Jan. 17, 1950 V. N. TRAMONTINI ET AL 2,494,785

HEAT EXCHANGER AND COMBUSTION CHAMBER CONSTRUCTION FOR INTERNAL-COMBUSTION AIR HEATERS

Filed Feb. 14, 1946 3 Sheets-Sheet 1

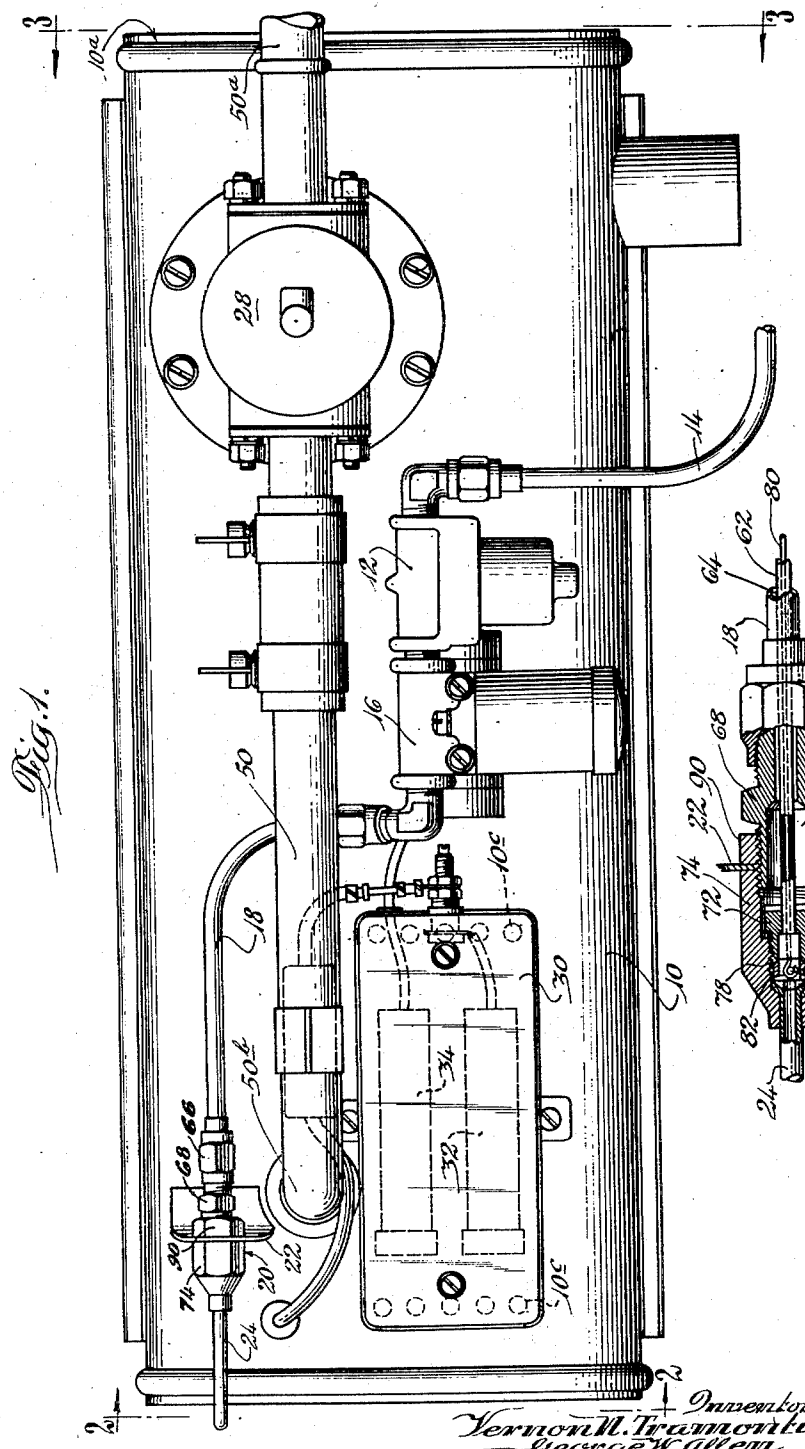


Fig. 1.

Fig. 8.

