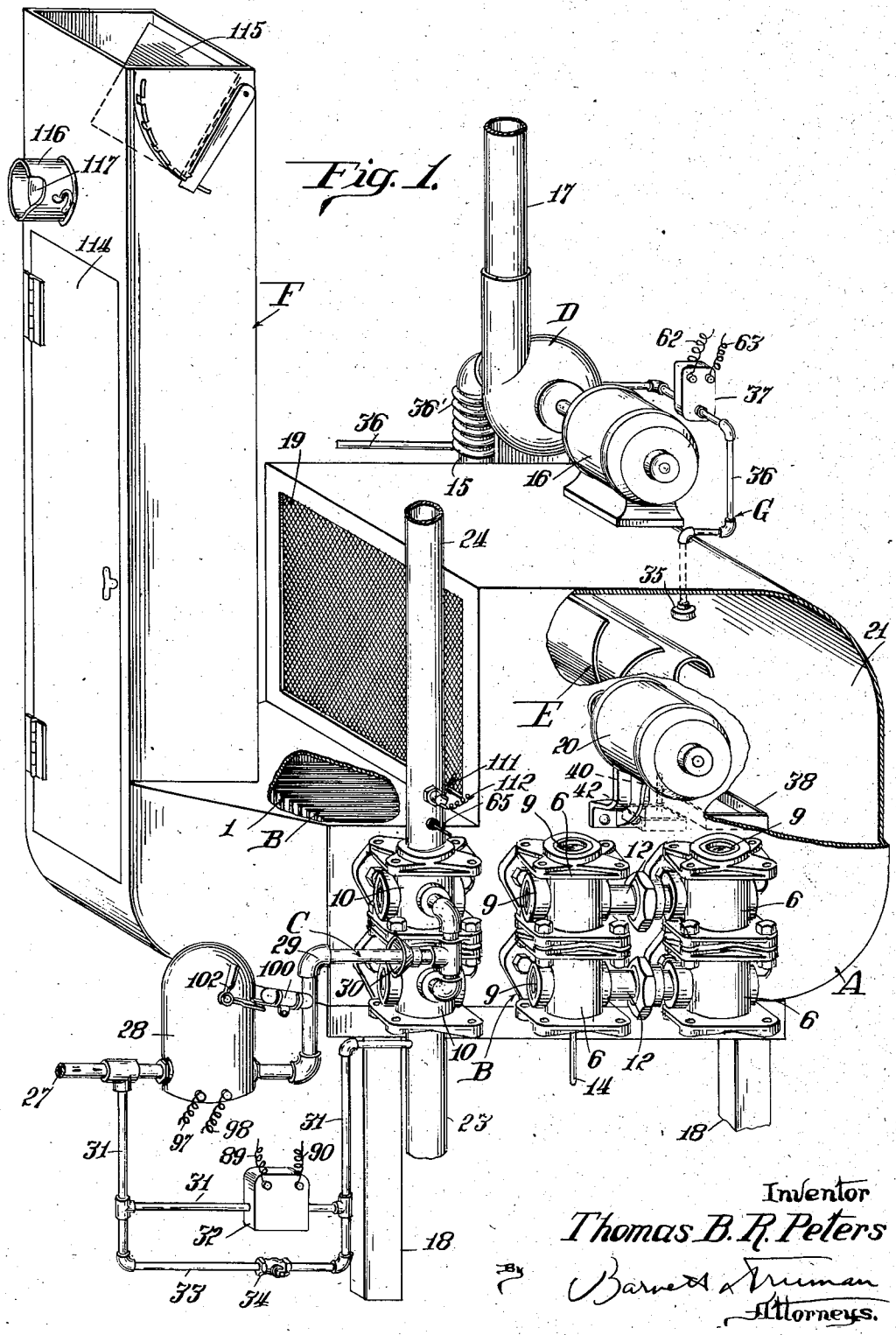
Dec. 1, 1936. T. B. R. PETERS 2,062,605

AIR CONDITIONING APPARATUS

Filed April 1, 1933 3 Sheets-Sheet 1

Fig. 1.



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AIR CONDITIONING APPARATUS

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Fig. 2.

