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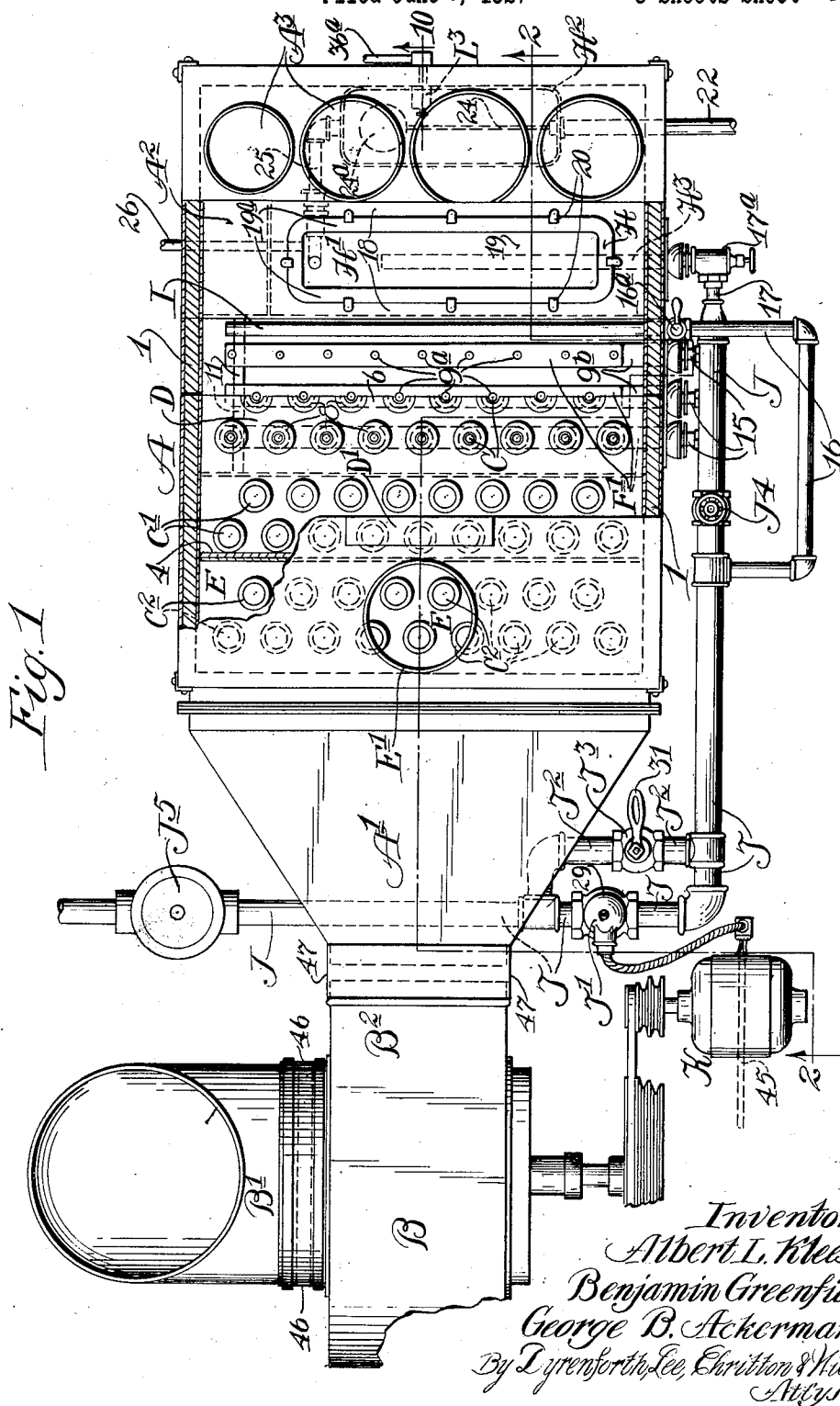
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A. L. KLEES ET AL