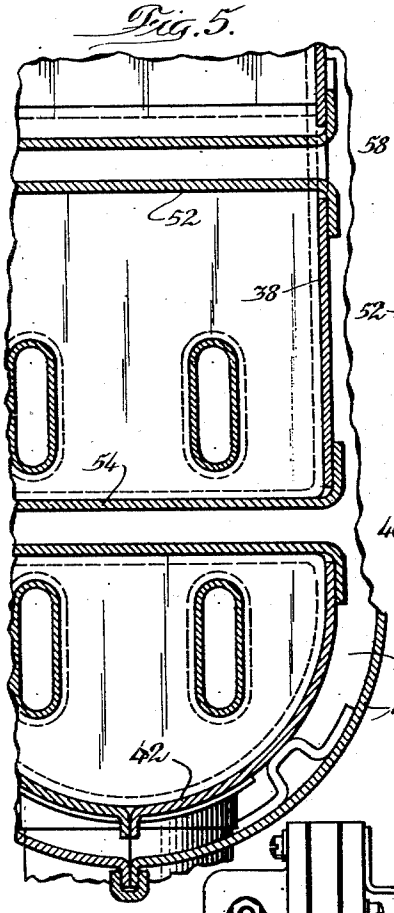
Inventors:
Vernon M. Tramontini
George W. Allen
By Williams, Bradbury & Hinkle
Attorneys.

Jan. 17, 1950 V. N. TRAMONTINI ET AL 2,494,785

HEAT EXCHANGER AND COMBUSTION CHAMBER CONSTRUCTION FOR INTERNAL-COMBUSTION AIR HEATERS

Filed Feb. 14, 1946 3 Sheets-Sheet 2

Fig. 5.



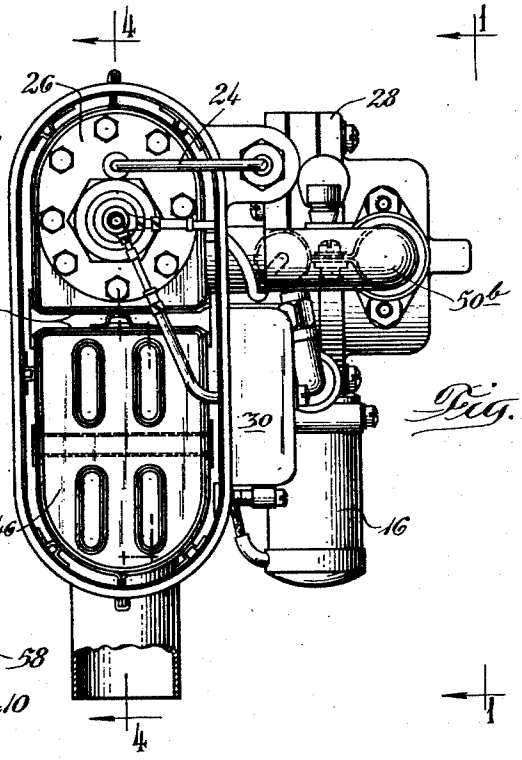


Fig. 2.

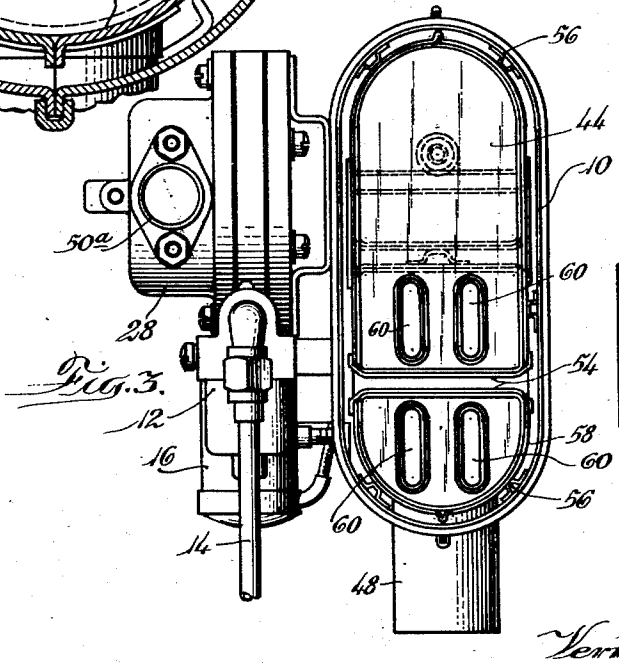
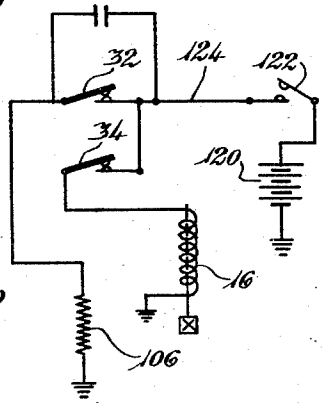


