

June 26, 1945.

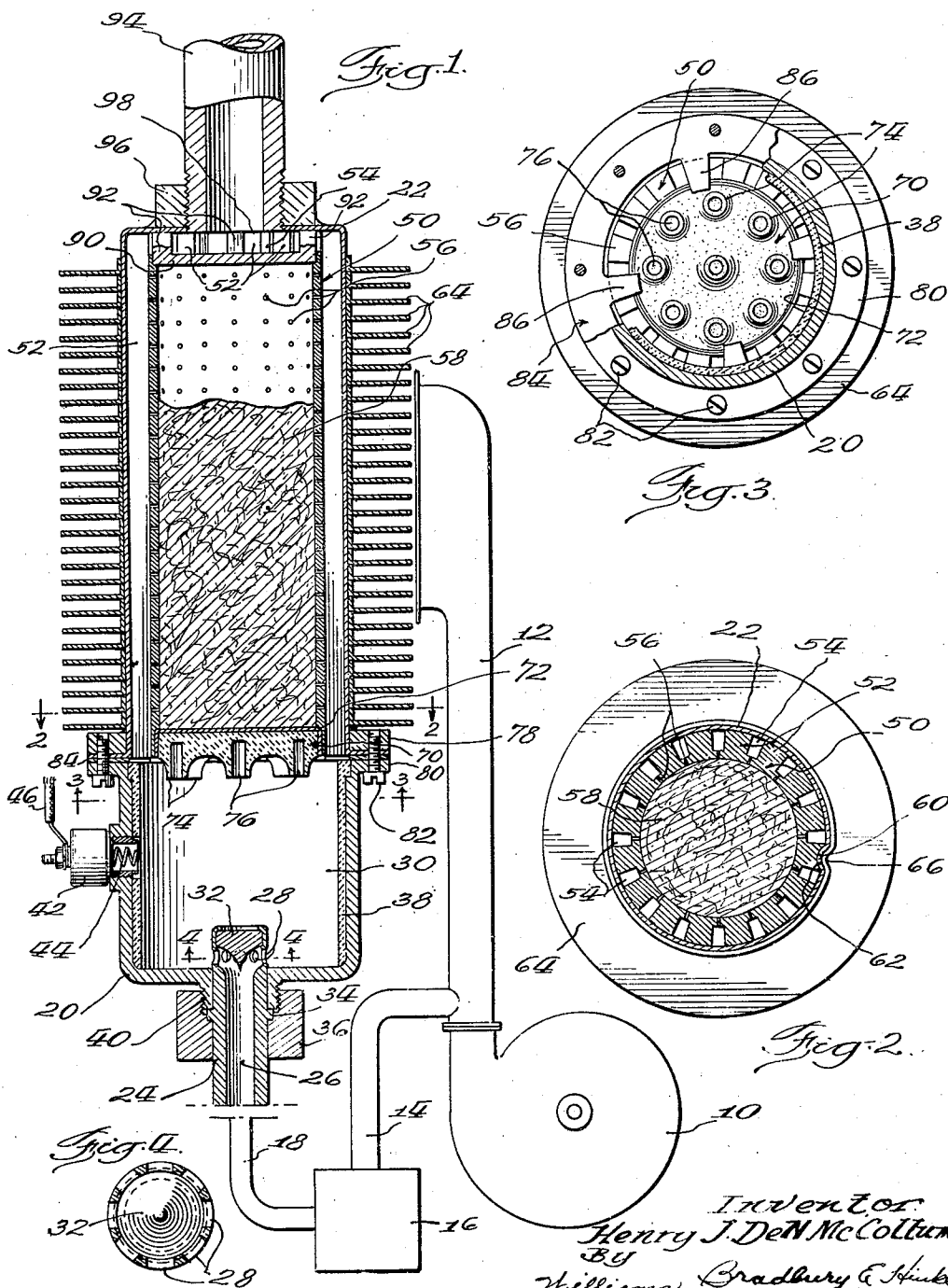
H. J. DE N. McCOLLUM

2,379,017

HEATING UNIT

Filed Feb. 10, 1941

3 Sheets-Sheet 1



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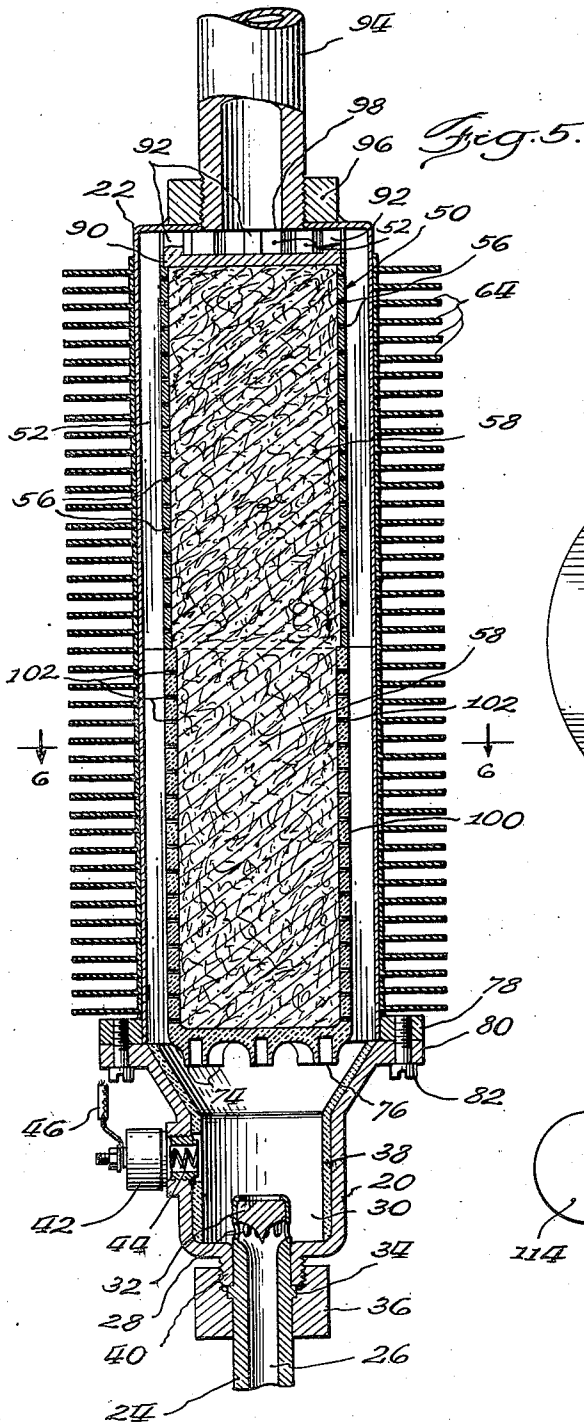
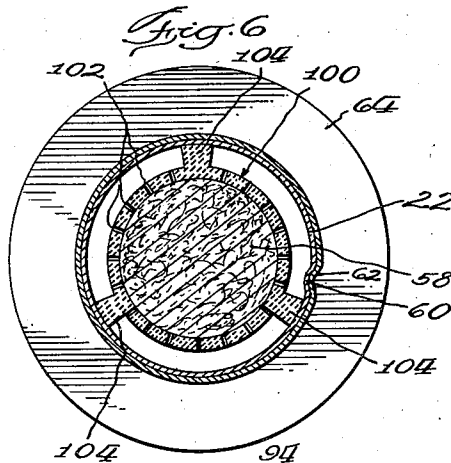