HOT AIR FURNACE

Filed June 9, 1927

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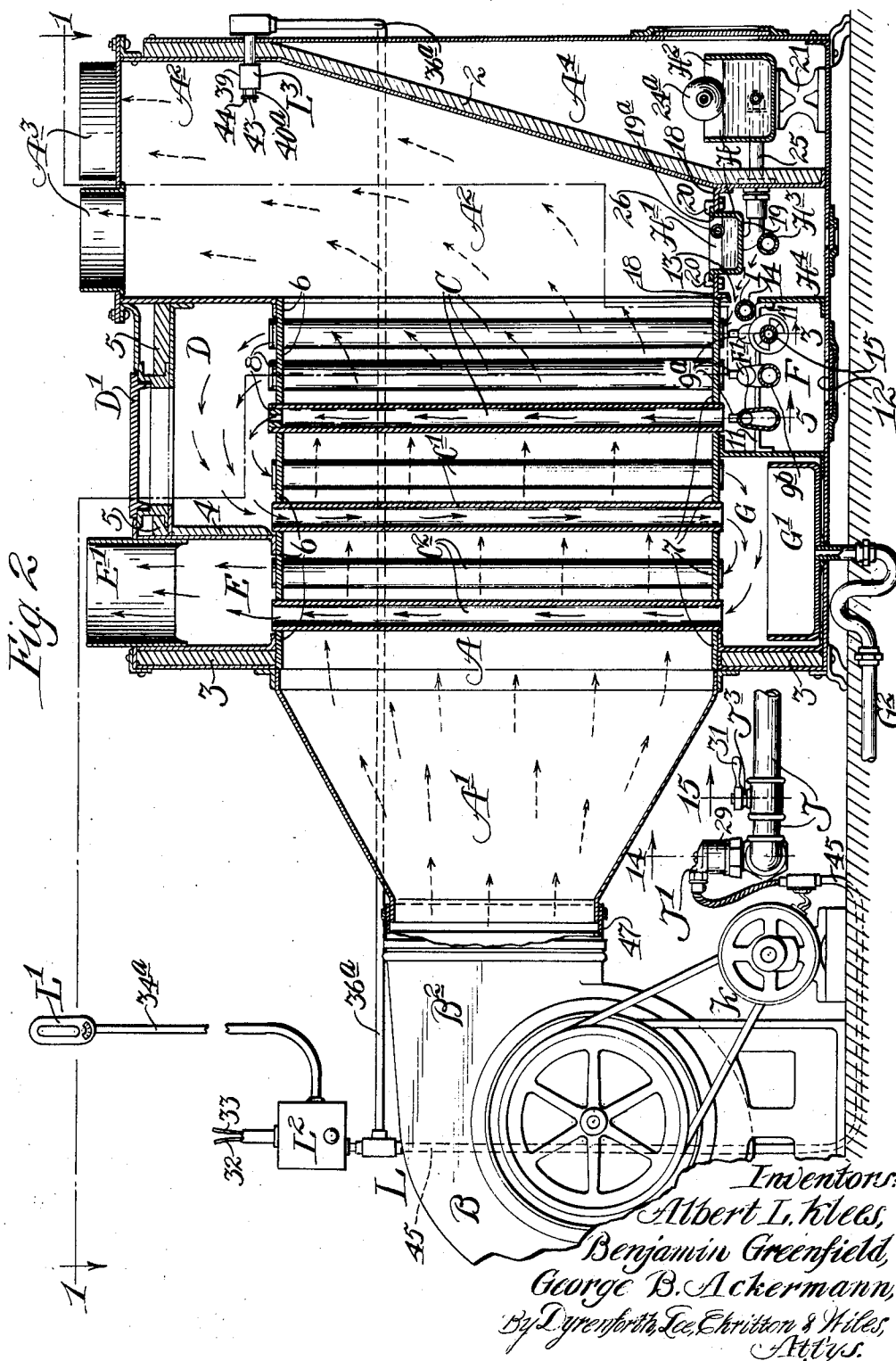
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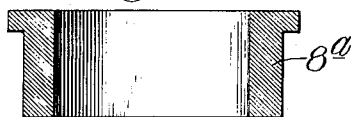
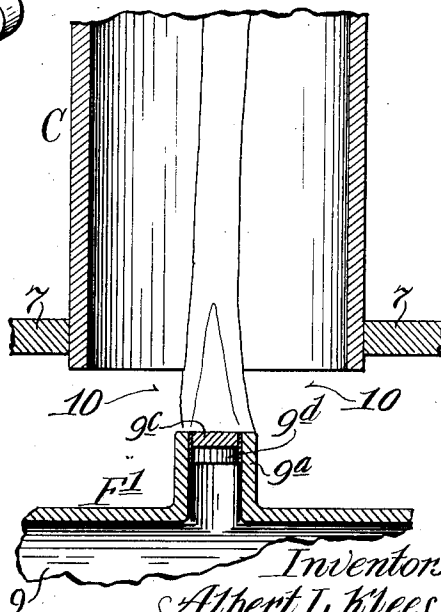
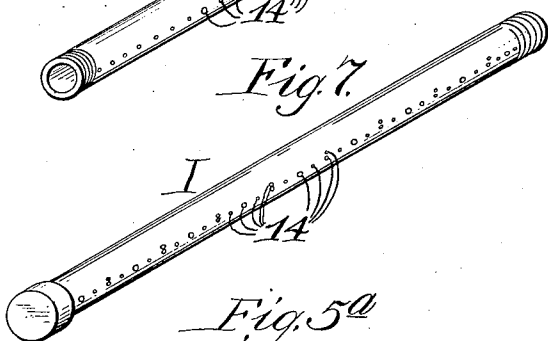
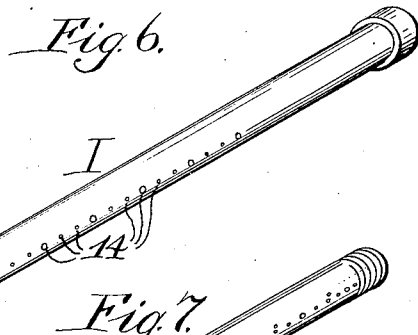
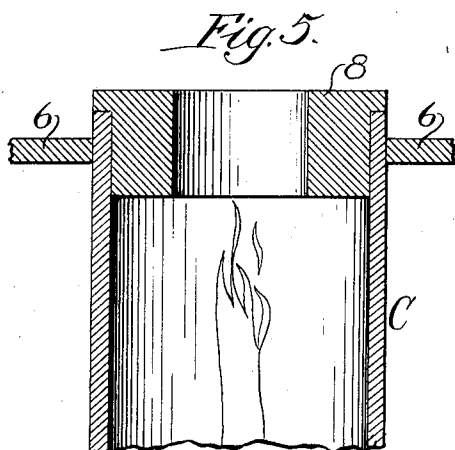
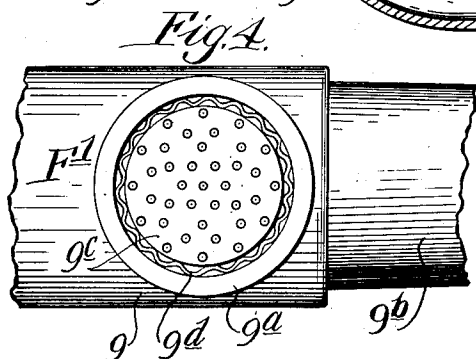
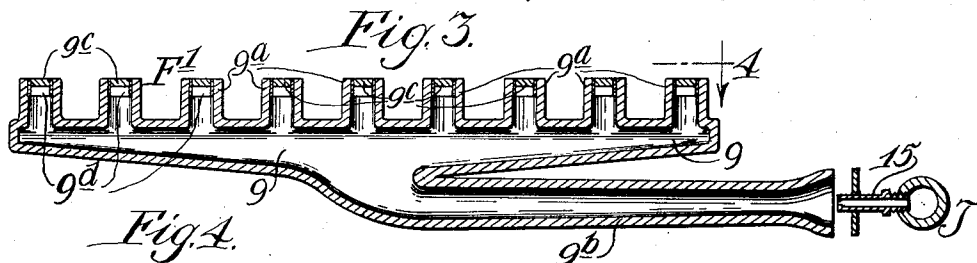
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5 Sheets-Sheet 3