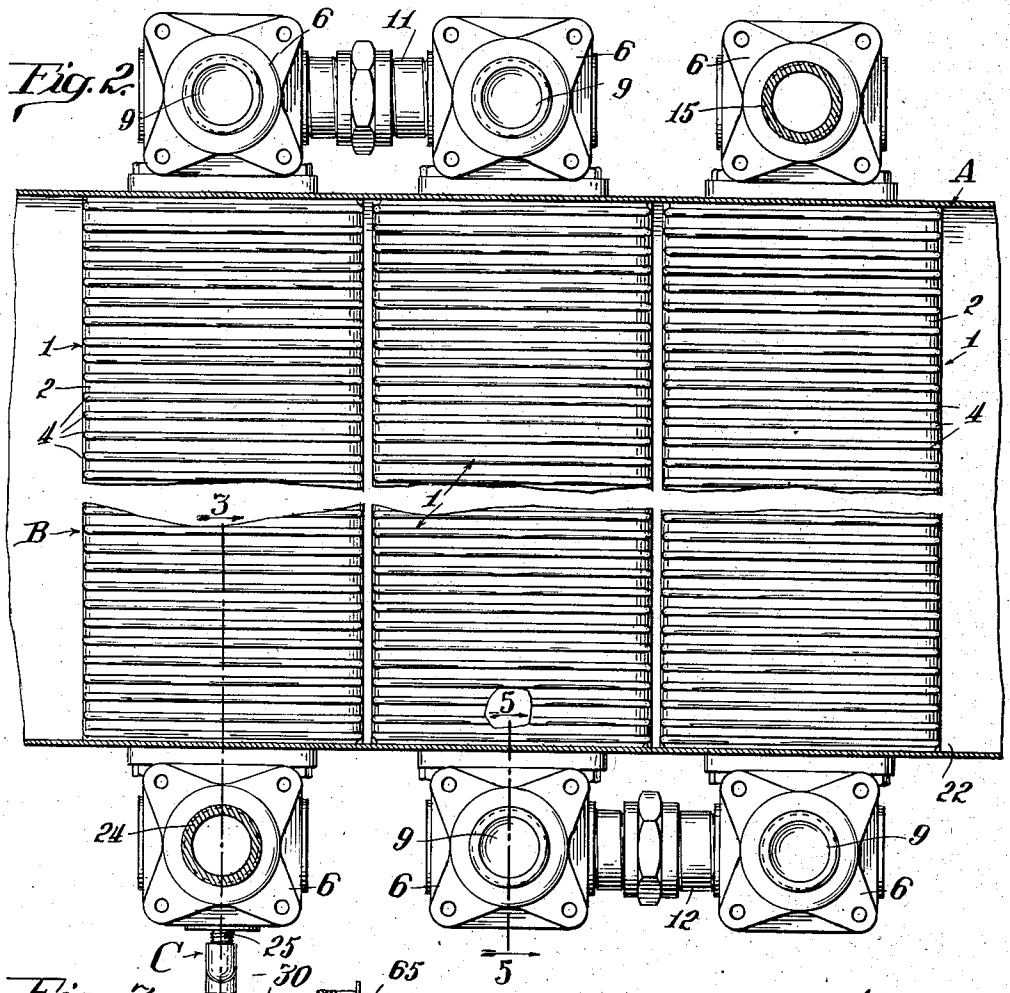


Fig. 3.

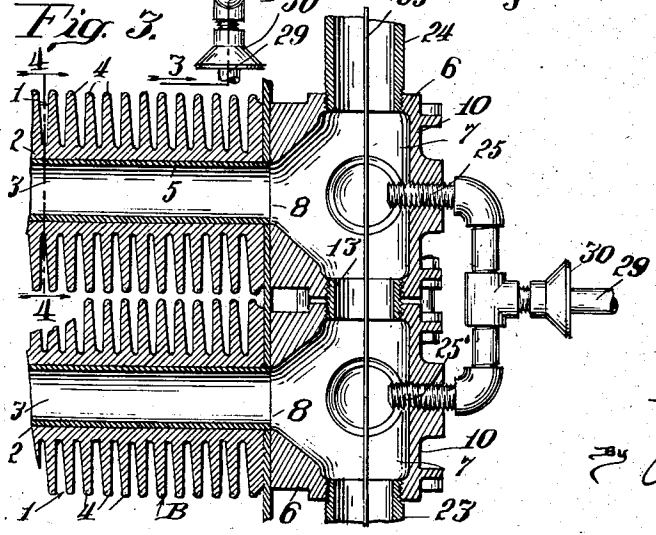
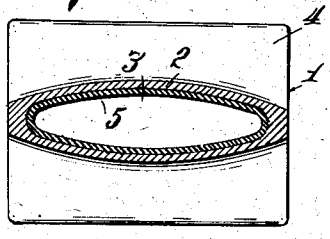


Fig. 4.