Fig. 3.

Fig. 6.



Inventors:
Vernon M. Tramontini
George W. Allen
By Williams, Bradbury & Hinkle
Attorneys.

Jan. 17, 1950 V. N. TRAMONTINI ET AL 2,494,785

HEAT EXCHANGER AND COMBUSTION CHAMBER CONSTRUCTION FOR INTERNAL-COMBUSTION AIR HEATERS

Filed Feb. 14, 1946 3 Sheets-Sheet 3

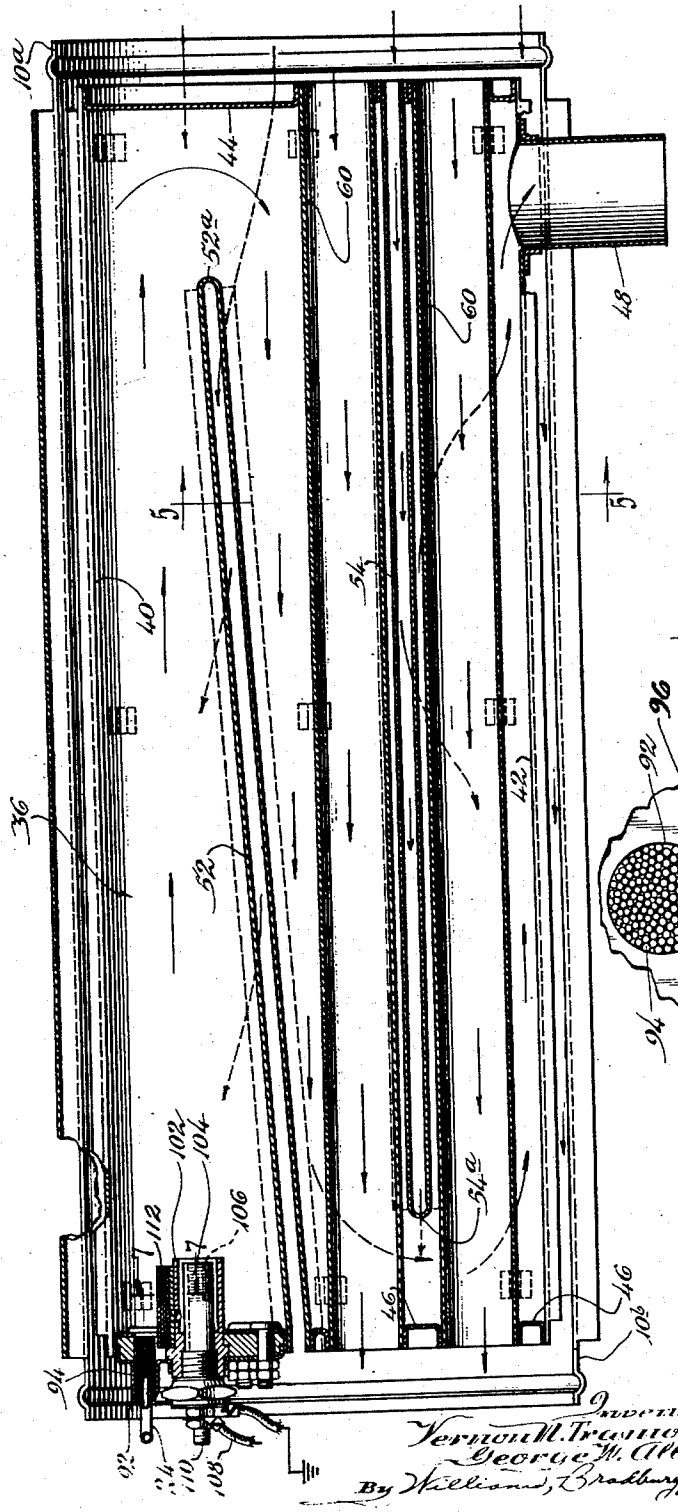


Fig. 4.

