 are covered with insulating material, indicated at *47a* and *44a* respectively.

The air to be heated is supplied to the chamber 46 through openings 50^a in the cylindrical outer wall 50 of the chamber, which openings are controlled by a ring damper 51 surrounding the wall 50 and provided with openings 51^a adapted to register more or less with the openings 50^a, the said damper being provided with a lug 52 connected by a rod 53 with the thermostatically-operated control 32.

Gas is supplied by a pipe 34 provided with a thermostatically controlled valve 36 such as has already been described, to an annular header 54. From this header, burner tubes 55 extend upwardly within the casing, being provided with flattened ends 55^a having burner slots 56, the slots being preferably located at substantially the bottoms of the openings 45 for heated air.

Because of the material of which the slab 43 is composed, the air passing through the chamber 46 will be heated in a most efficient manner, and loss of heat from such chamber by radiation will be prevented by the insulation 47^a. The header 54 and burner tubes 55 will also be heated by radiation from the combustion chamber, and the loss of heat by radiation from the casing 44 will be minimized by reason of the insulation 44^a. The gas issuing through the burner nozzles and blowing past the air ports 45 will pull the hot air out of the chamber 46 and the velocity of gas across the ports will control the amount of hot air drawn into the combustion chamber. It is necessary to inject by the action of the burner orifices or nozzles a large amount of air, substantially proportional to the flow of the gas in both forms of the invention, because the air requisite for proper and efficient combustion cannot be obtained by the action of a draft through the flues 6, the draft being broken, as shown in the drawings. The arrangement of the burner nozzles with reference to the air supply, in both forms of my invention, insures this large and proportional supply of air to the combustion chamber. Furthermore, by the manner of forming the mixture of gas and air, there is no danger of the gas firing back to the burner orifices or outlets in the event that the size of the gas fire is reduced to a minimum or in the event the gas pressure is greatly reduced.

The form of my invention illustrated in Figures 6 and 7 shows an adaptation of my invention to furnaces originally built for burning coal. The arrangement of the combustion chamber is shown similar to that in Figure 3. The chamber 46′ for preheating the combustion air is however, wholly within the furnace. Walls *44b* and *47b* of insulating refractory material tend to reduce the loss of heat from the casing 44′ and from the air preheating chamber respectively. The amount of air which is admitted is varied by variations in the rate of gas flow as previously described and may be additionally controlled by means of the thermostatically operated damper. Gas is supplied by a slow opening thermostatically operated valve as previously described. The arrows in Figure 6 show the path of the products of combustion through the upper portions of the furnace.

The air preheater is supported on a stand 90. The stand 90 with the preheater and the burner may be introduced through the ordinary ash pit door. Where necessary the preheater may be made in sections and cemented together after introduction into the furnace. The stand 90 may also be introduced in sections and bolted together after introduction into the furnace.

In the form of my invention shown in Figures 3 to 7 the refractories of which the combustion chamber is composed may be inserted through the door 57 provided in the walls of the boiler casing. It is not necessary that this door be the full height of the combustion chamber as in practice the combustion chamber is composed of sections which can be inserted through the door opening.

In the alternate form of my invention, the combustion chamber may be installed upon the bottom of the heater and the water jacket set in place around it. This construction simplifies the installation of the refractory material and increases the efficiency of the heating unit in that it eliminates the need for leaving door space in the side walls of the heater, thus permitting this space to be used as effective heating surface.

On account of the break in draft between flue sections 5 and 6 and the reduction in temperature of the combustion gases by the transfer of heat to the suronding water or steam, the natural draft through the combustion chamber is very small and the flow of air can be made very largely dependent on the induction caused by the flow of gas. Where this advantage is fully realized the thermostatic connections to the air controlling damper may be dispensed with and the damper permanently adjusted to any desired position.

A principal advantage of my fuel burning arrangement is that it secures substantially complete combustion of the fuel at all times. Perfect combustion is particularly hard to obtain when a large flow of gas is turned on while the combustion chamber is cold. This is because in such cases the rate of combustion in the cold combustion chamber is so low that the oxidation of the gas is not complete, and a heavy deposit of soot is formed within the combustion chamber. I have avoided this trouble however, by admitting only a limited amount of gas until such time as the interior of the combustion chamber has been heated to incandescence after which a greatly increased rate of gas flow is permissible.