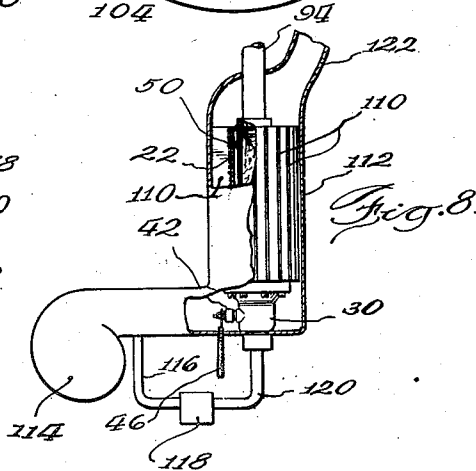
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HEATING UNIT

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3 Sheets-Sheet 2



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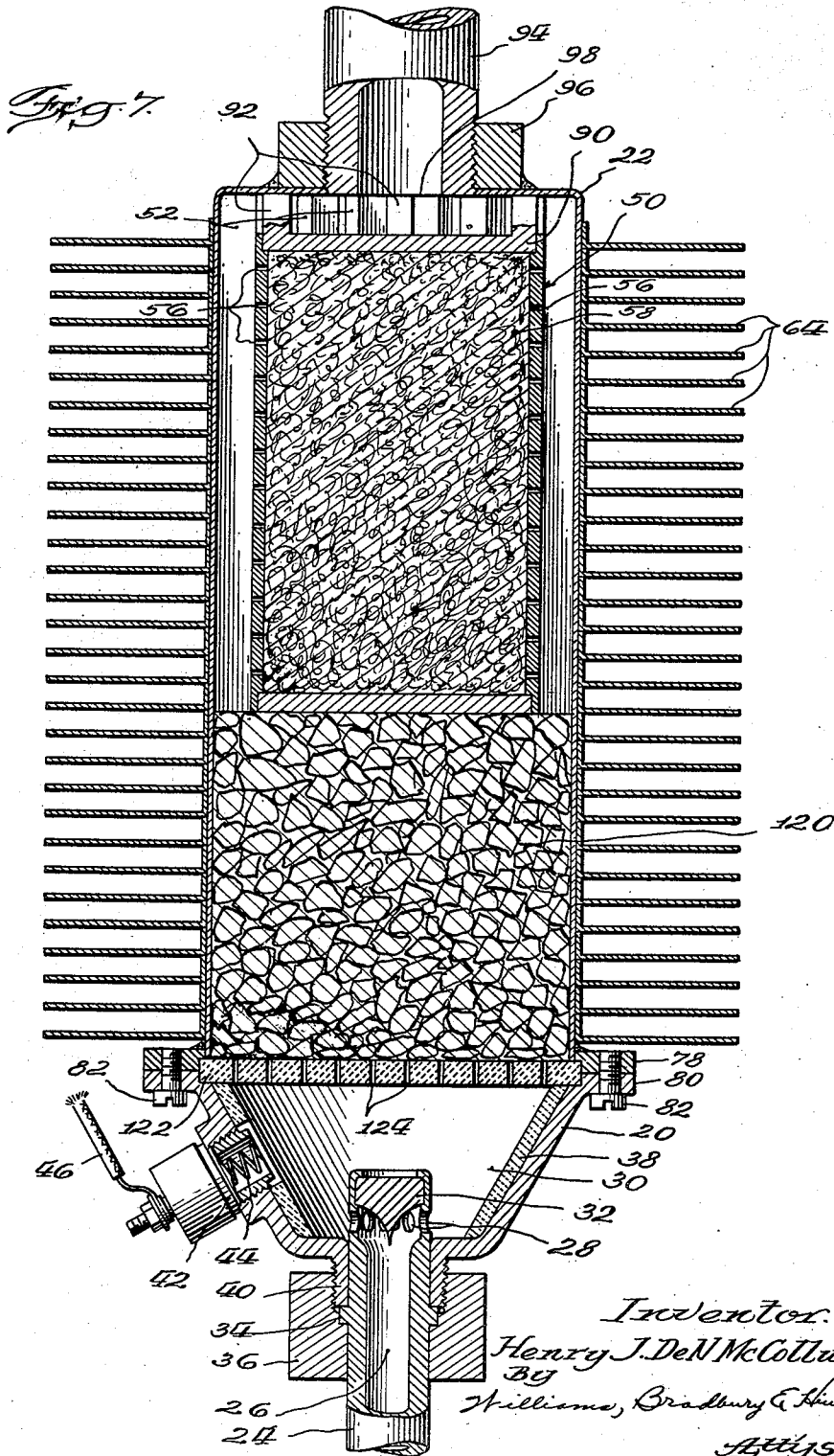
H. J. DE N. McCOLLUM