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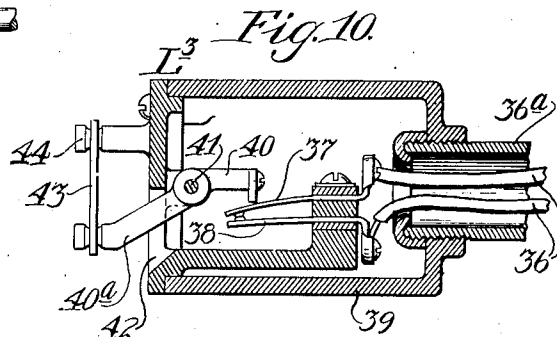
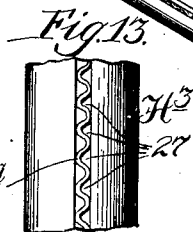
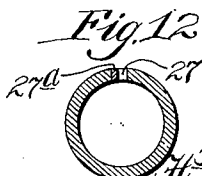
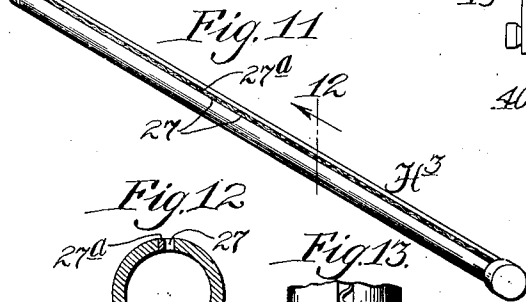
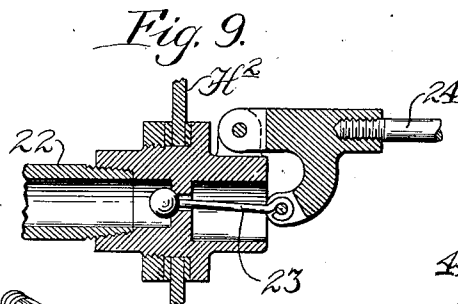
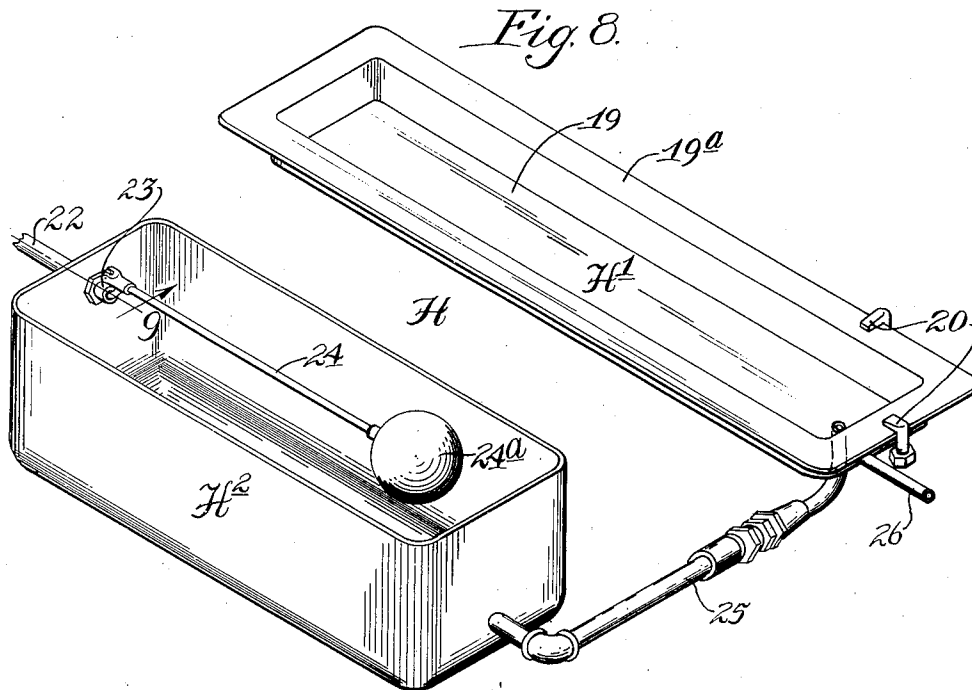
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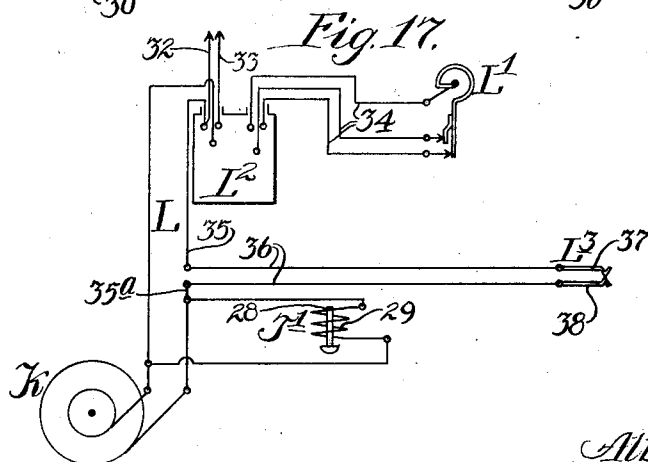
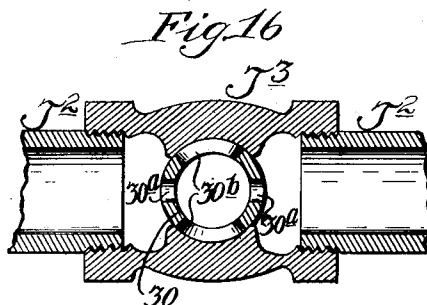
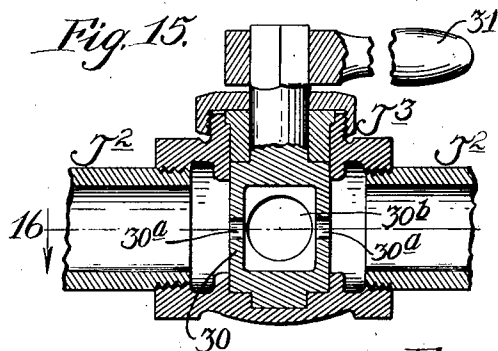
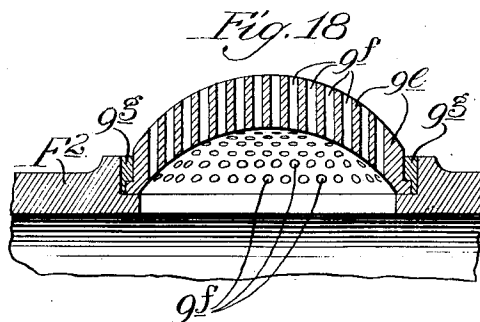
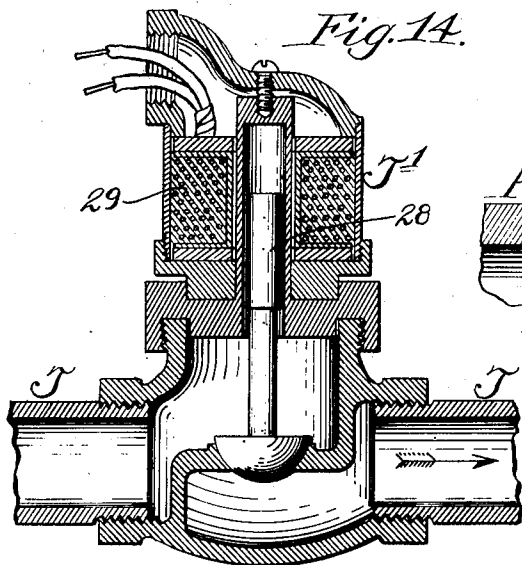
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HOT AIR FURNACE

