

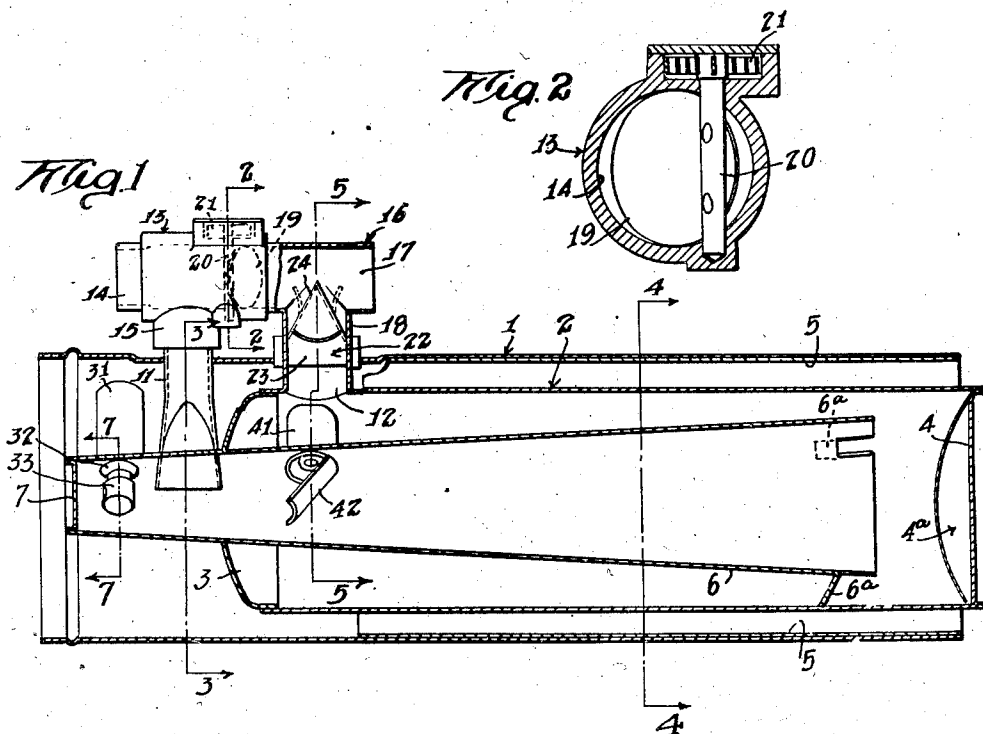
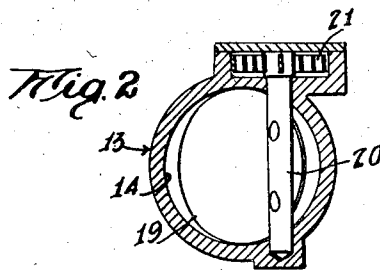
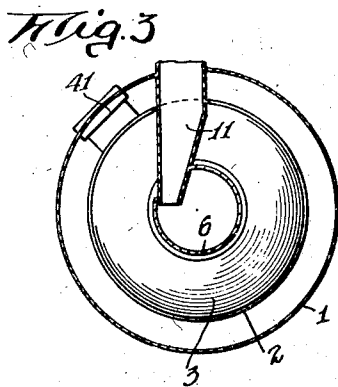
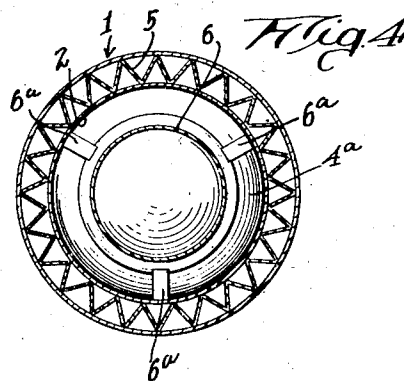
Sept. 7, 1948.