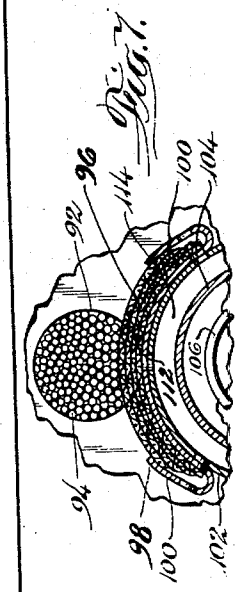


Fig. 7.

Inventors:
Vernon M. Tramontini
George M. Allen
By Williams, Bradbury & Hinkle
Attorneys

Patented Jan. 17, 1950 2,494,785

UNITED STATES PATENT OFFICE

2,494,785

HEAT EXCHANGER AND COMBUSTION CHAMBER CONSTRUCTION FOR INTERNAL-COMBUSTION AIR HEATERS

Vernon N. Tramontini and George W. Allen, Indianapolis, Ind., assignors to Stewart-Warner Corporation, Chicago, Ill., a corporation of Virginia

Application February 14, 1946, Serial No. 647,596

5 Claims. (Cl. 126—109)

1

This invention relates to internal combustion heaters of the type particularly designed for use on aircraft, although not limited to that use, and intended to employ liquid hydrocarbon fuel similar to that used in the engines of the aircraft.

One object of the invention is to provide an internal combustion heater of relatively compact form so that it can be mounted on the wall of the cabin of an airplane or other aircraft without projecting unduly into space required for other purposes. To accomplish this purpose the combustion chamber of the heater is horizontally extended but is of vertically elongated cross section so that the combustion chamber itself is of relatively limited width, and preferably the form of the chamber is such that it has flat parallel side walls so that one side of the heater may be mounted closely against the wall of the cabin while the other wall of the heater provides a convenient supporting surface for certain auxiliary equipment such as thermostatic control means, fuel control valves, and regulating mechanism for the combustion air supply.

Another object of the invention is to provide an internal combustion heater having a novel form of igniter for initiating and maintaining combustion of the liquid fuel.

It is also an object of the invention to provide new and improved means for atomizing the liquid fuel prior to its admixture with air for combustion in the heater.

Other objects and advantages of the invention will appear from the following description taken in connection with the drawings, in which:

Fig. 1 is a side elevation of an internal combustion heater embodying this invention, showing the auxiliary devices mounted on the side wall thereof;

Fig. 2 is an end elevation of the heater looking upstream thereof with respect to the direction of air flow through the heater and as indicated at line 2—2 on Fig. 1;

Fig. 3 is an end elevation looking downstream as indicated at line 3—3 on Fig. 1;

Fig. 4 is a vertical sectional view taken substantially as indicated at line 4—4 on Fig. 2;

Fig. 5 is a fragmentary vertical section on a larger scale and taken as indicated at line 5—5 on Fig. 4;

Fig. 6 is a wiring diagram of the electrical control means for the heater;

Fig. 7 is a detail sectional view taken as indicated at line 7—7 on Fig. 4; and

Fig. 8 is a fragmentary sectional view of a restrictor in the fuel feed line of the improved heater of the present invention.

2

There are many situations, particularly in modern aircraft, in which if a heater is to be accommodated it must be fitted into relatively small space, and to meet such requirements the present structure is provided with a combined combustion chamber and heat exchanger which is housed in a casing 10 having flat side walls and rounded top and bottom walls and edges so proportioned that its width is considerably less than its vertical dimension. This form of casing can be mounted flatly against a side wall of a cabin or compartment without unduly infringing upon the space available for other purposes, and its outwardly exposed wall then can be utilized for mounting auxiliary equipment or devices, thus placing such devices where they are readily accessible for adjustment or repair. As shown in Fig. 1, the casing 10 has attached to its exposed side wall a filter device 12 for the liquid fuel flowing from a suitable source of supply through the pipe 14 which is connected to the filter. A magnetic fuel control valve 16 is connected to the filter 12 and a pipe 18 leads from the valve to a restriction device 20 carried by a bracket 22 which is secured to the side wall of the heater. From the device 20 a fuel feed tube 24 leads around the end of the casing 10 and enters the end wall 26 of the combustion chamber within the casing. There also is mounted on the side wall of the casing 10 a combustion air regulator 28 and a housing 30 within which thermostatic control devices 32 and 34 are enclosed in proximity to the wall of the casing so as to be readily responsive to the temperature of the air flowing therethrough.