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3 Sheets-Sheet 3



UNITED STATES PATENT OFFICE

2,379,017

HEATING UNIT

Henry J. De N. McCollum, Chicago, Ill.; Thelma McCollum executrix of said Henry J. De N. McCollum, deceased

Application February 10, 1941, Serial No. 378,262

20 Claims. (Cl. 126-116)

My invention relates generally to heating systems and, more particularly, to an improved internal combustion heating unit for use in connection with heating systems for airplanes and the like.

In airplanes, elaborate safety precautions are taken to prevent fire. An internal combustion heating unit, to be totally safe, must be entirely enclosed so that there is no possibility of flame escaping from the heater. Previous internal combustion heating units will not operate satisfactorily when they are hermetically sealed and, therefore, some form of atmospheric relief must be provided. This may take the form of a port in the heating unit itself, or an opening in the fuel supply line or the exhaust line near the heater.

When previous heaters were hermetically sealed, a substantial quantity of the combustible mixture would pass into the combustion chamber and ignite. The rapid expansion caused by the ignition of this relatively large quantity of combustible mixture would cause an abrupt rise in pressure within the unit, which would prevent the flow of combustible mixture into the combustion chamber until the pressure diminished. The combustion chamber would then fill with combustible mixture which would ignite and repeat the process, resulting in an oscillating combustion. After the heating unit warmed up, these oscillations would become stabilized at a frequency corresponding to the resonance of the heating unit, causing phenomenon known as "motor boating." The rapid rise and fall in pressure in the interior of the heating unit would subject it to severe strains which would ultimately cause leaks which would make the heater unsafe to operate, both as to fire hazard and the danger of the escape of toxic gases of combustion into the air passing into the passenger compartment of the plane. As a result, previous heating units must employ a pressure relief opening which is usually placed in the combustible mixture intake.

It is, therefore, an object of my invention to provide a combustion chamber and heating unit assembly which is silent and stable in operation when it is hermetically sealed from the surrounding air.

Another object is to provide a heating unit which is efficient, compact, light in weight and easily installed, and which burns a large volume of a combustible mixture of fuel and air in a small space.

A further object is to provide an improved combustion chamber and heat exchanger which operates efficiently at high internal fluid velocities.

Other objects will appear from the following description, reference being had to the accompanying drawings, in which:

Fig. 1 shows a vertical cross-section of my improved heating unit, and diagrammatically repre-

sents a suggested combustible mixture supply system;

Fig. 2 shows a cross-section through the heat exchanger of my improved heating unit along the line 2-2 of Fig. 1;

Fig. 3 shows a cross-section through the combustion chamber of my heating unit along the line 3-3 of Fig. 1;

Fig. 4 shows a cross-section of the combustible mixture inlet of my heating system along the line 4-4 of Fig. 1;

Fig. 5 is a cross-sectional view of a modified form of my invention;

Fig. 6 is a cross-section through the line 6-6 of Fig. 5;

Fig. 7 is a cross-sectional view of another modified form of my improved heating unit; and

Fig. 8 is a diagrammatic representation, partially in cross-section and partially as a broken away view, of a suggested form for a heater incorporating my improved heating unit.

Referring to Fig. 1, a blower 10 forces air through a conduit 12, past the heat exchanger, and a conduit 14 supplies air from the outlet of the blower 10 to the inlet of a balanced carburetor 16 which mixes fuel with the air to form a combustible mixture which passes through a conduit 18 to the heater. The outer walls of the heating unit are formed by a generally cylindrical combustion chamber housing 20 and a generally cylindrical heat exchanger shell 22. The combustion chamber housing 20 is lined with a ceramic lining 24 to form a combustion chamber 26.