W. HOLBROOK
AIR HEATER HAVING REVERTED EXPANDING
COMBUSTION CHAMBER

2,448,595

Filed Sept. 16, 1944

2 Sheets-Sheet 1



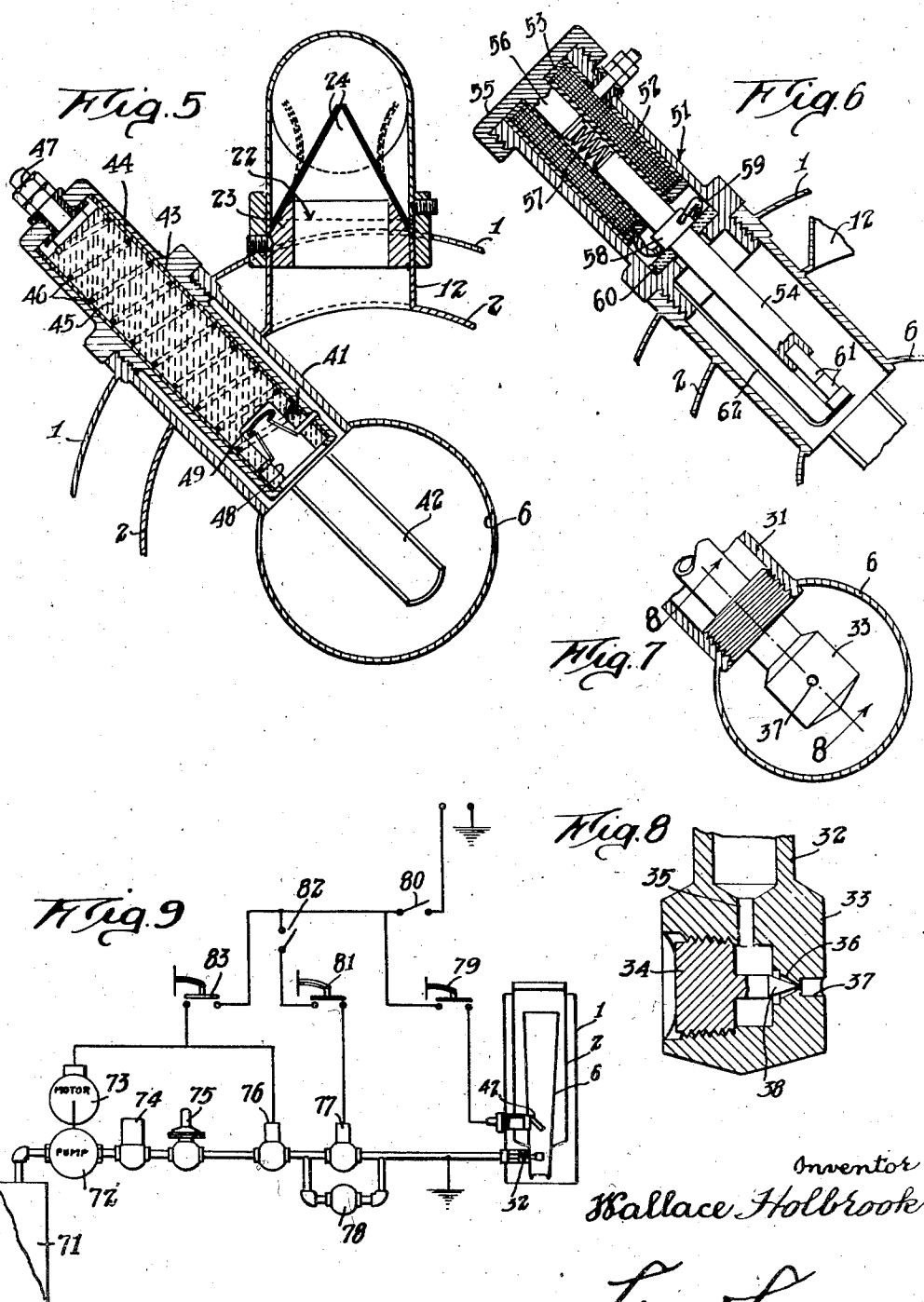
Sept. 7, 1948.

W. HOLBROOK
AIR HEATER HAVING REVERTED EXPANDING
COMBUSTION CHAMBER

2,448,595

Filed Sept. 16, 1944

2 Sheets-Sheet 2



Inventor
Wallace Holbrook

By *Lyon & Lyon*
attorneys

UNITED STATES PATENT OFFICE

2,448,595

AIR HEATER HAVING REVERTED EXPANDING COMBUSTION CHAMBER

Wallace Holbrook, Los Angeles, Calif.