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AIR CONDITIONING APPARATUS

Filed April 1, 1933 3 Sheets-Sheet 3

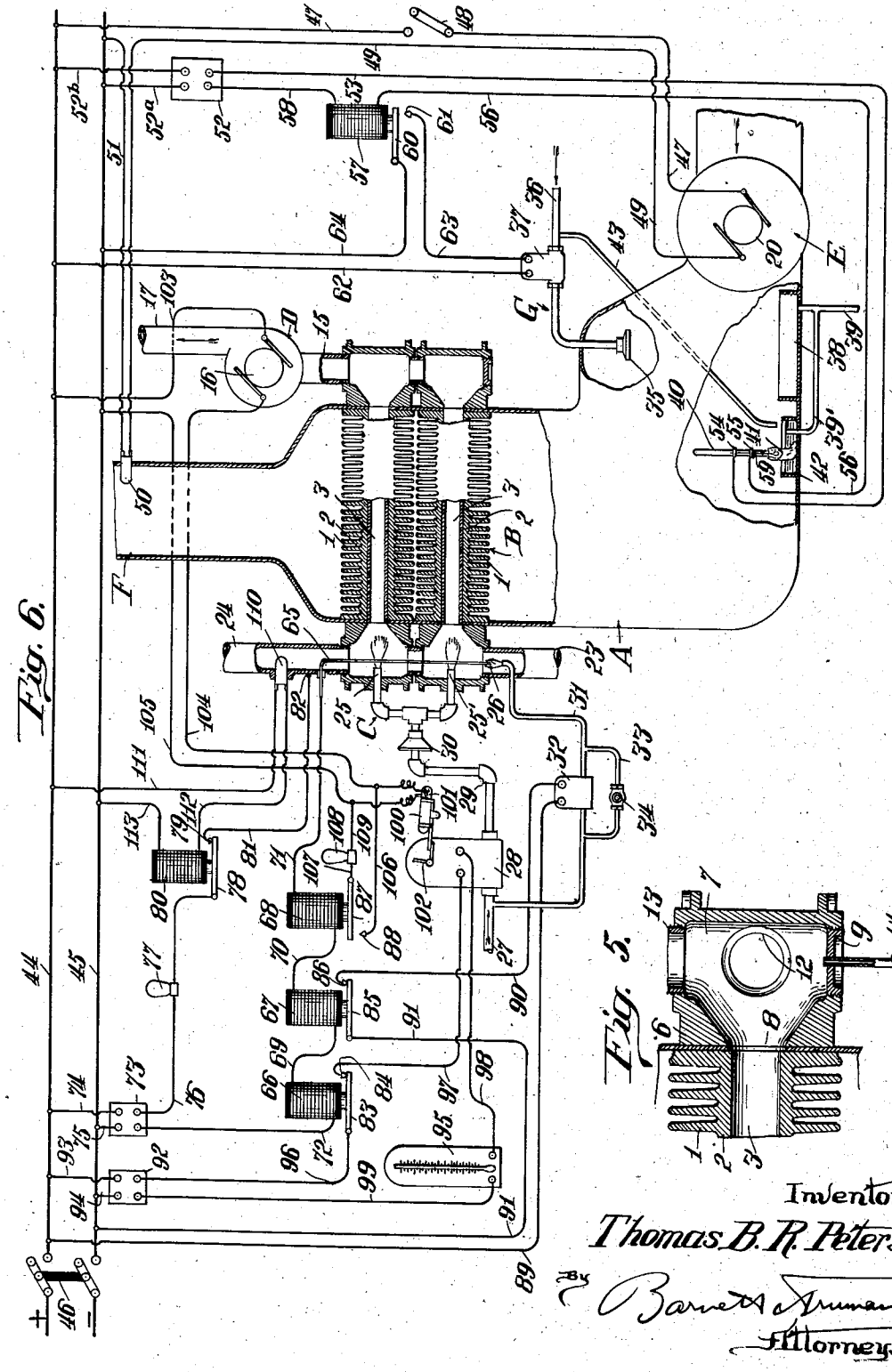

Fig. 6.

Fig. 5.

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2,062,605

UNITED STATES PATENT OFFICE

2,062,605

AIR CONDITIONING APPARATUS

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Application April 1, 1933, Serial No. 663,968

3 Claims. (Cl. 158—42.4)

This invention relates to new and useful improvements in air conditioning apparatus, particularly adapted for the heating and humidification of air, and includes means and methods of controlling the temperature and percentage of entrained moisture of the air, means and methods of controlling the combustion of the fuel, and means and methods of controlling the flow of the products of combustion and of the air to be heated through the heat exchanger.