Combustion mixture is supplied to the heater through a combustible mixture inlet tube 24 which extends a short distance through the closed end of the combustion chamber. The tube 24 has a generally cylindrical central passage 26 passing longitudinally through its center and closed at the end by a plug 28. Peripheral holes 28 through the wall of the tube 24 are provided immediately adjacent the closed end of the combustion chamber 26. These holes 28 are made of as large a total cross-sectional area as is conveniently possible. I have found that providing eight of these holes and spacing them $\frac{1}{32}$ of an inch apart gives a resulting structure which is sufficiently strong and which has desirable characteristics. The plug 28 and the end of the passage 26 are preferably shaped to provide a smooth passage for combustible mixture. The walls flare gradually outward from the main portion of the passage 26 into the combustion chamber so that the mixture enters the combustion chamber through holes 28 in a direction substantially perpendicular to the axis of the tube 24, and no eddies are formed within the tube 24. A flange 34 around the periphery of the tube 24 seats against a threaded nipple integrally formed in the housing 20 to prevent the tube 24 from ex-

tending into the combustion chamber 30 more than the proper distance. A threaded hexagonal collar 36, threaded over the nipple 40, seats against the opposite side of the flange 34 to hold the inlet tube in position and to provide for its easy removal should cleaning be necessary.

It is important that the combustible mixture inlet be relatively cool to decrease the rate of flame propagation therein and to prevent the cracking of hydrocarbon fuel passing through it to form carbon deposits which would interfere with the flow of combustible mixture. Therefore, the inlet tube is constructed to extend a short distance only into the combustion chamber. The passage 26 is preferably of a small cross-sectional area and the total cross-sectional area of the holes 28 is preferably somewhat larger so that the velocity of the combustible mixture through the passage 26 is greater than the rate of flame propagation therein, while the mixture enters the combustion chamber through holes 28 at a somewhat lower velocity. This arrangement prevents the flame from striking back from the combustion chamber 30 and at the same time reduces the velocity of the mixture passing into the combustion chamber so that it is readily ignited and burned.

An electrically operated igniter 42, having an electrically heated resistance element 44 of nichrome wire or other suitable material, is provided to ignite the combustible mixture in the combustion chamber 30. One terminal of the resistance element 44 is grounded and the electric circuit is completed through a wire 46 which connects the other terminal with a source of current supply. A thermostatic switch responsive to the temperature of the heating unit may be placed in series with the wire 46 to discontinue the energization of the igniter when combustion has been established. A manually operable switch may be provided to control the igniter. The resistance element 44 is preferably placed in a pocket which has an opening to allow combustible mixture to come into contact with the heated element 44. The combustible mixture passes into the pocket where it is retained and heated to above its flash point to cause a flash which ignites the remainder of the combustible mixture in the combustion chamber. If the resistance element were placed directly in the flow of combustible mixture, the amount of current required to operate the igniter would be larger inasmuch as the combustible mixture would tend unduly to cool the element 44 and it would be difficult to raise a portion of the mixture to a temperature above its flash point.

The heat exchanger assembly comprises a metal shell 22 which encloses an apertured ribbed or fluted cylinder 50, preferably of nickel plated copper which is constructed to act as a non-resonant chamber. As is shown more clearly in Fig. 2, this cylinder 50 has thickened radially extending ribs 52 around its periphery. These ribs 52 are separated by longitudinal grooves 54 which are closed on their fourth side by the shell 22 to form longitudinal extending passageways. Small holes 56 are drilled through the cylinder at the bottom of the grooves 54 to provide a restricted communication between these grooves and the interior of the cylinder 50. In the particular construction shown, the outside diameter of the ribs 52 is in the order of two inches and the grooves are sixteen in number. In this construction, I have found that desirable operating characteristics are obtained by making the holes 56 approximately .093 inch in diameter and placing them $\frac{1}{16}$ inch apart. The dimensions of the

heating unit may, of course, vary over wide ranges, depending on the requirements of the particular installation.

The center of the cylinder 50 is filled with a loose packing 58 of a heat and corrosion resistant mineral or metal wool such as stainless steel wool. A longitudinally extending groove or crease 60 is formed in the surface of the shell 22. This crease 60 engages a corresponding groove 62 in one of the radial ribs 52 to prevent the cylinder 50 from rotating with respect to the casing. Heat exchanger fins 64 may be pressed over the outer surface of the shell 22 to increase the heat exchange area thereof, and may be provided with a crease 66 which corresponds to and engages the crease 60 to prevent the fins 64 from rotating with respect to the shell 22.

The end of the cylinder 50 disposed toward the combustion chamber 30 is provided with a ceramic reigniter plate 70 which seats against the metal cup 72 to close the end of the cylinder 50. The side of the ceramic plate facing the combustion chamber has reigniter nipples 74 formed thereon. In the center of each of these reigniter nipples is a small cylindrical hole 76. When combustion occurs in the heater, the reigniter plate 70 becomes heated to a high temperature. Should the combustion flame become temporarily extinguished, combustible mixture will accumulate in the holes 76 and be heated by the walls thereof to cause a flash which will reignite the combustible mixture in the combustion chamber.

The adjacent open ends of the heat exchanger shell 22 and the combustion chamber housing 20 are provided with flanges 78 and 80, respectively, which are held together by screws 82 to retain the heat exchanger to the combustion chamber. Between these flanges 78 and 80 is an annular metal spider 84 which is provided with inwardly facing projections 86 to hold the ceramic plate in place and to hold the cylinder 50 against the closed ends of the shell 22. Inasmuch as the cylinder 50 is prevented from rotating by the engagement of the grooves 62 with the crease 60 in the shell 22 and the spider is kept from rotating by the screws 82, the projections 86 may be designed and arranged so that they do not obstruct the flow of the products of combustion into the grooves 54. A metal plate 88 closes the end of the cylinder 50 which faces the closed end of the shell 22. The metal plate 88 is held in place by legs 89 which rest against the closed end of the shell and seat the plate 88 against a shoulder on the internal surface of the cylinder 50. A hole 90 is provided to permit the escape of the products of combustion from the heat exchanger. An exhaust pipe 94, which is threaded into a nut 86 brazed to the heat exchanger shell 22, conducts the products of combustion from the heating unit.