Application September 16, 1944, Serial No. 554,473

9 Claims. (Cl. 126-116)

1

2

My invention relates to air heaters, and among the objects of my invention are:

First, to provide an air heater having an extremely large heat output in relation to its weight and size, thereby providing an air heater for airplanes, or other vehicles where weight and size are primary factors.

Second, to provide an air heater wherein the heating unit is capable of ignition even under extremely adverse conditions of temperature and altitude; that is, the heater is capable of ready and virtually instantaneous operation even when the starting temperature is as much as sixty-five degrees below zero Fahrenheit, and the altitude is 45,000 feet.

Third, to provide an air heater which incorporates a novel thermostat control element designed to regulate air flow through the combustion passage of the heater particularly during its warming-up period.

Fourth, to provide an air heater having heat transfer means associated with its combustion passage which efficiently transfers heat to air passing through a separate air duct or passage.

Fifth, to provide an air heater which is designed to burn liquid fuel, preferably gasoline, although it may operate with equal efficiency on a wide range of liquid or gaseous fuels.

Sixth, to provide an air heater which operates efficiently in any position; that is, on its side, or either end uppermost.

Seventh, to provide an air heater which incorporates a novel electrically operated ignition unit.

Eighth, to provide an air heater wherein the igniter and nozzle are readily accessible for removal and servicing without disturbing the heater installation.

With the above and other objects in view as may appear hereinafter, reference is directed to the accompanying drawing, in which:

Fig. 1 is a longitudinal sectional view of the air heater.

Fig. 2 is an enlarged fragmentary sectional view of the air bypass valve.

Fig. 3 is a transverse sectional view of the air heater taken through 3-3 of Fig. 1.

Fig. 4 is a transverse sectional view thereof taken through 4-4 of Fig. 1.

Fig. 5 is an enlarged fragmentary sectional view of the air heater taken through 5-5 of Fig. 1 showing the thermostat valve and one form of the ignition element.

Fig. 6 is an enlarged sectional view of a modified form of ignition element, with the air heater shown as fragmentary.

Fig. 7 is a fragmentary sectional view through 7-7 of Fig. 1, showing the fuel nozzle in elevation.

Fig. 8 is an enlarged fragmentary sectional view through 8-8 of Fig. 7, showing details of the fuel nozzle.

Fig. 9 is a diagrammatical view showing the fuel supply system and electrical control system employed in conjunction with the air heater.

My air heater is contained within a cylindrical outer shell 1 open at its ends. Within the outer shell 1 is a combustion chamber shell 2 which is likewise cylindrical but closed at its ends by end members 3 and 4. The end member 4 is protected by a convex baffle disc 4a secured to its inner side. The baffle disc 4a forms therewith a "dead" air space having, however, superficial communication with the interior of the combustion chamber to insure equalization of pressure. The combustion chamber shell 2 is supported in concentric relation with the outer shell 1 by an accordion ring 5, that is, a tubular structure formed by pressing the sheet material into zig-zag form and fitting it between the two shells. The accordion ring forms channels for the flow of air to be heated between the outer shell 1 and the combustion chamber shell 2, and extends a substantial portion of the length of the combustion chamber shell.

The channels formed by the accordion ring 5, shell 1 and shell 2 tend to straighten the flow of air.

A combustion cone 6 is secured in the forward or inner end member 3 of the combustion chamber shell 2. The smaller end of the combustion cone extends forwardly from the end member 3 to a point adjacent to the forward or entering end of the outer shell 1 and is closed by an end disc 7. The other or larger end of the combustion cone 6 extends within the combustion chamber shell to a point adjacent but spaced from the rearward end member 4 thereof. The larger end of the cone 6 is supported by tabs 8a bent from the cone to engage the walls of the shell 2.