The invention relates particularly to the art of air conditioning as applied to automatically controlled domestic plants as used in homes, small buildings, railway passenger coaches, or similar enclosures. The apparatus is of the type in which heat is derived from the combustion of fluid fuel such as oil or gas, the products of combustion being passed directly through a heat exchanger in which the greater portion of the heat units are transferred to a stream of the air to be heated which is forced through the heat exchanger and then conducted to the space wherein the heated air is to be utilized. A motor-driven fan is used for drawing the products of combustion successively through the heat exchange units and then discharging these products of combustion into and through an outlet flue after a maximum proportion of the heat units have been transferred to the air which is also forced through the heat exchanger by a power-driven blower. Means is provided for automatically controlling the operation of the combustion burners in accordance with temperature changes in the place to the heated, and means are provided for automatically controlling the fan which exhausts the products of combustion so that this fan will not be started in operation until after the burners have been ignited, and will be continued in operation for a brief interval after the burners have been extinguished so as to withdraw the remaining products of combustion from the heat exchanger. A pilot burner which normally burns continuously is positioned in an auxiliary flue leading into and from the main combustion chamber, and safety means is provided for cutting off the flow of fuel to all burners in the event that all of the flames are extinguished at any one time. Additional electrically operated safety mechanism is provided for cutting off the flow of fuel to the burners in case the fan ceases to operate to draw the products of combustion through the heat exchanger. Means is also provided for automatically introducing water into the air stream drawn through the heat exchanger so as to maintain a predetermined relative humidity in this air stream.

The principal object of this invention is to provide an improved air conditioning method and apparatus such as briefly described hereinabove and disclosed more in detail in the specifications which follow.

Another object is to provide an improved means for controlling and positively forcing the flow of products of combustion and air through the heat exchanger.

Another object is to provide means for thermostatically controlling the flow of fuel to the burners.

Another object is to provide improved means for cutting off the flow of fuel to the burners in case the fan ceases to function properly.

Another object is to provide improved means for cutting off the flow of fuel to all the burners in case all of the flames become extinguished.

Another object is to provide improved signalling apparatus for indicating that the pilot burner has been extinguished.

Other objects and advantages of this invention will be more apparent from the following detailed description of certain approved forms of apparatus constructed and operating according to the principles of this invention.

In the accompanying drawings:

Fig. 1 is a perspective view, partially broken away, showing the principal elements of the air conditioning apparatus.

Fig. 2 is a horizontal section through the heat exchanger, showing one bank of the heat exchange units in plan.

Fig. 3 is a partial vertical section, taken substantially on the line 3—3 of Fig. 2.

Fig. 4 is a detail vertical section through one of the heat exchange units, the view being taken substantially on the line 4—4 of Fig. 3.

Fig. 5 is a detail vertical section taken substantially on the line 5—5 of Fig. 2.

Fig. 6 is a wiring diagram, including a schematic showing of the principal elements of the air conditioning apparatus.

Briefly described, the apparatus comprises a main casing A which supports most of the other elements of the apparatus and also embodies the air conduit for directing the air to be h[illegible]d through the heat exchanger. W[illegible]hin the c[illegible]ng A is mounted the assembly B o[illegible]eat exch[illegible]ge units through which the produc[illegible]f combu[illegible]on are passed, the burner assembly [illegible]dicated [illegible]n-erally at C being connected direct[illegible]w[illegible]h the [illegible]et end of this heat exchange ass[illegible]b [illegible]and [illegible]he

motor driven fan D being connected with the outlet end of assembly B so as to draw the hot gases through the heat exchanger. The fan or blower indicated at E forces air through the casing A in contact with the heating element B and discharges this heated air through the outlet conduit F. A mechanism indicated generally at G is positioned within the casing A so as to add moisture to the air stream flowing through casing A and maintain the desired percentage of humidity in this air stream. Automatic control connections are provided for these several elements as will be hereinafter described.

The heat exchange assembly B comprises a plurality of similar heat exchange units 1 each comprising a casting formed with a central tubular portion 2 of elongated cross section enclosing the gas passage 3, a series of spaced apart fins 4 being cast integrally about the central tubular portion 2. In the preferred form here shown the fins 4 are so shaped as to give the unit an outer rectangular cross section making it convenient to arrange the units in closely spaced parallel rows or banks and providing a maximum of heat-transferring surface to be engaged by the air stream which passes in intimate contact with the exposed outer surfaces of the fins 4 and tubular conduit 2. Preferably these heat exchange units are cast integrally of aluminum, although other metals may be used. Those units positioned at the inlet end of the series, into which the highly heated products of combustion are directly discharged from the burners, are preferably provided with inner sleeves or linings 5 of Monel metal or other suitable heat-resisting metal. The remaining units of the series may be made entirely of aluminum. While the form of heat exchange unit just described is preferred, it will be apparent, as the description proceeds, that other forms of heat exchange units having adequate heat transfer surfaces could be substituted without departing from the general principles of this invention.