The combustion chamber itself is of the same cross sectional outline as the casing 10. The chamber in its entirety is indicated by the numeral 36 and it has side walls 38 connecting with semi-cylindrical top and bottom walls 40 and 42 respectively with end walls 44 and 46. The fuel feed pipe 24 enters the combustion chamber at one end and near the top wall, as seen in Fig. 4, while the exhaust pipe 48 for the products of combustion extends from the lower wall 42 near the opposite end wall 44. The air supply pipe 50, which furnishes air for combustion, enters the combustion chamber through the side wall, as seen in Fig. 1, delivering air toward the point at which the fuel enters through pipe 24, and the combustible mixture of fuel and air is ignited in this portion of the combustion chamber.

A hollow baffle 52 extends across the combus-

tion chamber connecting its side walls and thus initially confining the products of combustion to the upper portion of the chamber. This baffle **52** extends from one end wall **46** and terminates at a point spaced from the end wall **44** so that the hot gases must flow longitudinally from the point of ignition and around this terminal **52***a* of the baffle **52** before moving downwardly in the combustion chamber. Preferably, the baffle **52** is shown inclined upwardly toward the top wall **40** so as to gradually narrow the cross section of the passage which it provides for the products of combustion. Flowing around the terminal portion **52***a* the gases move in the opposite direction and toward the end wall **46**, being confined between the baffle **52** and the second baffle **54** disposed below it in spaced relation and so directed that the flow passage for the gases is additionally tapered toward the terminal end **54***a* of the baffle **54** which is spaced from the end wall **46** of the combustion chamber. Passing around this terminal of the baffle **54** the gases again flow toward the end wall **44** and escape by way of the exhaust passage **48**.

In thus traversing the length of the combustion chamber three times, the products of combustion transfer their heat to air flowing through the several passages which extend through and around the combustion chamber in heat exchange relation thereto. The outer casing **10**, as already noted, is of vertically elongated cross section similar to that of the combustion chamber and is uniformly spaced from the combustion chamber walls by brackets **56** interposed at intervals as indicated in Figs. 2 and 3, thus forming a jacket which extends from end to end of the heater and may be connected at one end to a suitable conduit through which air to be heated is supplied. Assuming that this air is furnished by a blower or from a ram in the usual manner, such conduit (not shown) may be coupled to the end of the casing at **10***a* and air for combustion may be supplied by a separate ram or by connecting the intake section **50***a* of the combustion air pipe into such conduit so that air will flow from it into the air regulator **28** and thence through the pipe **50** into the combustion chamber. The jacket space **58** formed between the wall of casing **10** and the walls of the combustion chamber is relatively narrow so that a comparatively thin layer of air flows through the jacket and is subjected to the heating effect of the hot walls of the combustion chamber. Additional air passages for the transfer of heat to the air flowing through the heater are the tubes **60** of which four are shown extending longitudinally through the combustion chamber in the spaces between the two baffles **52** and **54** and between the baffle **54** and the bottom wall **42**. The interior width of the tubes **60** is about the width of the jacket **58** so that the tubes offer a relatively large surface in comparison to their cross section for the transfer of heat from the gases in the combustion chamber to the air flowing through the tubes.