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5 Sheets-Sheet 5



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# UNITED STATES PATENT OFFICE.

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## HOT-AIR FURNACE.

Application filed June 9, 1927. Serial No. 197,697.

This invention relates particularly to hot air furnaces adapted to employ a fluid fuel, such as gas, fuel oil, or the like.

The primary object of the invention is to provide a furnace of high efficiency which is adapted to heat and circulate air, which may be used for heating residences, or for other purposes.

A further object of the invention is to provide, in conjunction with the improved furnace, a humidifier adapted to supply moisture to the heated air, the humidifier being preferably designed to supply to the air moisture properly proportioned to correspond with the temperature to which the rooms are heated.

The invention is illustrated in a preferred embodiment in the accompanying drawings, in which—

Fig. 1 is a broken plan view of a hot air furnace, partly in section, embodying the invention; Fig. 2, a broken vertical sectional view taken as indicated at line 2—2 of Fig. 1; Fig. 3, a vertical sectional view of one of the heating-burners employed, the section being taken as indicated at line 3 of Fig. 2; Fig. 4, a broken plan view taken as indicated at line 4 of Fig. 3; Fig. 5, a broken vertical sectional view taken as indicated at line 5 of Fig. 2 and showing one of the combustion-flues; Fig. 5<sup>a</sup>, a choker interchangeable with that shown in Fig. 5; Fig. 6, a perspective view of a pilot-burner; Fig. 7, a reverse perspective view of the same; Fig. 8, a perspective view of the evaporator-pan and water-supply tank of the humidifier employed; Fig. 9, a broken sectional view taken as indicated at line 9 of Fig. 8, and showing a detail of a float-control valve employed; Fig. 10, a broken sectional view taken as indicated at line 10 of Fig. 1 and showing a detail of a fuse-device controlling the electric circuits which control the blower-motor and fuel-valve, the fuse-device being preferably mounted in the upper portion of the hot-air flue of the furnace, as shown in Fig. 2; Fig. 11, a perspective view of the humidifier-burner; Fig. 12, a section taken as indicated at line 12 of Fig. 11; Fig. 13, a broken plan view, on

an enlarged scale, of the burner shown in Fig. 11; Fig. 14, a sectional view of a main automatically controlled fuel valve, the section being taken as indicated at line 14 of Fig. 2; Fig. 15, a sectional view of a by-pass valve associated with said main valve, the section being taken as indicated at line 15 of Fig. 2; Fig. 16, a plan sectional view taken as indicated at line 16 of Fig. 15; Fig. 17, a diagrammatic view illustrating the manner in which the automatic fuel-valve and blower-motor are controlled by means of a thermostat and safety-switch, said safety-switch being controlled by a fuse or other suitable device; and Fig. 18 is a broken sectional view of a modified form of burner-orifice.

Briefly, it may be stated here that in the preferred construction the furnace is provided with a group of upright combustion-flues, in front thereof with an adjacent group of return-flues, and in front of the return flues with a group of exit-flues which lead to the smoke-stack; also, that the furnace is equipped at its front side with a blower operated by an electric motor, said blower operating to force the air to be heated across and between the several groups of flues mentioned, the air to be heated coming first into contact with the relatively cool exit-flues, then into contact with the return-flues, and finally into contact with the highly heated combustion-flues, after which the air passes out through a hot-air flue, from which it is distributed, by means of suitable conduits, to the rooms to be heated; also, that the evaporator-pan of the humidifier is so disposed in the base of the furnace as to supply moisture to the heated air as it passes through the hot-air flue; also that the supply of fuel to the heating burners and the humidifier-burner is controlled by a main valve which is controlled by a thermostat, which thermostat serves also to control the operation of the blower-motor.