While any suitable number of these heat exchange units may be used, in the example here shown six of these units are arranged in two superposed horizontal banks of three units each. Each of the units 1 is provided at each end with a header 6 having an inner chamber 7 (see Fig. 5) communicating through opening 8 with the passage 3 in the casting 1. The header 6 may be an iron casting and is preferably provided in its opposite sides and in its top and bottom with threaded openings to be engaged by suitable conduit fittings whereby the units are connected in series. The threaded openings not used for this purpose may be closed by threaded plugs 9 in the usual manner.

As shown in Figs. 1 and 2, the headers 10 at the inlet end of the assembly B serve as a portion of the housing for the burner assembly C, and the headers 6 at the outlet end of the first units are connected by horizontal nipples or fittings 11 with the headers 6 at the inlet ends of the second row of units. The headers 6 at the outlet ends of this second row are connected by fittings 12 with the headers at the inlet end of the third row and so on throughout the series. While each horizontal bank of units may if preferred remain separate from the next adjacent bank, it is preferable to connect the superposed headers by vertical sleeves 13 (see Fig. 3) so that the superposed units throughout the series are connected in parallel, thus forming virtually a single series of increased capacity. Preferably drains 14 are provided in the bottom of certain of the headers 6 to permit the withdrawal of the condensate which forms from the products of combustion as they lose their heat to the air flowing in contact with the units 1. Ordinarily no such drains will be necessary for the first row of units into which the burners directly discharge the products of combustion, but such drains should be provided at the outlet ends of the units in each succeeding row of the series.

A pipe or conduit 15 leads from the header 6 at the outlet end of the last unit of the series to the fan D which is driven by the motor 16, this fan positively drawing the products of combustion through the heat exchange assembly B and discharging these cooled gases into the main flue 17.

The main casing A is mounted on a plurality of suitable supports 18, and the heat exchange assembly B is housed within the lower portion of this casing. A screened air inlet or filter 19 is provided at a suitable location in the upper portion of the housing, and the blower E driven by motor 20 draws in air through inlet 19 and forces this air downwardly through passage 21 and thence horizontally backward through passage 22 around and between the finned conduits of the heat exchanger B so that a maximum proportion of the heat is transferred to this air stream from the products of combustion flowing through these conduits. The heated air is discharged into the outlet conduit F and forced through this conduit, or its branches, to the locations where the heated air is to be utilized. It will be noted that this air stream contacts first with the heat exchange units adjacent the outlet end of the series, which are at the lowest comparative temperature, and then successively engages with the more highly heated units, contacting last with the unit into which the products of combustion are directly discharged from the burners C. In other words, the air stream flows in a direction substantially opposed to the direction of flow of the heating gases. This permits the temperature of the products of combustion to be lowered almost to the temperature of the inlet air before these combustion products are discharged into the outlet flue 17.

The housing for the burner assembly C comprises the connected headers 10 already referred to and an auxiliary flue comprising a lower inlet section 23 and an upper outlet section 24.

In the present example a pair of similar burners 25 and 25' are adapted to project the combustion materials into the respective headers 10, the combustion takes place within these headers and within the adjacent passages 3 of the heat exchange units at the inlet end of the series. A normally constantly burning pilot flame 26 is maintained within the inlet section 23 of the auxiliary flue directly beneath the main combustion chamber. In the present example, the burner assembly is adapted to utilize gaseous fuel, although by making suitable alterations in the type of burner used, oil or other liquid fuel might be substituted. The supply pipe 27 leads from a suitable source of fluid supply to the electrically operated automatic cut-off valve 28 from which pipe 29 provided with the usual air valve 30 leads through suitable branches to the two burners 25 and 25'. The fuel for pilot flame 26 is supplied through pipe 31 leading from the pipe 27 at the inlet side of valve 28. An electrically operated valve 32 is positioned in pipe line 31, this valve being open during the normal operation of the apparatus but closing automatically to shut off the flow of gas to the pilot burner when the safety circuit in which valve 32 is connected

is broken. If the pilot flame becomes extinguished the valve 32 will automatically close. In order to permit the pilot to be re-lighted, a by-pass pipe 33 is provided extending around the valve 32 and provided with a normally closed valve 34 which is preferably a push-button valve or other valve of an automatically closing type which must be manually held open while the pilot flame is being lighted. When the system is in normal operation, the by-pass 33 will remain closed and the pilot will receive its fuel through the pipe line 31 and valve 32. The combustion air for the burners flows in through flue 23 and valve 30. When the main burners are extinguished and fan D is not operating, the natural draft through auxiliary flue 24 serves as an outlet for the combustion gases from pilot flame 26, and also for the main burner flames when these burners are first ignited. However, during the normal operation of the system all of the combustion products will be drawn through the heat exchange assembly B by the suction provided by fan D, the gases being discharged through the main flue 17.