Further exchange of heat between the products of combustion and the air to be heated occurs in the hollow baffles **52** and **54**. The baffle **54** opens at one end through the end wall **44**, as seen in Fig. 3, so as to receive air from the ram or other source of supply and, as seen in Fig. 5, this baffle **54** opens laterally at both sides into the jacket space **58**, being closed only at the end **54***a*. The air entering the relatively narrow space between the top and bottom walls of the baffle **54** thus

moves longitudinally of the heater and also laterally into the jacket space **58** thr[illegible] passes from the heater for distribution with the other air flowing through the jacket. The baffle **52** is closed at its terminal portion **52***a* but opens laterally into the jacket space **58** as seen in Fig. 5 so that it can receive air from said space, and this air, absorbing heat from the upper and lower walls of the baffle **52**, escapes through the end of the baffle which opens through the end wall **46** of the combustion chamber, as seen in Fig. 2.

Thus, all the air flowing through the heater from the connection **10***a* to the outlet end at **10***b* is subdivided into relatively thin films or streams so that a large proportion of the air is brought into intimate contact with the heated walls of the combustion chamber or the tubes **60** or the baffles, all of said walls having their opposite surfaces exposed directly to the products of combustion and thus serving for efficiently transferring heat from the hot gases to the air. From the outlet at **10***b* it may be understood that the heated air is conveyed through a suitable conduit or conduits to the spaces where it is required for maintaining comfortable temperatures.

The air for combustion which is supplied through the pipe **50** is furnished to the heater at a substantially uniform pressure governed by the regulating device shown at **28** and more fully described in the co-pending application of Vernon N. Tramontini, Serial No. 647,597, filed February 14, 1946, and owned by the present assignee. The liquid fuel flowing to the combustion chamber through the pipe **18** is first passed through the restrictor **20** to prepare it for further atomization. This device includes a tube **62** (Fig. 8) which fits telescopically within the pipe **18** with some clearance, as indicated at **64**. The pipe **18** terminates in a compression coupling **66** of conventional form, and this coupling is attached to the threaded end of a fitting **68** which provides a chamber **70** through which the tube **62** extends to a plug **72** in which it is fitted tightly.

The fitting **68** is threaded for connection with a second fitting **74** having a chamber **76** which communicates with the chamber **70** and also accommodates the plug **72**, the threaded end of the plug being screwed into a reduced portion of the chamber **76**. A small rod or wire **80** lies loosely within the tube **62**, thus providing a very limited annular space for the flow of liquid fuel between the surface of the wire and the inner surface of the inner wall of the tube **62**. One end of the wire is formed as an eye at **82** and engages a pin **84** secured in an annular terminal **86** which is normally clamped in the reduced portion of the chamber **76** by the threaded end of the plug **72**. The clamping action of the plug **72** also serves to secure a locking washer **88** in engagement with the flared end of the tube **24** inside the fitting **74**, thus coupling the tubing **24** into the fitting.

As shown, the threaded portion of the fitting **68** carries a lock nut **90** so that when the threaded portion of the fitting **68** is passed through an opening in the bracket **22** and coupled to the fitting **74**, it may be clamped to the bracket by means of the nut **90**, as seen in Fig. 1. It will be seen that the part **86** serves to anchor the wire **80** in its working position in the length of small tubing **62**, but that if the device should become clogged it can be readily cleaned by separating the fittings **68** and **74** and then unscrewing the plug **72** which is formed with a screw driver slot at **72***a*. As the plug **72** is removed from the fitting

it carries with it the tube 62 and the wire 80, whereupon the wire may be withdrawn from the tube 62 so that the wire may be wiped clean and the tube 62 may be flushed or swabbed to free it of any accumulation of solid particles or gummy material. The parts are then easily replaced and the fitting reassembled for service.

The fuel flowing from the restrictor 20 through the tube 24 enters an atomizing chamber 92 which is filled with a plurality of small preferably metallic elements providing interstices through which the liquid must percolate before it can escape into the combustion chamber. For this purpose a bundle of fine copper wires, as indicated at 94, has been found satisfactory. The lower side of the chamber 92 opens against the absorbent pad 96 which is preferably formed of several layers of fine wire screening in which the wire is composed of Inconel or other suitable alloy. This pad is supported by a sheet metal saddle 98 having flanges 100 which are bent over against the pad to secure it, as shown in Fig. 7. The saddle 98 is mounted on a tubular shell 102 which supports the igniter tube 104 in spaced relation, as seen in Figs. 4 and 7. The igniter tube 104 houses the usual electrical heating coil 106 for which a feed wire is shown at 108 secured to the terminal binding post 110. The saddle 98 and the tubular shell 102 have registering apertures 112 through which the finely divided liquid fuel is released from the pad 96 on to the heated wall 104 of the igniter by which it is instantly vaporized so as to occupy the space 114 between the shell 102 and the tube 104. The vapor thus generated mixes with air at the outlet end of tube 102 and is ignited by the hot coil 106. The heat generated by this pilot flame quickly heats the absorbent pad 96 so that fuel is vaporized as rapidly as it enters the combustion chamber and mixes with the air tangentially introduced through the tube 50*b*. The mixture of fuel and air continues to burn in the combustion chamber as long as the fuel and air supplies are maintained.