The combustion cone 6 is intersected tangentially by the flattened inner end of an intake tube 11, which extends laterally through the outer shell 1. An exhaust tube 12 extends laterally from the combustion chamber shell 2 adjacent its forward end, and likewise projects through the outer shell 1. The intake and exhaust tubes are preferably in longitudinal alignment with respect to the outer shell 1. Between the intake tube and the exhaust tube 12 is formed a combustion chamber which increases in cross-sectional area. The combustion cone 6 is so proportioned that

the area at its larger end equals the area between this end and the combustion chamber shell. By reason of the tapered form of the combustion cone 6 an annular space is formed between the cone and the combustion chamber shell, which continues to increase from the forward or larger end of the combustion cone to the exhaust tube 12. The combustion chamber can thus be termed a reverted continuously expanding combustion chamber.

An air intake T-fitting comprising a cross-tube 14 and a leg tube 15, is mounted by its leg tube on the outer end of the intake tube 11. An exhaust T-fitting 16 comprising a cross-tube 17 and a leg tube 18 is fitted by means of its leg tube to the outer end of the exhaust tube 12. The cross-tubes 14 and 17 of the T-fittings telescope and are in alignment to form a common air conduit traversing the intake and exhaust tubes. Between the intake and exhaust tubes there is located in the cross-tube 14 of the T-fitting 13 an air bypass valve 19 in the form of a disc or plate journaled near one side by a stem 20. A spiral spring 21 is provided which is attached to the stem 20 in such a manner that it tends to maintain the valve 19 closed. Air flowing through the air conduit defined by the cross-tubes 14 and 17, tends to open the valve against the action of the spring 21.

Within the exhaust tube 12 and the leg tube 18 is positioned a thermostat control valve 22. The thermostat control valve includes a base ring 23 suitably secured within the tube, and a plurality of thermostat petals 24 of triangular form which are secured by their base ends to the ring 23 and extend upwardly to define a pyramid having its apex protruding into the cross-tube 17. Normally, the thermostat petals 24 are flat with their edges in approximate contact with each other. On heating, the petals curl outwardly from each other to increase the opening through the exhaust tube. While four petals 24 are shown, either a greater or lesser number may be used; even two may be employed by extending the base ring 3 to replace the omitted two petals.

Between the air intake tube 11 and the forward or smaller end of the combustion cone 6 is a fuel nozzle sleeve 31 which is preferably circumferentially displaced with respect to the intake tube 11. The fuel nozzle sleeve 31 extends through the outer shell 1. Within the sleeve is positioned a tubular fuel nozzle body 32 having a threaded portion which closes the sleeve, and terminates at its inner end in a head 33 centered in the combustion cone 6. The forward side of the head 33 is provided with a threaded socket which is closed by a plug 34. The socket communicates with the bore of the fuel nozzle body 32 through a passage 35. The base or rearward end of the socket is provided with a conical nozzle orifice 36 which discharges into a recess 37 formed in the rear side of the head 33. The plug 34 carries a conical needle 38 the apex angle of which is less than the apex angle of the nozzle orifice 36, so that the effective cross-sectional area of the nozzle orifice decreases towards its discharge end. The head 33 is so positioned that its nozzle discharges coaxially into the combustion chamber formed by the combustion cone 6. The fuel nozzle may be easily removed and the plug 34 adjusted or removed to facilitate cleaning the nozzle; however, by reason of the forwardly decreasing nozzle area made possible by the relative angles of the needle 38 and orifice 36, the orifice does not readily clog.

An igniter tube 41 intersects the combustion cone 6 and extends laterally through the combustion chamber shell 2 and outer shell 1. The radially inner end of the igniter tube 41 is provided with a scoop 42 directed into the combustion cone 6. The scoop is preferably semi-cylindrical and slopes forwardly toward the fuel nozzle.

Within the igniter tube 41 is positioned an igniter element which may take the form of the igniter element 43 shown in Fig. 5, or the igniter element 51 shown in Fig. 6. With reference to Fig. 5, the igniter element 43 comprises a tubular body 44 closed at its radially outer end and provided with a shoulder and screw threads for sealing engagement with the igniter tube 41. The body 44 receives a core 45 of ceramic material or other heat-resisting material. The core 45 is provided with a helical groove in which is wound a resistance coil 46, one end of which is attached to a terminal 47 which is insulated from and extends through the closed outer end of the body 44. The radially inner end of the core 45 is provided with a socket 48. Within the socket 48 is a filament 49 formed of platinum or other material capable of withstanding high heat. The filament 49 is electrically connected in series with the resistance coil 46, one end of the filament being grounded. The scoop 42 causes an eddy current which circulates into the socket 48 and carries fuel which, on contact with the heated filament 49, ignites. The operation of the igniter element will be brought out in more detail hereinafter.