In operation combustible mixture passes through the passage 26 at a velocity above the rate of flame propagation thereof, through peripheral holes 28 at a somewhat reduced velocity, and into the combustion chamber 30 where it is ignited by the heated resistance element 44 of the igniter 42. The gaseous products of combustion from the burning of this mixture pass from the combustion chamber into the passages formed by the grooves 54. The ends of the ribs 52 obstruct the flow of the gases and tend to break up any abrupt rise in pressure. The sharp change in velocity as the gases pass from the combustion chamber into the grooves 54, coupled with the frictional resistance of the walls thereof, tend to damp abrupt changes in pressure caused by

an explosion in the combustion chamber. The holes 56 gradually relieve sudden changes in pressure in the grooves 54 by allowing gases to pass to or from the center of the non-resonant cylinder 50. The holes 56 need not be circular in cross section as shown but may be formed in any other size and shape which tends to damp and break up sudden waves of pressure change. For instance, they could be replaced by long narrow slots, or by holes of irregular cross section. Oscillations and waves of pressure in the center of the cylinder 50 are absorbed by the loose packing 58 therein.

Inasmuch as the heating unit is non-resonant, the operation of the unit is stabilized and oscillating combustion is prevented. Therefore, no atmospheric pressure relief need be provided when the heating unit is installed in a long hermetically sealed conduit.

The heating unit gives excellent thermal performance. The hot gases of combustion pass through the passageways formed by the grooves 54 at a high velocity. The effect of this high velocity is to scour the surfaces in contact with these gases free from surface films of gas molecules having a high resistance to the conductance of heat. Inasmuch as each of these passageways has a relatively small cross-sectional area, there is a relatively large area of contact between the hot gases and the walls of the passages. As the shell 22 and the cylinder 50 are made of a material having a high thermal conductivity, and as the ribs 52 are of a relatively large cross-sectional area, heat is quickly and efficiently conducted from the gases of combustion to the fins 64 which convey the heat to the air being heated. The nickel plated surfaces of the walls of the grooves 54, and the heat exchanger shell 22 resist corrosion so that the operation of a heater does not cause an insulating film of oxide to form thereon. I have found that the combustion chamber 30 may be approximately $\frac{1}{100}$ of the size generally recommended for combustion chambers of similar capacity burning a similar combustible mixture.

It is preferable to operate my heating unit with its axis in a vertical position, so that any liquid fuel which separates from the combustible mixture passing into the heater when the heater is cold will accumulate adjacent the combustible mixture inlet and will enrich the incoming mixture and thus facilitate its ignition. While my heating unit will also operate satisfactorily in a horizontal position, in this case it may be advisable to provide three igniters spaced 120 degrees apart to insure ignition of the combustible mixture.

The embodiment shown in Fig. 5 is a modified form of my invention. The construction is much the same as that shown in the embodiment shown in Fig. 1, and described above, except that an apertured ceramic cylinder 100 is provided in the inlet end of the heat exchanger shell 22, and the hot gases flow past this cylinder before entering the grooves 54 in the fluted cylinder 50. The ceramic cylinder 100 is provided with small holes 102 which afford a restricted communication between the outside of the cylinder 100 and the inside thereof. These holes 102 may be of approximately the same diameter and spacing as the holes 56 in the cylinder 50. The end of the ceramic cylinder 100 adjacent the combustion chamber is closed, and thus serves the same function as the ceramic plate 70. Reigniter nipples 74 are formed integrally with this closed end,

and the cylinder 100 is retained in the shell 22 by three radially extending ribs 104, 120° apart, which space the cylinder 100 from the walls of the shell 22 and rest against the end of the ceramic lining 38 of the combustion chamber 30 to prevent the cylinder 100 from sliding longitudinally within the shell 22. The diameter of the cylinder 100 corresponds to the diameter of the cylinder 50 and the open end of the ceramic cylinder 100 rests against cylinder 50 to hold the two cylinders in place and to provide a substantially continuous non-resonant central chamber which is filled with a loose heat and corrosion resistant packing 58 of mineral or metal wool. Other portions of the apparatus correspond to portions of the apparatus described in connection with Fig. 1, and are similarly numbered.

When the ceramic cylinder 100 is used in the inlet of the heat exchanger casing 22, it is advantageous to reduce the size of the combustion chamber inasmuch as, during combustion, the ceramic cylinder becomes heated to a high temperature and combustion may be completed in the space between the walls of the cylinder 100 and the shell 22. A reduction in size of the combustion chamber reduces the magnitude of any explosion which may occur therein inasmuch as a smaller amount of combustible mixture may accumulate before it is ignited. The heat radiated from the ceramic cylinder facilitates combustion of the gases in contact therewith, and promotes efficient operation. Ceramic material has excellent heat radiating properties and the heat which is conducted or radiated from the hot gases to the ceramic cylinder is radiated to the shell 22 and conducted to the fins 64 which dissipate the heat in the air to be heated.

The holes 102 in the ceramic cylinder 100 act similarly to the holes 56 in the cylinder 50 in damping abrupt changes in pressure caused by an explosion in the combustion chamber. It is understood that these holes in the walls of the non-resonant chamber need not be of circular cross section, but may take the form of squares, slots, or other shaped openings of a size and shape which has a damping effect on abrupt pressure changes. The ribbed cylinder 50 acts to damp explosions in the manner set forth in the disclosure in connection with Figs. 1, 2 and 3.