After combustion has raised the temperature of the heater sufficiently to operate the thermostatic switch 32, said switch will open the ignition circuit, leaving combustion to maintain itself thereafter. If the heater should attain an excessive temperature above that at which it will ordinarily operate continuously, the thermostat 34 will operate as an overheat control to permit the fuel valve 16 to close and thus shut off the supply of liquid fuel completely. As soon as the temperature of the heater has dropped sufficiently to close the switch 34, the fuel valve 16 will open and fuel will again flow through the feed tube 24 and will begin to accumulate in the combustion chamber 36. A further drop in temperature will close the ignition switch 32, energizing the igniter and causing combustion to be resumed; but since the air supply through the pipe 50 is not discontinued when the fuel valve 16 is closed, the air flowing therefrom through the combustion chamber will tend to clear it of any excess fuel vapor which might accumulate in the interval between opening of the fuel valve 16 and energizing of the igniter. To render the thermostatic switches 32 and 34 promptly responsive to the changes in temperature of the air flowing through the jacket space 58, the housing 30 which encloses these switches may be secured in sealed relation to the side wall of the casing 10 and this wall may be formed with openings 10*c* communicating with the interior of the housing 30 so that a portion of the heated air may circulate through it in direct contact with the thermostatic elements of the switches.

Fig. 6 indicates diagrammatically the electrical connections which operate through the thermostat switches 32 and 34. A battery 120 is shown as the current supply with one pole grounded and the other pole connected through a manual switch 122 and conductor 124 to the thermostatic switches 32 and 34. The igniter coil 106 and the solenoid for the fuel valve 16 are shown connected to these switches and grounded.

Although in the foregoing description it has been assumed that the air to be heated—sometimes referred to as the "ventilating air"—flows into the jacket space 58 and tubes 60 from the end adjacent the exhaust pipe 48 and leaves the heater at the end which supports the igniter and the fuel inlet, it may be understood that the operation will not be materially affected if the connections are reversed so that the air from the ram enters the casing 10 at 10*b* and the heated air leaves the casing at 10*a*. The arrangement of the ventilating air connections will usually be determined by convenience of installation and may even be reversed after the heater itself has been installed and mounted.

We claim:

1. In a heater of the character described, means forming an elongated combustion chamber having vertically elongated side and end walls, a series of hollow baffles extending between said side walls longitudinally of said combustion chamber from said end walls and arranged to define a continuous tortuous passageway through the combustion chamber, said baffles being open to the exterior of the combustion chamber along said side and end walls, means forming an inlet adjacent one end of said passageway through which fuel and air are adapted to be supplied, an exhaust outlet for products of combustion adjacent the opposite end of said passageway, a jacket disposed in spaced relation to the side walls of said combustion chamber to define a ventilating air passageway surrounding the same, said jacket and end walls defining intake and outlet chambers at opposite ends of said combustion chamber and said hollow baffles being supplied with a flow of ventilating air through the open ends and sides thereof, and a plurality of tubes extending longitudinally of said passageway and supported adjacent opposite ends in said end walls, said tubes opening at opposite ends into said intake and outlet chambers to adapt the same for the passage of ventilating air therethrough.