This adjustment of the rate of gas flow to produce complete combustion at all times is obtained by the use of the slow opening valve shown in Figure 8 where the chain 86 is raised slowly, as for instance, by winding around a drum (not shown) driven at a suitable speed by a motor in the thermostatically controlled element 37. The rate of raising this chain and the attached lever 70 is such as to cause slow opening of the valve thus giving suitable regulation of the gas flow to the combustion chamber to secure the result described.

After the walls of my combustion chamber have been heated to incandescence it is possible to secure complete combustion of gas in the chamber at a very high rate due to the accelerated velocity of oxidation at high temperatures and the speed with which the heat liberated within the combustion chamber is transmitted through the walls and radiated to the water containing casing. I have found it possible to continuously liberate heat in this way for example at a rate in excess of 400,000 B. t. u./hr./cu. ft. of combustion chamber when firing city gas without damage to my heater.

While my invention has been described primarily with reference to a domestic heater for water or steam, my improved heater is also obviously adaptable to a wide variety of other uses, such as heating an air heating furnace, supplying hot gases for drying purposes, etc., and it is not my desire to consider it limited to application for the specific purposes illustrated.

I claim:

1. In a heating device, a combustion chamber having an inner wall of continuous non-metallic refractory material capable of being heated to incandescence, said inner wall surrounding the hottest portion of said combustion chamber, an outer wall of continuous non-metallic refractory material of thermal conductivity in excess of 0.006 calorie/cm^3/°C./sec., said outer wall surrounding the inner one to form an annular passage for the products of combustion, a container for material to be heated substantially surrounding the combustion chamber and adapted to be heated by radiation therefrom and by contact with the products of combustion, and means for introducing a combustible mixture into the combustion chamber.

2. In a heating device, a combustion chamber having an inner wall of continuous non-metallic refractory material capable of being heated to incandescence, said inner wall surrounding the hottest portion of said combustion chamber, an outer wall of continuous non-metallic refractory material of thermal conductivity in excess of 0.006 calorie/cm^3/°C./sec., said outer wall surrounding the inner one to form an annular passage for the products of combustion, a container for material to be heated substantially surrounding the combustion chamber and adapted to be heated by radiation therefrom and by contact with the products of combustion, means for preheating the gas and air for combustion, and means for introducing the preheated gases into the combustion chamber.

3. In a heating device, a combustion chamber having an inner wall of continuous non-metallic refractory material capable of being heated to incandescence, said inner wall surrounding the hottest portion of said combustion chamber, an outer wall of continuous non-metallic refractory material of thermal conductivity in excess of 0.006 calorie/cm³/°C./sec., said outer wall surrounding the inner one to form an annular passage for the products of combustion, a container for material to be heated substantially surrounding the combustion chamber and adapted to be heated by radiation therefrom and by contact with the products of combustion, means for introducing a combustible mixture into the combustion chamber, means for igniting said mixture, and a thermostatically operated device for regulating the supply of fuel.

4. In a heating device, a combustion chamber having an inner wall of continuous non-metallic refractory material capable of being heated to incandescence, said inner wall surrounding the hottest portion of said combustion chamber, an outer wall of continuous non-metallic refractory material of thermal conductivity in excess of 0.006 calorie/cm³/°C./sec., said outer wall surrounding the inner one to form an annular passage for the products of combustion, a container for material to be heated substantially surrounding the combustion chamber and adapted to be heated by radiation therefrom and by contact with the products of combustion, means for introducing a combustible mixture into the combustion chamber, means for igniting said mixture, and a thermostatically operated slow-opening valve controlling the supply of fuel.

5. In a heating device, a combustion chamber having an inner wall of continuous non-metallic refractory material capable of being heated to incandescence, said inner wall surrounding the hottest portion of said combustion chamber, an outer wall of continuous non-metallic refractory material of thermal conductivity in excess of 0.006 calorie/cm³/°C./sec., said outer wall surrounding the inner one to form an annular passage for the products of combustion, a container for material to be heated substantially surrounding the combustion chamber and adapted to be heated therefrom and by contact with the products of combustion, means for introducing a combustible mixture, a thermostatically operated device for regulating the supply of fuel, and means for preventing the full flow of fuel until the combustion chamber has been heated to incandescence.