Reference is now directed to the modified igniter element 51 shown in Fig. 6. This igniter comprises a body member 52 which is screw-threaded to the igniter tube 41 and extends outwardly therefrom. Within the body 52 is a solenoid 53 which actuates an armature 54 extending into the igniter tube 41. The outer end of the body 52 is closed by a cap 55 having a central boss which forms a stop 56 extending into the solenoid 53. A spring 57 is interposed between the stop 56 and the armature 54. The armature 54 is provided with a flange 58 located adjacent the inner end of the solenoid 53. A pig-tail 59 electrically connects the armature in series with the solenoid 53. The armature is guided by an insulation washer 60 which also serves to protect the solenoid 53 from heat. The radially inner end of the armature 54 carries one of a pair of ignition contacts 61, the other of which is supported and grounded by a bracket 62. The igniter element 51 is designed to vibrate. When the ignition contacts 61 are in engagement, the solenoid 53 is energized which causes the armature to break the contacts, de-energizing the solenoid and allowing the spring 57 to urge the armature to again close the ignition contacts. The solenoid also functions at least in part as an inductive member to increase the current at the moment the contacts disengage to produce a strong arc capable of igniting the fuel. The rapidity with which the ignition contacts make and break a circuit, is determined by the constants of the spring 57 and the duration of the arc after the contacts are disengaged.

Fuel is supplied to the air heater from a tank 71 through a pump 72 driven by a motor 73. The fuel, on leaving the pump, first passes through a strainer or filter 74, then through a pressure regulator valve 75, then in series through a pair of solenoid valves 76 and 77. A bypass line is provided around the solenoid valve 77 and includes an orifice or resistor valve 78. The

5

igniter element 43 or 51 is adapted to be controlled through a thermostat switch 79 which is normally closed, but which opens when the temperature within the heater has reached a predetermined amount; for example, 175° F. A main switch 80 is in series with the igniter switch 79 between the igniter switch and a source of electrical energy, not shown. Also controlled by the main switch 80 is a low thermostat switch 81 which is normally closed, but designed to open at for example, 300° F. A manually operated switch 82 is placed in series with the thermostat switch 81 for the purpose of rendering the thermostat switch 81 inoperative when the manual switch is open. The power supply is also connected to a high heat thermostat switch 83 which controls the solenoid valve 76 and motor 73. This switch may, for example, be set to open at 350° F. The temperature values given above are of course arbitrary and may vary considerably, depending upon the location of the thermostats relative to the air heater and the conditions under which it is desired to operate the air heater.

Operation of my air heater is as follows: The main switch 80 is first closed. In the initial condition all the thermostat switches 79, 81 and 83 are closed. Consequently, the motor 73 actuates the pump 72 to deliver fuel from the nozzle 36. The air heater is positioned in an air stream, either a natural air stream if the heater is installed on a vehicle, or an artificially supplied air stream if otherwise mounted. A portion of the air stream flows through the outer shell 1 around the combustion chamber shell 2. A portion of the air stream also flows through the air conduit formed by the cross-tubes 14 and 17 of the T-fittings. By reason of the air bypass valve 19 a substantial part of the air flowing through the air conduit is diverted through the intake tube 17 through the combustion chamber formed by the combustion cone 6 and combustion chamber shell 2, and returned to the air conduit through the exhaust tube 12. The air is introduced into the combustion chamber tangentially so that it flows therethrough with a swirling movement.

Initially, particularly before ignition, the fuel is in the form of fine droplets, some of which impinge on the scoop 42, and by reason of their mass are deflected into contact with the igniter element. Very little of the air itself is so deflected once the pressure in the ignition socket has built up slightly above that in the combustion chamber. This is highly important for in airplane installations the air may be extremely cold, perhaps 65° below zero Fahrenheit, and any substantial circulation of such cold air across the igniter, would interfere with its operation. Once the fuel ignites and the combustion chamber warms up, the fuel particles are more finely divided, if not in actual gaseous form, by the time they reach the scoop so that they have insufficient mass to be effectively deflected by the scoop into contact with the igniter. Thus, during the ignition period the igniter is intimately in contact with the fuel, but after ignition is more or less isolated therefrom.