In the embodiment shown in Fig. 7, a packing 120 of chips of ceramic material is provided in the inlet end of the heat exchanger shell 22. These chips are retained in place by apertured plate 122 having holes 124 therein to allow the products of combustion to pass from the combustion chamber. The ribbed cylinder 50 may be retained in place by the packing 120, or may be secured by other suitable means. Inasmuch as this ceramic packing 120 is heated to a high temperature by the products of combustion, the combustion chamber may be smaller than that used in the embodiment shown in Fig. 1 and combustion may continue within the ceramic packing 120.

The reigniter nipples may be dispensed with inasmuch as, should combustion be extinguished, combustible mixture will gather in the interstices of this ceramic material and be ignited to ignite the combustible mixture in the combustion chamber. The irregular channels for the passage of products of combustion provided by the interstices between the fragments of ceramic material 120 tend to break up, damp and destroy an abrupt rise in pressure caused by an explosion within the combustion chamber 30.

The ribbed cylinder 50 acts in the manner disclosed in connection with Figs. 1, 2 and 3 to facilitate the transference of heat from the products of combustion and to prevent oscillating combustion. Other parts of this embodiment of my invention correspond to similar parts shown in Figs. 1, 2 and 3 and are similarly numbered.

Referring to Fig. 8, which illustrates a heater incorporating my improved heating unit, a plurality of longitudinal fins 110 extend radially from the shell 22 of the heat exchanger and are brazed or welded thereto. A cylindrical casing 112 encloses the entire heating unit. An electrically operated blower 114 supplies air under pressure to the inlet of the casing 112. A conduit 116 connects a point adjacent the outlet of the blower 114 with the inlet of a balanced carburetor 118, and a conduit 120 connects the outlet of the balanced carburetor 118 with the inlet of the combustion chamber 30. An electrically operated igniter 42 is provided to ignite the combustible mixture within the combustion chamber 30. If desired, a thermostatic switch, responsive to the temperature of the heating unit, may be placed in series with the igniter 42 to discontinue the energization of the igniter when the temperature of the heater rises to near its operating value. A conduit 122 connects the outlet of the casing 112 with the space to be heated. Other portions of the heater correspond to similar portions of the heater shown in Fig. 1 and described in connection therewith, and are similarly numbered.

In operation, the blower 114 draws air from the atmosphere and compresses it. A small portion of this air flows through the conduit 116 to the balanced carburetor 118 where it is mixed with fuel to form a combustible mixture, and the combustible mixture passes through the conduit 120 to the combustion chamber 30 where it is burned. The gases of combustion pass from the combustion chamber through the heat exchanger, heating the fins 110, and are discharged through the exhaust pipe 94. The bulk of the air compressed by the blower passes into the casing 112, past the fins 110 where it is heated, and through the conduit 122 to the space to be heated.

While a particular construction of the non-resonant chamber has been disclosed, it is understood that a chamber may be given non-resonant properties by the use of baffles to break up sound waves or pressure waves within the chamber, or by the use of any material within the chamber which will tend to absorb these waves. It is also understood that the provision of restricted openings of a size and shape which break up sound waves or pressure waves passing into or out of the chamber will cause the chamber to have substantially non-resonant properties when used for the purposes of my invention.

While I have disclosed my invention in connection with particular embodiments thereof, it will be apparent to those skilled in the art that numerous variations therefrom may be made without departing from the underlying principles of my invention, and I therefore wish to include within the following claims all such modifications as may be apparent to those skilled in the art by which substantially the results of my invention can be attained by substantially the same or equivalent means.

I claim:

1. In an internal combustion heating unit, the combination of means providing a combustion chamber for burning a combustible mixture of

fuel and air, means for supplying combustible mixture to said combustion chamber, a heat exchanger receiving the gases of combustion therefrom and having an outlet for discharging said gases, a shell of heat conducting material forming the casing for said heat exchanger, means providing a non-resonant, sound-inhibiting chamber within said shell and disposed to provide space for the passage of said gases of combustion between said chamber and said shell, walls enclosing said chamber, and a plurality of restricted passages through said walls affording acoustic communication between said space and the interior of said chamber.

2. In an internal combustion heating unit, the combination of means providing a combustion chamber for burning a combustible mixture of fuel and air, means for supplying combustible mixture to said combustion chamber, and a heat exchanger receiving the gases of combustion therefrom, having an outlet, and comprising a metal shell, means providing a non-resonant, sound-inhibiting chamber therein shaped generally to correspond to the outline thereof, and so disposed with relation to said shell as to provide space between the walls of said shell and the walls of said chamber for the passage of the products of combustion from said combustion chamber to said outlet, and a plurality of restricted passages affording communication between said space and the interior of said chamber whereby sound may enter said chamber and be absorbed therein.

3. In an internal combustion heating unit the combination of means providing a combustion chamber for burning a combustible mixture of fuel and air, means for supplying said combustible mixture to said combustion chamber, a heat exchanger for receiving the gases of combustion from said combustion chamber, having an outlet and comprising a shell of heat conducting material, means providing a sound-inhibiting chamber of heat conducting material within said shell and shaped to correspond in outline thereto, a plurality of ribs of heat conducting material between and engaging said shell and said chamber and disposed in the direction of flow of gases through said heat exchanger for conducting heat from said chamber and said gases to said shell, and having spaces between them for the passage of combustible mixture from said combustion chamber to said outlet, and sound-absorbing material in said chamber, said last-named means having openings connecting said spaces with the interior of the chamber formed in said means, said openings forming acoustic couplings between said spaces and said material.