In the preferred embodiment which is illustrated, A designates a heating-chamber which may be of rectangular form and which is equipped at its front side with an intake air-conduit A' and which is equipped

at its rear side with a hot-air flue A<sup>2</sup>; B, a blower provided with an intake conduit B<sup>1</sup> and an outlet conduit B<sup>2</sup> which communicates with the conduit A<sup>1</sup>; C, a group of combustion-flues which preferably are disposed in an upright position in the rear portion of the air-heating chamber A; C', a group of return-flues disposed in the chamber A immediately in front of the flues C; C<sup>2</sup>, a group of outlet-flues, or exit-flues, disposed in front of the return-flues; D, a chamber surmounting the heating-chamber above the combustion and return-flues; E, a chamber surmounting the heating-chamber above the exit-flues and communicating with a smoke-stack E'; F, a burner-chamber, within which are mounted heating-burners F', one of which is shown in detail in Fig. 3; G, a sub-chamber disposed in front of the burner-chamber F and below the return and exit-flues, the chamber G being equipped with a drain-pan G' from which leads a drain-pipe G<sup>2</sup>; H, a humidifier comprising an evaporator-pan H', a water-supply tank H<sup>2</sup>, and a burner H<sup>3</sup>, the burner H<sup>3</sup> being located in a burner-chamber H<sup>4</sup> disposed back of the main burner-chamber F; I, a pilot-burner (Figs. 2, 6 and 7) which is adapted to light the main (heating) burners and the humidifier-burner; J, a fuel-supply pipe equipped with a thermostatically controlled main valve J' and provided with a by-pass J<sup>2</sup> equipped with a by-pass valve J<sup>3</sup>, the pipe J serving to supply the heating burners F' and the humidifier-burner H<sup>3</sup>, as well as the pilot-burner I; K, an electric motor belted to a pulley on the shaft of the fan of the blower B; and L, an electric circuit controlling the operation of the motor K and the main fuel-valve J', said circuit being equipped with a thermostat L', a relay L<sup>2</sup> and a fuse-controlled switch L<sup>3</sup>, as will be understood from Figs. 2, 10 and 17.

The main portion of the body of the furnace consists of the heating-chamber A, the surmounting chambers D and E, and the sub-chambers G and F. These chambers may be constructed in any desired manner. They may be formed conveniently, for the most part, from sheet-metal.

The furnace body is provided with side walls 1 which may constitute the sides of the heating-chamber A and the sub-chambers and superposed chambers. The front, or left hand side of the heating-chamber, as viewed in Fig. 2, is open to the flaring conduit A<sup>1</sup> which communicates with the outlet-conduit B<sup>2</sup> of the blower. The hot-air conduit A<sup>2</sup> is parallel with the rear side of the heating-chamber A and is open thereto. The upper portion of the hot-air flue A<sup>2</sup> communicates with a series of outlet-flues A<sup>3</sup> which may lead to the rooms which are to be heated.

The rear wall of the hot-air flue A<sup>2</sup> slopes at its lower portion, as indicated at 2; and back of this sloping wall is located a chamber A<sup>4</sup> in which the tank H<sup>2</sup> is conveniently located.

The lateral walls of the furnace preferably are provided with heat-insulating material, as appears from Fig. 1. Insulation may be used at other points, if desired. As shown at Fig. 2, insulation is used at the points 3, 4 and 5; and above the chamber D is a safety door, or closure D', adapted to relieve the pressure in case of an accumulation of gas and explosion thereof.

The heating-chamber A is provided with a top-plate 6 and a bottom-plate 7 which have perforations therethrough which receive the expanded ends of the tubes which constitute the combustion-flues, return-flues and exit-flues.

The rear group of flues C, that is the combustion-flues, are shown as consisting of three transverse rows of upright tubes. These tubes preferably are equipped at their upper ends with chokers 8. Interchangeable chokers having passages of graduated sizes are provided, so that the correct size may be selected, according to the gas-consumption required. Their use renders unnecessary the regulation of the secondary air-supply and improves the result. In Fig. 5<sup>a</sup>, 8<sup>a</sup> designates one of the chokers which is interchangeable with the choker 8 shown in Fig. 5.

The heating-burners F', which may be termed the main burners, preferably are of the form shown in Fig. 3. Thus each burner comprises an elongated burner-head 9 which may be of approximately tubular cross-section, the burner-head being equipped at its upper side with a series of tubular bosses 9<sup>a</sup> forming burner-orifices, and said chamber 9 having connected with its bottom wall at a central point a mixer tube 9<sup>b</sup>. The burner-head 9, the row of burner-orifices 9<sup>a</sup> thereon, and the mixer-tube 9<sup>b</sup> may be of integral formation. They may, for example, be of cast-metal. The burner-orifices 9<sup>a</sup> are spaced apart in such a manner as to make a burner-orifice co-axial with each combustion-flue. The orifices 9<sup>a</sup> preferably are fitted with perforate disks 9<sup>c</sup> of lava, encircled by a corrugated metal strip 9<sup>d</sup> which is interposed between the periphery of the lava disk and the encircling wall of the hollow boss. The manner in which the burner-tip is located axially between a combustion-flue C is illustrated in Fig. 5. Those skilled in the art will understand that the space 10 between the burner-tip and the bottom of the combustion-flue should be properly adjusted.

The main burners F' are mounted on horizontal bars 11 with which the burner-chamber F is equipped. The bars 11 may be ver-

tically adjustable, if desired. A secondary air supply is admitted to the burner-chamber F through a register 12, which may be adjusted to admit the desired supply.

5 A passage 13 between the burner-chamber F and the burner-chamber H<sup>4</sup> serves to permit the products of combustion from the humidifier-burner H<sup>3</sup> to pass through the combustion-flues C. As shown in Fig. 2, 10 the pilot-burner I is a tubular member located at the opening 13 and provided on opposite sides with perforations 14, whereby the flames from the pilot-burner are directed towards the main burners and the humidifier-burner.

15 The fuel-supply pipe J is equipped with nipples 15 through which gas may pass to the mixture-tubes 9<sup>b</sup> of the main burners, as appears from Figs. 1 and 3. The pipe J has 20 a branch 16 which supplies the pilot-burner I, the branch 16 being equipped with a pilot-valve 16<sup>a</sup>. The pipe J also has an extension 17 equipped with a valve 17<sup>a</sup> through which the humidifier-burner H<sup>3</sup> is supplied. The 25 pipe J is provided with a hand-valve J<sup>4</sup> to enable the gas to be kept from the main burners and humidifier-burners until after the pilot has been lighted.