The means G is provided for adding additional moisture to the air stream which is drawn into and forced through casing A, when this becomes necessary in order to maintain the desired relative humidity in this air stream. This mechanism comprises a sprayer 35 positioned within casing A, preferably in the intermediate air passage 21, the sprayer being supplied with water through pipe 36 provided with the automatic electrically operated cut-off valve 37. This water may be pre-heated by first passing the water through a coil 36' positioned about the exhaust pipe 15. The excess water from sprayer 35, not absorbed by the air stream, is caught in a pan 38 provided with drain 39 (see Fig. 6). A suitable humidostat 40 is positioned within casing A in the path of the air stream so as to automatically control the water supply valve 37. In the preferred form here shown this humidostat comprises a wet bulb thermostat having its bulb inclosed by a wick or boot 41 which extends into a receptacle 42 maintaining a constant supply of water. As here shown, a bleeder pipe 43 extends from the main water supply pipe 36 and drips into receptacle 42 which is provided with a drain pipe 39' to remove excess water. Alternatively the pan or receptacle 42 might be supplied with water from the water collected in pan 38 from the sprayer 35.

The safety circuits and automatic control connections will now be described, referring more particularly to Fig. 6. The main power lines 44 and 45 are energized from a suitable source of electric supply through the main power switch 46. The motor 20 for operating the main air blower E which forces the air stream through the heating apparatus is energized through the following circuit: from positive main 44 through wire 47, switch 48, motor 20, wire 49, temperature-controlled stack switch 50, and wire 51 to the negative main 45. With switch 48 closed the blower E will operate provided the air in discharge stack F has been raised to a suitable temperature so as to close the automatic switch 50. This switch 50 prevents the circulation of cold air when the system is first started up, and permits the blower E to continue to operate after the burners are shut off to extract the remaining heat units from the conducting surfaces of the heat-exchanger B.

A low voltage control circuit for the humidostat 40 extends from the transformer 52 (energized from the power lines through wires 52a and 52b) through wire 53 to upper contact 54 positioned in the thermostat stem. A lower contact 55 in this thermostat stem is connected through wire 56 with the relay magnet 57 from which wire 58 extends back to transformer 50. The mercury column 59 of the thermostat is normally in engagement with the lower contact 55, and when the desired wet-bulb temperature is reached (which corresponds to the desired relative humidity of the air) this mercury column will engage the upper contact 54 thus completing the control circuit and energizing the magnet coil 57 so as to lift the armature 60 out of engagement with the fixed contact 61. The energizing circuit for water supply valve 37 extends from positive main 44 through wire 62, valve 37, wire 63, fixed contact 61, armature 60, and wire 64 to the negative main. When the magnet 57 is deenergized, the armature 60 will fall or be drawn into engagement with fixed contact 61 thus completing the valve actuating circuit and opening the valve 37, so that the sprayer 35 will operate. It will be apparent that the lower the relative humidity of the air stream may be, that is the less the percentage of entrained moisture in the air, the greater will be the rate of vaporization from the wick 41, thus absorbing heat from the thermometer and lowering the mercury column 59. As the relative humidity of the air is increased, the rate of vaporization will be decreased and the mercury column will rise. When the desired relative humidity is attained, the mercury column will engage the upper contact 54 thus completing the control circuit and causing magnet 57 to be energized thus lifting armature 60 and breaking the valve actuating circuit so that valve 37 will automatically close and shut off the supply of water to the sprayer 35. Conversely, as the relative humidity of the air is lowered, the control circuit will be broken by mercury column 59 falling out of engagement with contact 54 thus deenergizing magnet 57 and closing the valve actuating circuit to open valve 37 and again start the sprayer 35 in operation.