It should be pointed out that by reason of the recess 37 surrounding the nozzle orifice, any deposits of soot or the like which might settle on the nozzle head 33, does not settle over the orifice itself.

Initially, the flow of gases from the combustion chamber is restricted by the thermostat control valve 22. However, the thermostat petals 24

6

are rapidly heated and curl outwardly from each other to the dotted line positions shown in Fig. 1.

Although suited for other vehicles or even home use, the air heater is primarily intended for use on airplanes, and in such installations the velocity of the air stream may vary over wide limits. The air bypass valve 19 in the air conduit, tends to maintain a uniform flow of air through the combustion chamber. If the air velocity increases, the bypass valve 19 opens, permitting a larger quantity of air to flow directly through the air conduit formed by the cross-tubes 14 and 17 of the T-fittings. Furthermore, the larger quantity of air thus bypassing the combustion chamber, tends to cool the thermostat petals 24 and hold the volume of air passed through the combustion chamber between desirable limits even though the air velocity varies over a wide range. Also it should be observed that the continuously expanded form of the combustion chamber offsets, in part, the tendency of the velocity of gases to increase due to temperature rise permitting more efficient heat exchange. The reduction in velocity of gases below the condition obtaining without continuous expansion of the walls of the combustion chamber results in a higher pressure at the discharge end of the combustion chamber. The by-pass valve 19 tends to maintain a low pressure region in the discharge end of the air conduit so that the gases are drawn from the exhaust tube of the combustion chamber at relatively high velocity. When the by-pass valve is closed, the pressure in the discharge end of the air conduit is reduced so that although a larger volume of gas flows through the combustion chamber the increased pressure differential insures proper exhaust of the combustion gases.

If it is desired to run the air heater at low heat, the manual switch 82 is closed. The thermostat switch 81 is set at a lower temperature than thermostat switch 83; consequently, it opens first. This does not cut off the operation of the air heater, but reduces the quantity of fuel supplied. If conditions are such that this reduced quantity of fuel is sufficient to raise the temperature of the air heater above the setting of the high heat thermostat 83, this thermostat then operates as a safety means and cuts off the motor as well as the solenoid valve 36, shutting off the air heater entirely.

At a suitable low point in the combustion chamber, that is, in the side of the shell 2, or in the closed end of the combustion cone 6, may be located a drain tube (not shown) to drain off any excess liquid fuel should the air heater operate any appreciable time before ignition.

Many other embodiments of the invention may be resorted to without departing from the spirit of the invention.

I claim:

1. An air heater comprising: a tubular outer shell open at its ends, a tubular inner shell closed at its ends; radiator elements between said shells; a combustion cone disposed within said inner shell and forming an expanding inner combustion passage, said cone defining with said inner shell an expanding outer combustion passage continuing from the larger end of the inner combustion passage; means forming an inlet for air and exhaust for gases located respectively at the smaller end of said inner passage and at the larger end of said outer passage; and a fuel nozzle directed into the smaller end of said combustion cone.

2. An air heater comprising: means defining a reverted combustion chamber having means forming an adjacently disposed air intake passage and gas exhaust tube; an air duct defined in part by said combustion chamber means for the transfer of heat from said combustion chamber to air flowing in said air duct said air duct including an outer shell to confine the air around said combustion chamber means and radiator elements extending from said combustion chamber means into said air duct; a fuel nozzle directed into said combustion chamber; an air conduit traversing said intake passage and exhaust tube, and a bypass valve in said air conduit between said intake and exhaust tubes; and yieldable means tending to close said bypass valve to divert air from said air conduit into said intake tube for return through said exhaust tube.

3. An air heater comprising: means defining a reverted combustion chamber, means forming a lateral air intake passage at one end and means forming a lateral exhaust tube for gases at its other end, the ends of said combustion chamber and said passages and tube being disposed in adjacent relation; an air duct defined in part by said combustion chamber means for the transfer of heat from said combustion chamber to air flowing in said air duct; a fuel nozzle directed into said combustion chamber; and a thermostat valve in said exhaust tube, said thermostat valve normally throttling flow from said combustion chamber and adapted to open upon heating of said combustion chamber to increase the flow therethrough.