30 A gas-pressure regulator J<sup>5</sup> is provided in the course of the pipe J and is set to supply uniform pressure to the burners.

The drain-pan G' is properly located in the sub-chamber G to collect condensation which may drain back from the flues, chiefly 35 the exit-flues C<sup>2</sup>, which are the coolest. It will be understood that the gases are hottest in the combustion-flues C; less hot in the return-flues C'; and still cooler in the exit-flues C<sup>2</sup>. The flues are properly proportioned to carry away the products of combustion, taking into consideration the shrinkage 40 in volume as the gases are cooled. The flues of the several rows preferably are staggered with relation to each other, as will be understood from Fig. 1. The purpose is to insure 45 contact between the air which is being heated and the flues, as the air passes through the heating-chamber transversely with relation to the flues.

50 It is desirable to make the flues C<sup>2</sup>, particularly, of a metal which will be resistant to corrosion from the gases and vapors passing therethrough, or the condensations collecting in the flues and trickling back into the drain-pan G'.

55 The burner-chamber H<sup>4</sup> of the humidifier is surmounted by a plate, or hanger, 18. This plate is longitudinally slotted, and the body-portion 19 of the evaporator-pan H' depends through the slot into the chamber H<sup>4</sup>. The pan is provided with a flange 19<sup>a</sup> which rests upon the plate and is secured to the plate by anchor bolts 20.

60 The tank H<sup>2</sup> is mounted on supports 21 65 located in the base of the chamber A<sup>4</sup>. The

tank H<sup>2</sup> is equipped with an inlet pipe 22 guarded by a float-valve 23 which is operated through the medium of a lever 24 equipped with a ball float 24<sup>a</sup>. A pipe 25 connects the tank H<sup>2</sup> with the evaporator-pan H'. 70 The evaporator-pan is equipped with an overflow pipe 26. Water is maintained in the evaporator-pan at the level of the water in the tank H<sup>2</sup>, as will be understood from Fig. 2. 75

The humidifier-burner H<sup>3</sup> is shown in detail in Figs. 11-13. As shown, it comprises a pipe provided with a longitudinal slot 27 in which is held a corrugated strip 27<sup>a</sup>. However, the burner may be of any suitable 80 construction.

The pilot-burner I employed is shown in Figs. 6 and 7; and from Fig. 2 it will be noted that the burner is so disposed that it will serve to light the main burners and the 85 evaporator-burner.

The arrangement of the by-pass J<sup>2</sup> with relation to the automatic fuel-valve J' is shown in Fig. 1. A detail of the main valve is shown in Fig. 14, from which it will be 90 noted that the valve-stem is equipped with a core 28 which co-acts with a solenoid 29, which, as shown in Fig. 17, forms a part of the electric circuit L.

The by-pass valve J<sup>2</sup> is shown in Figs. 15 95 and 16 as a valve having a plug 30 whose stem is equipped with a handle 31. The plug is provided with a small passage 30<sup>a</sup> and at right angles thereto with a large passage 30<sup>b</sup>. The passage 30<sup>a</sup> may serve to permit 100 the passage of sufficient gas to keep the pilot-burner going and, also, if desired, to maintain a low flame at the main burners and the humidifier-burner. If desired, the valve J<sup>2</sup> may be open to permit passage of gas 105 through the large passage 30<sup>b</sup>, in which case sufficient gas will be permitted to pass to serve the burners to full capacity. This is a desirable feature in case the electric circuit should fail and the valve J' thus fail to open. 110 Obviously, the cock 30 may be set so as to serve the burners at any desired capacity. The pilot-burner may be turned off when desired.

Referring to Figs. 2 and 17, the main line 115 wires of the electric circuit L are designated 32 and 33. The thermostat L' is intended to be mounted in one of the rooms to be heated. It is connected with the relay L<sup>2</sup> in a known manner, the wires 34 shown in the diagram 120 extending through a conduit 34<sup>a</sup>, as shown in Fig. 2. One of the wires 35, 35<sup>a</sup> leading to the motor and to the solenoid 29 has interposed in its course wires 36 which lead through a conduit 36<sup>a</sup> to the safety-switch 125 L<sup>3</sup>, which, as shown in Fig. 2, is mounted in the upper portion of the hot-air flue A<sup>2</sup>. The wires 36 are connected with switch-points 37 and 38 shown diagrammatically in Fig. 17. As shown in Fig. 10, these 130

switch-points are mounted in a casing 39 and normally are held in contact with each other by means of a lever 40 pivoted at 41 and having an arm 40<sup>a</sup> projecting through  
 5 a slot 42 in the casing. The projecting end of the lever is connected by a fuse-link 43 with a stud 44 which projects from the switch-box. It will be noted that the fuse-link 43 is exposed to the temperature of hot  
 10 air in the flue A<sup>2</sup>; and should a dangerous rise in temperature occur, the fuse-link will release the lever 40 and permit the contact 37, which is a spring-contact, to separate from the contact 38. In this manner, one  
 15 line leading to the motor and solenoid will be interrupted, thus stopping the operation of the blower and closing the valve J'.

In Fig. 2, the wires leading to the motor and automatic fuel-valve are carried in a  
 20 conduit 45.

The blower B may be equipped with any suitable fan. It is preferred, however, to employ a sirocco fan which is capable of passing air at high velocity across the heating  
 25 flues. This mode of operation greatly increases the effectiveness of the heat transfer. To lessen the noise which might be caused by the vibration of the fan, the intake-conduit B' is connected to the fan-casing  
 30 through the medium of a sleeve of soft flexible material, such as canvas, this sleeve being designated 46 in Fig. 1; also a canvas sleeve 47 is employed to connect the outlet nozzle B<sup>2</sup> of the fan-casing with the intake-conduit A' of the heating-chamber.  
 35

It will be understood that the intake-conduit B' may be connected with a return-pipe from the rooms to be heated, if desired. The system may be operated with or without the  
 40 use of the blower. Thus, in mild weather, it may operate without the use of the blower; and, in cold weather, the blower may be employed to increase the heating capacity of the plant.