A safety flame-controlled circuit of known type comprises a wire or rod 65 which is insulated from the metallic portions of the burner assembly but extends vertically downward through auxiliary flue 24 so as to normally extend through the main burner flames and project into the pilot flame 26. Three similar relay magnet coils 66, 67 and 68 are connected in series by wires 69 and 70, and the other terminal of magnet 68 is connected through wire 71 with the flame-engaging rod 65. The other terminal of magnet 66 is connected through wire 72 with one terminal of transformer 73 which is energized from the mains 44 and 45 through wires 74 and 75. A wire 76 in which a suitable vacuum tube 77 is connected extends from the other terminal of transformer 73 to the movable armature 78 which is normally held in engagement with fixed contact 79 by the energized relay coil 80. Wire 81 extends from fixed contact 79 and is grounded at 82 on the metallic structure of the burner assembly. As long as any one of the burner flames contacts with the rod 65 this safety circuit will be completed as follows: From transformer 73 through wire 76, tube 77, armature 78, fixed contact 79, wire 81, the metallic structure of the burner assembly and the flame or flames to rod 65, wire 71, relay coils 68, 67 and 66, and wire 72 back to the transformer. The relays 66, 67 and 68 will

thus be normally energized, but will be deenergized when all of the flames have been extinguished. Since the main burner flames are ignited and extinguished at intervals during the normal operation of the heating apparatus, it is the constantly burning pilot flame 26 which normally maintains this control circuit complete.

Relay coil 66 normally holds the movable armature 83 in engagement with fixed contact 84. Relay coil 67 normally holds the armature 85 in engagement with the fixed contact 86. Relay coil 68 normally holds the armature 87 out of engagement with the fixed contact 88, but this armature 87 will be moved into engagement with fixed contact 88 when coil 68 is deenergized.

The cut-off valve 32 in the supply pipe 31 leading to the pilot burner is normally held open by current flowing over the following circuit: From positive main 44 through wire 89, valve 32, wire 90, fixed contact 86, armature 85, and wire 91 back to the negative main. When the pilot flame is extinguished, relay 67 will be deenergized thus permitting armature 85 to move out of engagement with fixed contact 86 thus breaking this valve actuating circuit and permitting valve 32 to automatically close and cut off the supply of fuel to the pilot burner.

Transformer 92 is energized from the mains 44 and 45 through wires 93 and 94. The thermostat indicated at 95 is positioned at any desired location within the building so as to be responsive to temperature changes at that location and control the main fuel supply valve 28. The control circuit extends from transformer 92 through wire 96, armature 83, fixed contact 84, wire 97, valve 28, wire 98, thermostat 95, and wire 99 back to transformer 92. When this circuit is completed valve 28 will be opened, and when the circuit is broken valve 28 will automatically close. The thermostat 95 is adapted to break this circuit when the desired temperature has been attained in the building, thus causing valve 28 to close and temporarily shut down the main burners. Also, in case the pilot flame 26 is extinguished, the relay 66 will be deenergized thus breaking the circuit between armature 83 and fixed contact 84 and causing the main valve 28 to close.

The pivotally mounted mercury-tube switch 100 is provided in one end portion with a pair of spaced apart fixed contacts which will be bridged by the mercury globule 101 when the switch is tilted to the position shown in Fig. 6. The valve operating mechanism for valve 28 is provided with suitable mechanism such as indicated at 102 for tilting the mercury tube switch 100 so as to close this switch after valve 28 has been completely opened, and conversely to tilt switch 100 in the opposite direction so as to open this switch after the valve 28 has been completely closed. The motor 16 which operates the fan D is energized through the following circuit: From positive main 44 through wire 103, motor 16, wire 104, mercury tube switch 100, and wire 105 back to the negative main 45. The delay action mechanism 102 permits the motor 16 and fan D to remain inoperative until the valve 28 has been opened and the main burner flame is ignited from pilot 26, but immediately thereafter the fan D is started in operation to draw the products of combustion from the burners through the heat exchange assembly B and discharge the cooled gases through the outlet flue 17. When the main burners are extinguished, the fan D will remain in operation for a short time to withdraw the remaining gases from the heat exchanger, this continued action being provided by the delayed opening of the switch 100, and the natural coast of the fan mechanism.

When the pilot flame is extinguished and relay coil 68 is deenergized, a shunt circuit is completed from wire 104 through wire 106, fixed contact 88, movable armature 87, wire 107, signal light 108, and wire 109 to wire 105 of the motor circuit. The illuminated signal light 108 will indicate that the pilot flame has been extinguished and should be relighted.

A normally closed temperature-operated circuit breaker 110 is positioned in the outlet section 24 of the auxiliary flue. Relay coil 80 is normally energized through the following circuit: From positive main 44 through wire 111, circuit breaker 110, wire 112, relay coil 80, and wire 113 to the negative main. In case the fan 16 should cease to function while the main burners are in operation, the products of combustion will no longer be drawn through the heat exchanger B but will be drawn upwardly by the natural draft through flue 24. This excessive temperature in flue 24 will cause the circuit breaker 110 to open thus deenergizing the relay 80 and permitting the armature 78 to move out of contact with fixed contact 79 thus breaking the main control circuit and deenergizing the several relays 66, 67 and 68 and causing both gas valves to be closed and the signal 108 to be illuminated.