4. An air heater comprising: means defining a reverted combustion chamber with its ends adjacent each other, an intake tube communicating with one end of said chamber and an adjacently disposed exhaust tube communicating with the other end of said chamber; an air duct defined in part by said means for the transfer of heat from said combustion chamber to air flowing in said air duct; a fuel nozzle directed into said combustion chamber, and an air conduit traversing said intake and exhaust tubes; a pressure responsive air bypass valve in said air conduit between said intake and exhaust tubes; yieldable means tending to close said bypass valve to divert air into said intake tube for subsequent return to said air conduit through said exhaust tube; and a thermostat valve in said exhaust tube including temperature sensitive means projecting into said air conduit, said thermostat valve tending when cool to throttle flow through said combustion chamber and when heated to permit increased flow through said combustion chamber.

5. An air heater comprising: means defining a reverted continuously expanding combustion chamber; an air duct surrounding said means, radiating elements extending from said means into said air duct for the transfer of heat from said combustion chamber to air flowing in said air duct; an air intake tube intersecting the smaller end of said combustion chamber tangentially to cause helical flow of air through said chamber; an exhaust tube from the larger end of said combustion chamber; and a fuel nozzle directed axially into said combustion chamber from its smaller end through the region of air intake from said air intake tube.

6. An air heater comprising: means defining a reverted continuously expanding combustion chamber having intake and outlet ends in proximity to each other; an air duct defined in part by said means for the transfer of heat from said com-

bustion chamber to air flowing in said air duct; an air intake tube intersecting the intake end of said combustion chamber tangentially to cause helical flow of air through said chamber; an exhaust tube from the outlet end of said combustion chamber in proximity to said intake tube; a fuel nozzle directed axially into said combustion chamber from its smaller end through the region of air intake from said air intake tube; an air conduit traversing said intake passage and exhaust tube, and a bypass valve in said air conduit between said intake and exhaust tubes; and yieldable means tending to close said bypass valve to divert air from said air conduit into said intake tube for return through said exhaust tube.

7. An air heater comprising: means defining a reverted continuously expanding combustion chamber having said intake and outlet ends in proximity to each other; an air duct defined in part by said means for the transfer of heat from said combustion chamber to air flowing in said air duct; an air intake tube intersecting the intake end of said combustion chamber tangentially to cause helical flow of air through said chamber; an exhaust tube from the outlet end of said combustion chamber in proximity to said intake tube; a fuel nozzle directed axially into said combustion chamber from its smaller end through the region of air intake from said air intake tube, and an air conduit traversing said intake and exhaust tubes; a pressure responsive air bypass valve in said air conduit between said intake and exhaust tubes; yieldable means tending to close said bypass valve to divert air into said intake tube for subsequent return to said air conduit through said exhaust tube; and a thermostat valve in said exhaust tube including temperature sensitive means projecting into said air conduit, said thermostat valve tending when cool to throttle flow through said combustion chamber and when heated to permit increased flow through said combustion chamber.

8. A construction as set forth in claim 3, wherein said thermostat valve comprises a supporting member and bimetallic petals converging therefrom, said petals adapted to curl away from each other on heating to open the passage through said exhaust tube.

9. A construction as set forth in claim 7, wherein said thermostat valve comprises a supporting member and a plurality of bimetallic petals converging therefrom to form the sides of a pyramid, said petals adapted to curl away from each other on heating to open the passage through said exhaust tube.

WALLACE HOLBROOK.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
738,619	Matthews	Sept. 8, 1903
1,670,819	Morris et al.	May 22, 1928
1,711,365	Summers	Apr. 30, 1929
1,755,727	Cramer	Apr. 22, 1930
1,923,614	Clarkson	Aug. 22, 1933
2,097,255	Saha	Oct. 26, 1937
2,112,391	Anxionnaz	Mar. 29, 1938
2,292,339	Mayo	Aug. 4, 1942
2,332,094	McCollum	Oct. 19, 1943
2,362,571	McCollum	Nov. 14, 1944
2,366,416	McCollum	Jan. 2, 1945
2,393,167	Holthouse	Jan. 15, 1946