It will be understood by those skilled in the art that in case of the use of oil for heating purposes, the flow of oil to the burners may be induced by means of a blower in the usual manner; and, if desired, a  
 50 separate supply for the humidifier-burner may be provided. In such case, if desired, the pipe serving the humidifier-burner may be a separate pipe, and may have its independent valve controlled by the same thermostat which controls the operation of the  
 55 main burners.

In the improved furnace, an evaporator-pan adapted to provide a large water area is preferably employed. The heat supply to the  
 60 evaporator-burner may be regulated by the valve 17<sup>a</sup>. The heat supplied by the humidifier-burner is proportional to the heat supplied by the main burners, since the fuel supplied to the humidifier-burner is proportional

to the fuel supplied to the main burners. This  
 65 is true regardless of whether the burners operate at full capacity, or at partial capacity.

The lower the external temperature, the greater the heat which will be required to heat a building, and the greater the need for  
 70 humidifying the heated air. It has been found that in a climate corresponding with the winter climate of the northern part of the United States, the comfort range of humidity in heated rooms ordinarily will be  
 75 from 35% to 45% humidity in the air; and the percentage of humidity can be kept within the best range by supplying to the humidifying-burner about 10% of the fuel employed in the furnace. Ordinarily, this  
 80 will be sufficient to evaporate the necessary amount of water to humidify the heated air to the proper degree. It will be understood, however, that the ratio between the fuel supplied to the main burners and the humidifier-  
 85 burner may be varied to meet the needs for varying climates and different seasons. On the other hand, it is necessary to guard against too high an evaporation, which might lead to the condensation of vapor on  
 90 the windows; and, on the other hand, it is necessary to guard against too little evaporation, leading to discomfort on account of dryness of the heated air. For rooms heated to about 70° F., about 38% to 40% humidity  
 95 is desirable.

The operation of the improved furnace may be stated briefly:

The by-pass valve J<sup>3</sup> is, in any case, left sufficiently open to supply the pilot-burner, and it may be left sufficiently open to maintain low flames in the main burners and humidifier-burner. When the temperature in the rooms drops below the desired temperature, the thermostat L' operates to close  
 100 the electric circuit, thus opening the main fuel-valve J' and setting the blower in operation. The operation continues until the temperature in the rooms reaches the desired degree, when the thermostat serves to stop the  
 105 operation of the motor and close the valve J'. In the case of a dangerous rise in temperature, the fuse-link 43 will melt, thus permitting the switch L<sup>2</sup> to open, thus interrupting the circuit. This will stop the  
 110 operation of a blower and close the main fuel-valve J'. The heat delivered by the humidifier-burner is proportionate to the heat supplied by the main burners; hence, the amount of water evaporated will bear a certain relation to the heat employed in heating  
 115 a building. The products of combustion from the humidifier-burner will pass through the combustion-flues C of the furnace and will ultimately reach the smoke-stack. The  
 120 main burners are so adjusted with relation to the combustion-flues C that the gases will be burned wholly, or almost entirely, within  
 125

the combustion-flues. The adjustment may be such that the flames from the burner-tips which are located centrally below the several combustion-flues may extend practically through the combustion-flue, as illustrated in Fig. 5. Thus, the air passing through the heating-chamber A will all be subjected to about the same degree of heating. The gases passing through the exit-flues C<sup>2</sup> will be so lowered in temperature that condensations are likely to occur in the exit-flues, and thus sulphurous acid may come in contact with the exit-flues. For this reason, it is preferred to make the exit-flues of non-corrosive metal which will withstand the attack of the wet gases and sulphurous acid. The condensations will drain back into the pan G', which should also be of non-corrosive metal. Ultimately, the condensed fluids will escape through the pipe G<sup>2</sup> to the sewer.

In Fig. 18 is shown a modified main (heating) burner F<sup>2</sup>. In this case the elongated burner-head is provided at its upper side with a series of orifices (one shown) having counter-sinks, or circular sockets, in which are mounted part-spherical burner-tips 9<sup>a</sup> having passages 9<sup>f</sup> therethrough. These burner-tips may be of lava or other refractory material, if desired, and the passages may be symmetrically arranged throughout the area of the burner-tip. The burner-tip is shown secured in the socket by cement 9<sup>e</sup>.

Other embodiments of the invention will be described in an application which is in course of preparation, in which application it is intended to claim the principle of the humidifier in its broadest applications as well as another species of the invention.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, but the appended claims should be construed as broadly as permissible, in view of the prior art.

What we regard as new, and desire to secure by Letters Patent, is:

1. In a furnace, an air-heating chamber, combustion-flues, return-flues, and exit-flues extending through said chamber, and means whereby air may circulate through said chamber transversely across said flues, the incoming air coming first into contact with said exit-flues.

2. In a furnace, an air-heating chamber, groups of combustion-flues, return-flues and exit-flues extending across said chamber, and means for forcing air through said chamber transversely across said flues.

3. In a furnace, an air-heating chamber, a hot-air flue at the rear of said chamber and open thereto, an intake air-duct connected with the open front side of said chamber, a group of combustion-flues in the rear portion of said chamber, main burners associ-

ated with said combustion-flues, a group of return-flues in front of said combustion-flues and communicating therewith, and a group of exit-flues in front of said return-flues and communicating therewith.

4. In a furnace, an air-heating chamber open at its front and rear sides, a hot-air flue adjacent the rear side of said chamber and open thereto, an intake-conduit forming a front for said chamber, a group of upright combustion-flues disposed in the rear portion of said chamber, a group of return-flues disposed in front of said combustion-flues and communicating with the upper ends thereof, a group of exit-flues in front of said return-flues and communicating at their lower ends with said return-flues, a burner-chamber beneath said combustion-flues, and burners disposed in said burner-chamber.

5. In a furnace, an air-heating chamber, a sub-chamber affording a burner-chamber beneath the rear portion of said first-named chamber, a second sub-chamber in front of said burner-chamber, a group of combustion-flues extending through the rear portion of said air-heating chamber and communicating at their lower ends with said burner-chamber, a group of return-flues adjacent said combustion-flues and communicating at their lower ends with said second sub-chamber, a chamber surmounting said groups of flues and affording communication between the same, a group of exit-flues adjacent said return-flues and communicating at their lower ends with said second sub-chamber, an outlet chamber above said exit-flues and communicating therewith, burners in said burner-chamber, a hot-air flue affording a rear end for the air heating-chamber, and an inlet air-flue connected with the front end of the air-heating chamber.