6. In a heating device, a combustion chamber having an inner wall of continuous non-metallic refractory material capable of being heated to incandescence, said inner wall surrounding the hottest portion of said combustion chamber, an outer wall of continuous non-metallic refractory material of thermal conductivity in excess of 0.006 calorie/cm³/°C./sec., said outer wall surrounding the inner one to form an annular passage for the products of combustion, a container for material to be heated substantially surrounding the combustion chamber and adapted to be heated by radiation therefrom and by contact with the products of combustion, means for introducing a combustible mixture into the combustion chamber, and a fuel inlet with an air inlet so disposed in relation thereto as to cause air for combustion to be drawn in and mixed with the fuel.

7. In a heating device, a combustion chamber having an inner wall of continuous non-metallic refractory material capable of being heated to incandescence, said inner wall surrounding the hottest portion of said combustion chamber, an outer wall of continuous non-metallic refractory material of thermal conductivity in excess of 0.006 calorie/cm³/°C./sec., said outer wall surrounding the inner one to form an annular passage for the products of combustion, a container for material to be heated substantially surrounding the combustion chamber and adapted to be heated by radiation therefrom and by contact with the products of combustion, means for introducing a combustible mixture into the combustion chamber, a fuel inlet with an air inlet so disposed in relation thereto as to cause air for combustion to be drawn in and mixed with the fuel at a rate dependent upon the fuel flow.

8. In a heating device, a combustion chamber having an inner wall of continuous non-metallic refractory material capable of being heated to incandescence, said inner wall surrounding the hottest portion of said combustion chamber, an outer wall of continuous non-metallic refractory material of thermal conductivity in excess of 0.006 calorie/cm³/°C./sec., said outer wall surrounding the inner one to form an annular passage for the products of combustion, a container for material to be heated substantially surrounding the combustion chamber and adapted to be heated by radiation therefrom and by contact with the products of combustion, means for introducing a combustible mixture into the combustion chamber, a fuel inlet so disposed in relation thereto as to cause air for combustion to be drawn in and mixed with the fuel, means for igniting said mixture, and a thermostatically operated slow-opening valve controlling the supply of fuel.

9. In a heating device, a combustion chamber having an inner wall of continuous non-metallic refractory material capable of being heated to incandescence, said inner wall surrounding the hottest portion of said combustion chamber, an outer wall of continuous non-metallic refractory material of thermal conductivity in excess of 0.006 calorie/cm³/

°C./sec., said outer wall surrounding the inner one to form an annular passage for the products of combustion, a container for material to be heated substantially surrounding the combustion chamber and adapted to be heated by radiation therefrom and by contact with the products of combustion, means for introducing a combustible mixture into the combustion chamber, means for igniting said mixture, and thermostatic controls on the conduits supplying fuel and air respectively.

10. In a heating device, a combustion chamber having an inner wall of continuous non-metallic refractory material capable of being heated to incandescence, said inner wall surrounding the hottest portion of said combustion chamber, an outer wall of continuous non-metallic refractory material of thermal conductivity in excess of 0.006 calorie/cm^3/°C./sec., said outer wall surrounding the inner one to form an annular passage for the products of combustion, a container for material to be heated substantially surrounding the combustion chamber and adapted to be heated by radiation therefrom and by contact with the products of combustion, means for introducing a combustible mixture into the combustion chamber, a fuel inlet so disposed in relation thereto as to cause air for combustion to be drawn in and mixed with the fuel, means for igniting said mixture, a thermostatically operated slow-opening valve controlling the supply of fuel, and a draft-breaking opening in an offtake for the products of combustion.

11. In a heating device, a combustion chamber within a fluid container but spaced therefrom and adapted to heat the container by radiation from a wall of the combustion chamber, said wall being composed of a continuous non-metallic refractory material having a thermal conductivity in excess of 0.006 caloric/cm^3/°C./sec., a burner for supplying a combustible mixture to said combustion chamber, means for igniting said mixture, and a thermostatically operated slow-opening valve controlling the supply of fuel.