It will be noted that when the main flame controlled circuit is broken, an energizing circuit for fan 16 is completed through the signal light 108 and switch 87, 88. This permits the fan 16 to continue to operate to withdraw gases from the heat exchanger. The motor 16 may be stopped by opening the main switch 46. This shunt circuit also permits the fan motor 16 to be energized and fan D to be operated before the system is started up, to discharge any unflashed gases or products of combustion from the apparatus before the burners are ignited.

When the apparatus is to be started in operation, main switch 46 will first be closed, thus starting the fan D to withdraw any unflashed gases from the system. Switch 48 may also be closed, but the main blower E will not start until the air in stack F has been raised to a suitable temperature so as to close the automatic switch 50. The manually operated valve 34 in by-pass 33 is now opened so as to furnish gas to the pilot light which is ignited in any suitable manner. With this pilot light burning, the main control circuit will be established so as to energize the relays 66, 67 and 68. From this time on the system will function in the normal manner under control of the room thermostat 95, and the fan D will only operate at such times as the main burners are functioning. The main air blower E will remain continuously in operation so long as the air in discharge conduit F has been raised to a suitable temperature, unless the motor circuit is broken by opening the switch 48. The humidifying apparatus G will operate entirely automatically to add moisture to the air stream whenever necessary to maintain the desired relative humidity.

In the preferred form of the apparatus herein disclosed, a portion of the discharge air conduit F is adapted to be used as a drying apparatus, particularly for drying laundry, although it might be used for other drying purposes. A door 114 is provided in one wall of the stack or conduit F to provide access to that portion

of the conduit which forms the drying chamber. A normally open valve or damper 115 is provided in stack F directly above the drying chamber, and an auxiliary discharge conduit 116 leads from this chamber, this auxiliary conduit being provided with a normally closed valve 117. When the dryer is to be used, valve 115 is closed and valve 117 open so that the odors from the drying laundry will not be carried into the building but will be discharged through the auxiliary outlet 116.

I claim:

1. In heating apparatus, a combustion chamber, a fluid-fuel burner operatively associated with the combustion chamber, a normally constantly burning pilot-burner, means for supplying fuel to both burners, a thermostatically controlled electrically actuated valve for the main burner and a normally open electrically controlled valve for cutting off the supply of fuel to the pilot-burner, a main discharge flue, a main discharge passage connecting the combustion chamber and the main flue, a motor-driven fan for drawing the products of combustion through the main passage for heat-transfer purposes and discharging these gases through the main flue, an auxiliary flue leading directly from the combustion chamber operative to vent the combustion chamber of gases when the fan is not in operation, and means comprising a control circuit including the valves and a temperature-responsive switching mechanism operatively associated with the auxiliary flue to cause said valves to close if a predetermined temperature is exceeded in the auxiliary flue.

2. In heating apparatus, a combustion chamber, a fluid-fuel burner operatively associated with the combustion chamber, means for supplying fuel to the burner comprising an electrically actuated valve, a main discharge flue, a main discharge passage connecting the combustion chamber and main discharge flue, a motor-driven fan for drawing the products of combustion through the discharge passage for heat-transfer purposes and discharging the gases through the main flue, an auxiliary flue leading directly from the combustion chamber operative to vent the combustion chamber of gases when the fan is not in operation, and means comprising a control circuit including the valve and a temperature-responsive switching mechanism operatively associated with the auxiliary flue to cause said valve to close to cut off the supply of fuel to the burner if a predetermined temperature is exceeded in the auxiliary flue.

3. In heating apparatus, a combustion chamber, a fluid-fuel burner operatively associated with the combustion chamber, means for supplying fuel to the burner including an electrically actuated valve, a main discharge flue, a main discharge passage connecting the combustion chamber and main discharge flue, a motor-driven fan for drawing the products of combustion through the discharge passage for heat-transfer purposes and discharging the gases through the main flue, an auxiliary flue leading directly from the combustion chamber operative to vent the gases when the fan is not in operation, an electrical actuating circuit for the fan motor, a switch in said circuit positioned to be closed when said valve is opened, and vice versa, so that the fan will normally operate when the burner is in operation, a temperature-responsive switch operatively associated with the auxiliary flue, and electrically operated mechanism controlled by said last-mentioned switch for closing the valve whereby if the fan fails to operate, the passage of heated gases through said auxiliary flue will shut down the burner.

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