6. In a furnace, an air-heating chamber, a hot-air flue at the rear side thereof and communicating therewith, an air-inlet flue at the front side of said heating-chamber and communicating therewith, a blower connected with said air-inlet flue, a sub-chamber below the rear portion of said air-heating chamber and affording a burner-chamber, a second sub-chamber in front of said burner-chamber, a group of upright combustion-flues in the rear portion of said air-heating chamber and communicating at their lower ends with said burner-chamber, a group of return-flues in front of said combustion-flues and communicating at their lower ends with said second sub-chamber, exit-flues in front of said return-flues and communicating at their lower ends with said second sub-chamber, a chamber superposed above the rear portion of said air-heating chamber and forming communication between the upper end of the com-

bustion-flues and return-flues, and a smoke-stack communicating with the upper ends of said exit-flues.

7. In a furnace, a main burner for supplying heat, a humidifier and a burner for supplying heat thereto, a common fuel supply-pipe having branches supplying said burners in predetermined ratio, and a thermostatically controlled valve controlling the passage of fuel through said fuel supply-pipe.

8. In a furnace, a main burner for heating purposes, a humidifier and a burner for supplying heat thereto, an air blower, an electric motor for said blower, a valve controlling the supply of fuel to said burners, and a thermostat controlling said motor and valve.

9. In a furnace, an air-heating chamber, heating flues extending across the same, main burners associated with said heating-flues, a hot-air flue communicating with said air-heating chamber, a humidifier adapted to supply vapor to the heated air, a burner for heating said humidifier, a blower communicating with the air-heating chamber and a motor for said blower, a valve controlling the supply of fuel to the main burners and said second-mentioned burner, and a thermostat controlling the operation of said motor and said valve.

10. In a furnace, an air-heating chamber, a hot-air flue affording an outlet therefrom, an air-inlet flue connected with said air-heating chamber, combustion-flues, return-flues and exit-flues extending through said air-heating chamber, a sub-chamber affording a burner-chamber disposed beneath said combustion-flues, a sub-chamber forming means of communication between said return-flues and said exit-flues, a humidifier having an evaporator-pan opening into the lower portion of said hot-air flue; a burner-chamber beneath said evaporator-pan, main burners in said first-named burner-chamber, a burner in said last-named burner-chamber, a pilot-burner disposed between the main burners and the second mentioned-burner, and a fuel supply-pipe communicating with said burners.

11. In a furnace, an air-heating chamber, a hot-air flue forming a back for said chamber, a group of upright combustion-flues in the rear portion of said air-heating chamber and arranged in a plurality of transverse rows, a sub-chamber affording a burner-chamber beneath said combustion-flues, a plurality of elongated burners in said burner-chamber, each burner being equipped with a series of burner-tips disposed beneath the respective flues of the corresponding row, a group of return-flues in front of said combustion-flues and comprising a plurality of transverse rows, a group of exit-flues in front of said return-flues and comprising a plural-

ity of transverse rows, a sub-chamber forming means of communication between the lower ends of the return-flues and exit-flues, a chamber surmounting the rear portion of the air-heating chamber and affording communication between the upper ends of the combustion-flues and return-flues, a chamber surmounting the front portion of the air-heating chamber and communicating with the upper ends of the exit-flues, means for draining the second-mentioned sub-chamber, and means for admitting air to the front portion of said air-heating chamber.

12. In a furnace, an air-heating chamber, a hot-air flue forming a back for said chamber, a group of upright combustion-flues in the rear portion of said air-heating chamber and arranged in a plurality of transverse rows, a sub-chamber affording a burner-chamber beneath said combustion-flues, a plurality of elongated burners in said burner-chamber, each burner being equipped with a series of burner-tips disposed beneath the respective flues of the corresponding row, a group of return-flues in front of said combustion-flues and comprising a plurality of transverse rows, a group of exit-flues in front of said return-flues and comprising a plurality of transverse rows, a sub-chamber forming means of communication between the lower ends of the return-flues and exit-flues, a chamber surmounting the rear portion of the air-heating chamber and affording communication between the upper ends of the combustion-flues and return flues, a chamber surmounting the front portion of the air-heating chamber and communicating with the upper ends of the exit-flues, means for draining the second-mentioned sub-chamber, a blower communicating with the front portion of said air-heating chamber, a motor for actuating said blower, a pipe for supplying fuel to said burners, a valve controlling the passage of fuel through said pipe, and a thermostat controlling said motor and valve.

13. A furnace comprising an air-heating chamber, a hot-air flue forming a rear end for said chamber, means for circulating air through said chamber from the front side thereof, combustion-flues in the rear portion of said air-heating chamber, return-flues in front of said combustion-flues, exit-flues in front of said return-flues, a main burner-chamber disposed beneath said combustion-flues, main burners in said burner-chamber, a burner-chamber disposed back of said main burner-chamber and equipped with a burner, an evaporator-pan mounted in the bottom of said hot-air flue over said second-mentioned-burner, a chamber back of said second-mentioned burner-chamber, a water-tank in said last-mentioned chamber communicating with said evaporator-pan, and a float controlled valve in said tank controlling the admission of water thereto.

14. In combination with a furnace, heating-burners, a fuel supply-pipe therefor, a valve controlling the passage of fuel through said pipe, a thermostat controlling the opening of said valve, a pilot-burner, a by-pass about said valve, and a valve controlling said by-pass, said last-named valve being adapted to admit to full capacity fuel to the main burners.
15. In a furnace, an air-heating chamber, heating flues extending therethrough, means for conducting air to and away from said air-heating chamber, main burners for supplying heat to said flues, a humidifier and a burner for supplying heat thereto, and means for supplying fuel to the main burners and said second-mentioned burner at a predetermined ratio.

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