4. In an internal combustion heating unit, the combination of means providing a combustion chamber for burning a combustible mixture of fuel and air, means for supplying combustible mixture to said combustion chamber, and a heat exchanger for receiving the gases of combustion therefrom, having an outlet, and comprising a shell of heat conducting material, means providing a closed sound-inhibiting chamber of heat conducting material within said shell, having walls disposed generally to conform to the outline of said shell, and provided with ribs extending longitudinally along the outside thereof and engaging the internal surface of said shell, said ribs having spaces between them providing passages for conducting said gases of combustion

from said combustion chamber to said outlet, and a plurality of restricted openings in the walls of said closed chamber affording communication between said passages and the interior of said cylinder.

5. An internal combustion heating unit having means providing a combustion chamber for burning a combustible mixture of fuel and air, means for supplying combustible mixture to said combustion chamber, a heat exchanger for receiving the gases of combustion therefrom, and comprising a metal shell open at one end to receive said gases from said combustion chamber and having an outlet for discharging said gases, means providing a non-resonant, sound-inhibiting chamber having walls of ceramic material within said shell adjacent said open end and so disposed with respect to said shell as to provide space for the passage of said gases between said walls and said shell, means providing a second non-resonant chamber having metal walls disposed generally to conform to the outline of said shell located within said shell between said first-mentioned chamber and said outlet, a plurality of longitudinally extending ribs engaging said metal walls and the inside of said shell and having spaces between them to provide passages for the flow of said gases between said metal cylinder and said metal shell, and a plurality of restricted openings in said walls affording communication between said passages and the interiors thereof.

6. An internal combustion heating unit comprising means providing a combustion chamber for burning a combustible mixture of fuel and air therein, means for supplying combustible mixture to said combustion chamber, a heat exchanger receiving the gases of combustion from said chamber and comprising a metal shell open at one end to receive said gases of combustion and having an outlet at the other end, a packing of ceramic fragments filling that part of said shell adjacent said open end, means for retaining said packing in place, means providing a non-resonant, sound-inhibiting chamber having metal walls within said shell adjacent said outlet, a plurality of ribs engaging the outside of said metal walls and the inside of said shell and having spaces between them to provide passages for the flow of products of combustion from said packing to said outlet, whereby said ribs conduct heat from said metal walls and said products of combustion to said shell, and a plurality of restricted openings in said walls affording communication between said passages and the interior of said non-resonant chamber.

7. In an internal combustion heating unit, the combination of means providing a combustion chamber burning a combustible mixture of liquid fuel and air, a dead end inlet tube extending a short distance into said chamber for supplying combustible mixture thereto, a central passage through said tube for conducting combustible mixture at a velocity above the rate of flame propagation thereof, and holes of greater total cross-sectional area than said passage around the periphery of that portion of said tube extending into said chamber to conduct said mixture from said passage into said chamber, whereby said mixture enters said chamber in a direction substantially perpendicular to the axis of said tube, and a heat exchanger, having an inlet for receiving the gases of combustion from said combustion chamber, having a non-resonant chamber therein in communication with the gases of combustion from said combustion chamber, and

having an outlet for discharging said gases of combustion.

8. In an internal combustion heating unit the combination of means providing a combustion chamber burning a combustible mixture of fuel and air therein, means for supplying combustible mixture to said combustion chamber, a heat exchanger receiving the gases of combustion from said chamber and comprising a shell of heat conducting material having an opening to receive the gases of combustion from said combustion chamber, an outlet for discharging the gases of combustion therefrom, means providing a non-resonant, sound-inhibiting chamber within said shell, shaped generally to conform to the outline thereof and so disposed with relation to said shell as to provide space between said chamber and said shell for the passage of the gases of combustion from said combustion chamber to said outlet, metal walls enclosing that portion of said non-resonant chamber adjacent said outlet, a plurality of ribs affixed to the outside of said walls and disposed in the general direction of flow of gases of combustion from said chamber to said outlet, said ribs engaging the inner surface of said shell to space said walls from said shell and to provide passages to said gases of combustion between said ribs, walls of a ceramic material enclosing that portion of said chamber adjacent said combustion chamber and spaced from the walls of said shell to provide for the passage of gases of combustion between said walls and said shell, and a plurality of restricted openings in said walls affording communication between the interior of said non-resonant chamber and said passages.

9. An internal combustion heating unit comprising means providing a combustion chamber for burning a mixture of fuel and air therein, means for supplying combustible mixture to said combustion chamber, a heat exchanger receiving the products of combustion from said combustion chamber and having an outlet, said heat exchanger comprising a shell of heat conducting material, means providing a non-resonant, sound-inhibiting chamber within said shell, walls of heat conducting material enclosing that portion of said non-resonant chamber adjacent said outlet and shaped generally to conform to the outline of said shell, longitudinally extending ribs on the outer surface of said walls, said ribs being disposed in the direction of flow of gases of combustion through said heat exchanger and engaging the inner surface of said shell to form passages between said ribs for the flow of said gases of combustion, walls of ceramic material enclosing that portion of said chamber adjacent said combustion chamber and spaced from said shell to provide for the passage of gases of combustion between said walls and said shell, a plurality of restricted openings in the walls of said non-resonant chamber affording communication between the interior of said chamber and said passage, and a loose packing of a heat and corrosion resistant material substantially filling said non-resonant chamber.