12. In a heating device, a double-wall combustion chamber adapted to radiate heat from its walls to an adjacent body, a burner which maintains intense combustion within the inner wall of said chamber, means for introducing a combustible mixture into the combustion chamber, a fuel inlet so disposed in relation thereto as to cause air for combustion to be drawn in and mixed with the fuel, means for igniting said mixture, and a thermostatically operated slow-opening valve controlling the supply of fuel.

13. In a gas furnace, a burner, a combustion chamber of continuous non-metallic refractory above said burner, a pilot ignition arrangement adjacent to said burner, a thermostatically controlled valve for admitting gas to said burner, said valve being so constructed as to open slowly whereby the walls of the furnace are at first subjected to a gradually increasing temperature and the combustion of fuel is always approximately complete as the inner wall of the combustion chamber approaches incandescence; and means for inducing a current of air at the gas outlet to the burner which supply of air is proportional to the supply of gas issuing from the outlets.

14. The combination, with a longitudinally extending annular heater, of a combustion chamber of non-metallic refractory within the said heater and comprising an inner member and an outer member surrounding and spaced from the inner member and having a cover spaced from the adjacent end of the inner member to provide an annular return passage for products of combustion, the outer member having one or more outlet openings at the end thereof opposite its cover, a casing extending from the receiving end of the inner member, a gas burner in said casing, an air supply for said casing, said supply of air being drawn in by the gas issuing from the fuel outlet for said burner, and thermostatically-controlled means for regulating the supply of air to the said casing and of gas to said burner.

15. The combination, with a vertically disposed annular heater, of a vertically extending combustion chamber within the said heater, a casing extending downwardly from the said chamber and communicating with the bottom thereof, said casing being in the form of a Venturi tube, gas supply tubes with flattened orifices within said casing each provided with a discharge orifice arranged within the contracted portion of said casing, said orifices being arranged in a circle substantially concentric with the Venturi tube, and means for supplying air to said casing below the contracted portion thereof.

16. The combination, with a vertically disposed annular heater, of a vertically extending combustion chamber within the said heater, a casing extending downwardly from the said chamber and communicating with the bottom thereof, said casing being in the form of a Venturi tube, gas supply tubes within said casing each provided with a discharge orifice arranged within the contracted portion of said casing, and means for supplying air to said casing below the contracted portion thereof, the said combustion chamber having a wall of high heat radiating qualities arranged to heat by radiation the said casing and the air and the burner tubes therein.

17. The combination, with a vertically disposed annular heater, of a combustion chamber within the said heater and extending upwardly from the lower portion thereof, a

casing extending downwardly from and communicating with the bottom of said combustion chamber, gas supply tubes with outlets located within the said casing, and means for supplying air into said casing, to mingle with gas from the said outlets, the said combustion chamber comprising a wall of high heat-radiating qualities arranged to heat by radiation the gas and the air in and supplied to said casing.

18. The combination, with a vertically disposed annular heater, of a combustion chamber within the said heater and extending upwardly from the lower portion thereof, a casing extending downwardly from the combustion chamber and communicating therewith, gas supply tubes with outlets in said casing, and means for supplying air to said casing, the gas outlets and the air supplying means being so arranged that the amount of air supplied to the casing and to the combustion chamber will be approximately proportional to the rate of delivery of gas from the said outlets into the casing and into said combustion chamber.

19. The combination, with a vertically disposed annular heater, of a combustion chamber within said heater and extending upwardly from the lower portion thereof, a casing extending downwardly from the combustion chamber and communicating therewith, the said casing being in the form of a Venturi tube, gas supply tubes in said casing having their orifices in the contracted portion of said tube, and means for supplying air to said casing below the gas orifices whereby the amount of air injected into the combustion chamber by the gas will be approximately proportional to the rate of flow of gas from the gas orifices.

20. The combination, with a vertically disposed annular heater having a large central opening within the bottom thereof, of an annular plate removably secured to the portion of the heater surrounding such opening, an upwardly extending combustion chamber supported by said plate, a casing extending downwardly from the central opening in said plate, means for supplying to the combustion chamber and through said casing a mixture of combustible gas and air, an insulating coating below said plate and on the outside of said casing, and a preheating chamber for the gas supply in the lower part of said casing.

In testimony whereof I affix my signature.

JOHN W. CANNON.