2. In a heater of the character described, means forming an elongated combustion chamber having vertically elongated side and end walls, a series of hollow baffles extending between said side walls longitudinally of said combustion chamber from said end walls and arranged to define a continuous tortuous passageway through the combustion chamber, said baffles being open to the exterior of the combustion chamber along said side and end walls, means forming an inlet adjacent one end of said passageway through which fuel and air are adapted to be supplied, an exhaust outlet for products of combustion adjacent the opposite end of said passageway, an elongated jacket disposed in spaced relation to the side walls of said combustion chamber to define a longitudinally extending ventilating air passageway surrounding the

same, means including said jacket defining inlet and outlet chambers for ventilating air at the opposite ends of said combustion chamber, said hollow baffles being supplied with a flow of ventilating air through the open ends and sides thereof, and a plurality of tubes extending longitudinally of said passageway communicating at opposite ends with the inlet and outlet chambers for ventilating air to provide for the flow of ventilating air therethrough.

3. In a heater of the class described, means forming an elongated combustion chamber having side walls and front and rear end walls, a hollow baffle extending between said side walls from said rear wall to a point adjacent said front wall in a plane parallel to the longitudinal axis of said combustion chamber, a second hollow baffle extending between said side walls from said front wall to a point adjacent said rear wall in a plane inclined to the plane of the first mentioned baffle, said inclined baffle cooperating with said combustion chamber and horizontal baffle to define intercommunicating passageways in said combustion chamber tapering progressively from end to end of said inclined baffle and said horizontal baffle cooperating with said combustion chamber to define a passageway of constant cross sectional area communicating with the tapering passageway, means forming an inlet adjacent the large end of said tapering passageway through which fuel and air are adapted to be supplied, an exhaust outlet adjacent the end of said passageway of constant cross section remote from said tapering passageway, and an elongated jacket disposed in spaced relation to the side walls of said combustion chamber to define a longitudinally extending ventilating air passageway surrounding said combustion chamber, said jacket and end walls defining intake and outlet chambers at opposite ends of the combustion chamber and said hollow baffles being open along said side and end walls and being supplied with a flow of ventilating air through the open ends and sides thereof.

4. In a heater of the class described, means forming an elongated combustion chamber having side and end walls, a series of elongated generally U-shaped baffles extending longitudinally of said combustion chamber alternately from opposite end walls thereof a distance less than the length of said combustion chamber to define a continuous tortuous passageway through said combustion chamber, said side and end walls of said combustion chamber being slotted to define openings for receiving and supporting said baffles adjacent the peripheral edges of the latter, peripheral flanges on lateral edges of said baffles adapted to engage the side walls of said combustion chamber along the slotted openings therein, said hollow baffles being open to the

exterior of said combustion chamber along the side and end walls of the latter, means forming an inlet adjacent one end of said passageway through which fuel and air are adapted to be supplied, an exhaust outlet for products of combustion adjacent the opposite end of said passageway, and an elongated jacket disposed in spaced relation to the side walls of said combustion chamber to define a longitudinally extending ventilating air passageway surrounding the same and extending from end to end thereof, said jacket and end walls defining intake and outlet chambers at opposite ends of said combustion chamber and said hollow baffles being supplied with a flow of ventilating air through the open ends and sides thereof.

5. In a heater of the character described, means forming an elongated combustion chamber having side and end walls, a series of hollow baffles extending longitudinally of said combustion chamber alternately from opposite end walls thereof a distance less than the length of said combustion chamber to define a continuous tortuous passageway therethrough, said baffles being supported by said end and side walls and being open along the sides and ends of the combustion chamber to the exterior of the latter, means forming an inlet adjacent one end of said passageway through which fuel and air are adapted to be supplied, an exhaust outlet for products of combustion adjacent the opposite end of said passageway, and an elongated jacket disposed in spaced relation to the side walls of said combustion chamber to define a longitudinally extending ventilating air passageway surrounding said combustion chamber and extending from end to end thereof, said jacket and end walls defining intake and outlet chambers at opposite ends of said combustion chamber and said hollow baffles being supplied with a flow of ventilating air through the open ends and sides thereof.

VERNON N. TRAMONTINI.
GEORGE W. ALLEN.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
110,889	Bartlett	Jan. 10, 1871
116,908	Wood	July 11, 1871
1,137,675	Speer	Apr. 27, 1915
1,334,741	Dundon	Mar. 23, 1920
1,690,119	Kelley	Nov. 6, 1928
1,933,330	Johnson	Oct. 31, 1933
1,935,852	Long	Nov. 21, 1933
2,162,411	Stephens	June 13, 1939
2,239,175	Unser	Apr. 22, 1941