10. An internal combustion unit comprising means providing a combustion chamber for burning a mixture of fuel and air therein, means for supplying combustible mixture to said combustion chamber, a heat exchanger adjacent said combustion chamber and receiving the gases of combustion therefrom, an outlet for discharging said gases of combustion from said heat exchanger, said heat exchanger cooperating with

said combustion chamber and outlet to form a continuous passage for gases, said heat exchanger comprising a shell of heat conducting material and having means providing a non-resonant, sound-inhibiting chamber therein adjacent said outlet, said last-named means providing a plurality of small openings connecting said sound-inhibiting chamber with said passage, a packing of fragments of ceramic material substantially filling that portion of said heat exchanger adjacent said combustion chamber, and means for retaining said fragments in place.

11. An internal combustion heating unit comprising means providing a combustion chamber for burning a combustible mixture of fuel and air therein, means for supplying said mixture to said combustion chamber, a heat exchanger adjacent said combustion chamber for receiving the gases of combustion therefrom, and an outlet for discharging said gases of combustion from said heat exchanger, said heat exchanger comprising a shell of heat conducting material, a non-resonant chamber within said shell and shaped generally to conform to the outline of said shell, walls of heat resistant material enclosing said non-resonant chamber and so disposed with respect to said shell as to provide space for the passage of said gases of combustion between said walls and said shell, a plurality of restricted openings through said walls affording communication between the inside and outside thereof, and a plurality of nipples of ceramic material, each having a small open cavity, affixed to that portion of said walls adjacent said combustion chamber.

12. A heater comprising a hermetically sealed casing, an inlet conduit for conveying a combustible mixture of fuel and air thereto, a discharge conduit for conveying the products of combustion therefrom, means for maintaining a substantial pressure difference between said inlet and outlet conduits to cause rapid flow through said casing, a combustion chamber at the inlet end of said casing, electrical means to ignite the fuel mixture in said combustion chamber, an enclosure in said casing forming a compartment occupying the major portion of the space within said casing and providing longitudinally extending passageways between it and the inner wall of said casing, said enclosure having a plurality of spaced apertures connecting said passageways with said compartment, and an inert air vibration damping material substantially filling said compartment.

13. The combination set forth in claim 12 in which said enclosure is made of copper plated with nickel.

14. The combination set forth in claim 12 in which said damping material is stainless steel wool.

15. The combination set forth in claim 12 in which said enclosure is formed in part by a hollow ceramic cup-shaped element with its closed end forming one wall of said combustion chamber and in part by a ribbed hollow metal cylinder, the ribs of which form said passageways and are in good heat conducting contact with said casing.

16. The combination set forth in claim 12 in which said casing is surrounded by heat conducting longitudinally extending fins enclosed in a housing, and in which the means for maintaining the substantial pressure difference between the inlet and outlet conduits causes flow of air to be heated through the space between said casing and said housing.

17. A heating unit for burning a combustible mixture of fuel and air, comprising means pro-

viding a combustion chamber, means for supplying combustible mixture to said combustion chamber, a heat exchanger having an outlet and receiving the products of combustion from said combustion chamber, said heat exchanger and combustion chamber forming a passage for conducting combustion gases to said outlet, means providing a non-resonant, sound-inhibiting chamber in said passage, said last-named chamber being formed by an elongated tubular member having a plurality of relatively small holes formed therein and widely spaced from each other, said holes opening into said passage and forming acoustic couplings between said passage and the interior of said last-named chamber, and means for removing the products of combustion from said heat exchanger.

18. In a heating unit generating heat by the burning of a combustion mixture of fuel and air therein, the combination of means providing a combustion chamber for burning said combustible mixture, a heat exchanger receiving the products of combustion therefrom and having an exhaust outlet, said combustion chamber and heat exchanger forming a sealed path leading to said exhaust outlet, means providing a sound-inhibiting chamber in said path and a plurality of restricted communications between said path and the interior of said chamber, and means defining longitudinally extending passageways conducting the products of combustion from said combustion chamber, through said heat exchanger, to said outlet, said means being in heat conductive relationship with the walls of said heat exchanger.

19. In a heating unit generating heat by the burning of a combustible mixture of fuel and air therein, the combination of means providing a combustion chamber for burning said combustible mixture, a carburetor having an air inlet and connected to said combustion chamber for supplying a combustible mixture thereto, a heat exchanger receiving the products of combustion from said combustion chamber and having an exhaust outlet, said combustion chamber and heat exchanger forming a path leading to said exhaust outlet and conducting products of combustion thereto, said inlet and outlet being adapted for exposure to different pressures to produce flow through said combustion chamber and heat exchanger, and means providing a sound-inhibiting chamber in said path, said last-named means having a plurality of restricted communications between said path and the interior of said sound-inhibiting chamber and forming acoustic couplings therebetween.

20. In an internal combustion heating unit, the combination of means providing a combustion chamber burning a combustible mixture of fuel and air, an inlet tube connected to said chamber for supplying combustible mixture thereto, a heat exchanger receiving the products of combustion from said combustion chamber and having an exhaust outlet, said combustion chamber and heat exchanger forming a path leading to said exhaust outlet and conducting products of combustion thereto, means providing a sound-inhibiting chamber in said path, said last-named means affording a plurality of restricted openings between said path and the interior of said sound-inhibiting chamber, and sound-absorbing material in said sound-inhibiting chamber for absorbing sound entering said last-named chamber through said restricted openings.