March 19, 1935. J. J. SLOYAN 1,994,968

HEAT GENERATOR

Filed Oct. 29, 1930 4 Sheets-Sheet 1

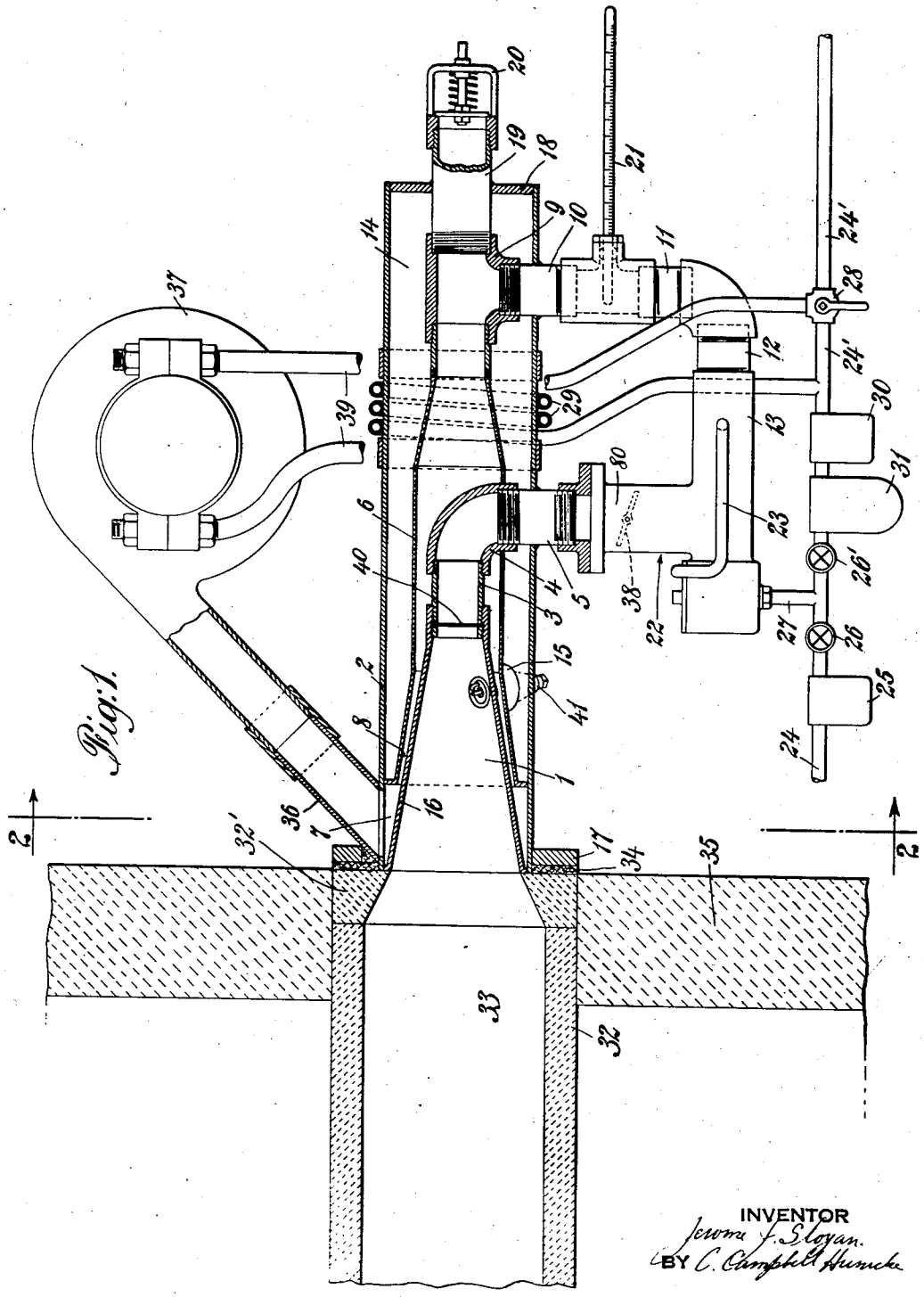


Fig. 1.

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Fig. 6.

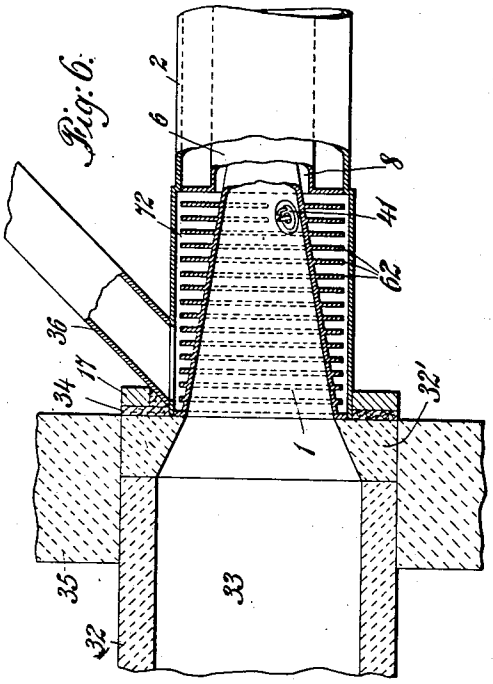
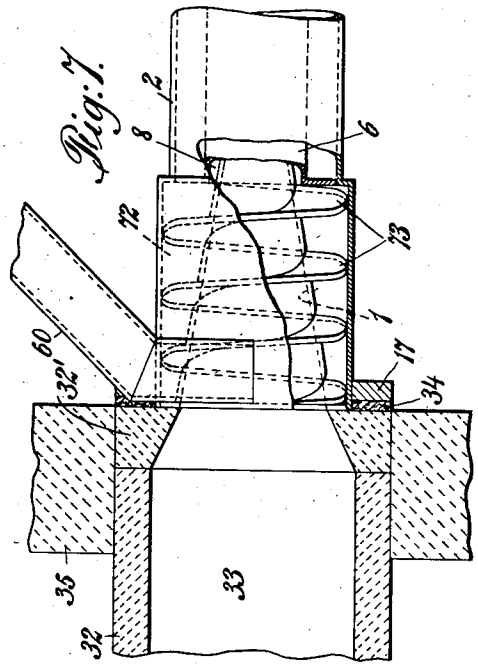


Fig. 1.



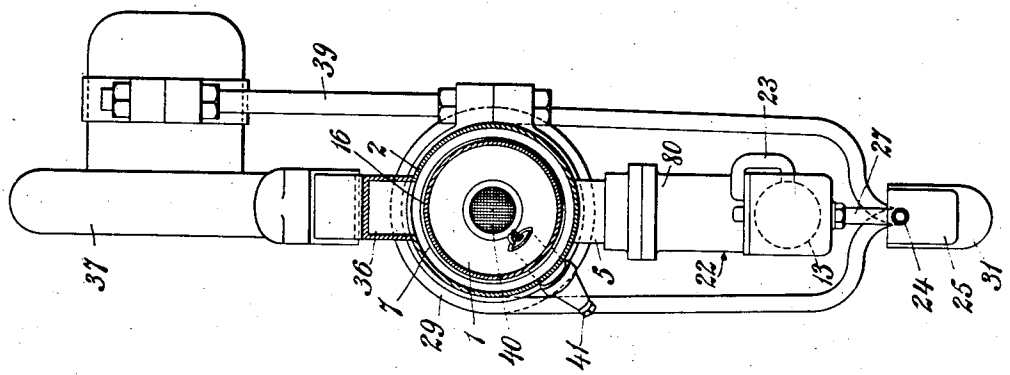


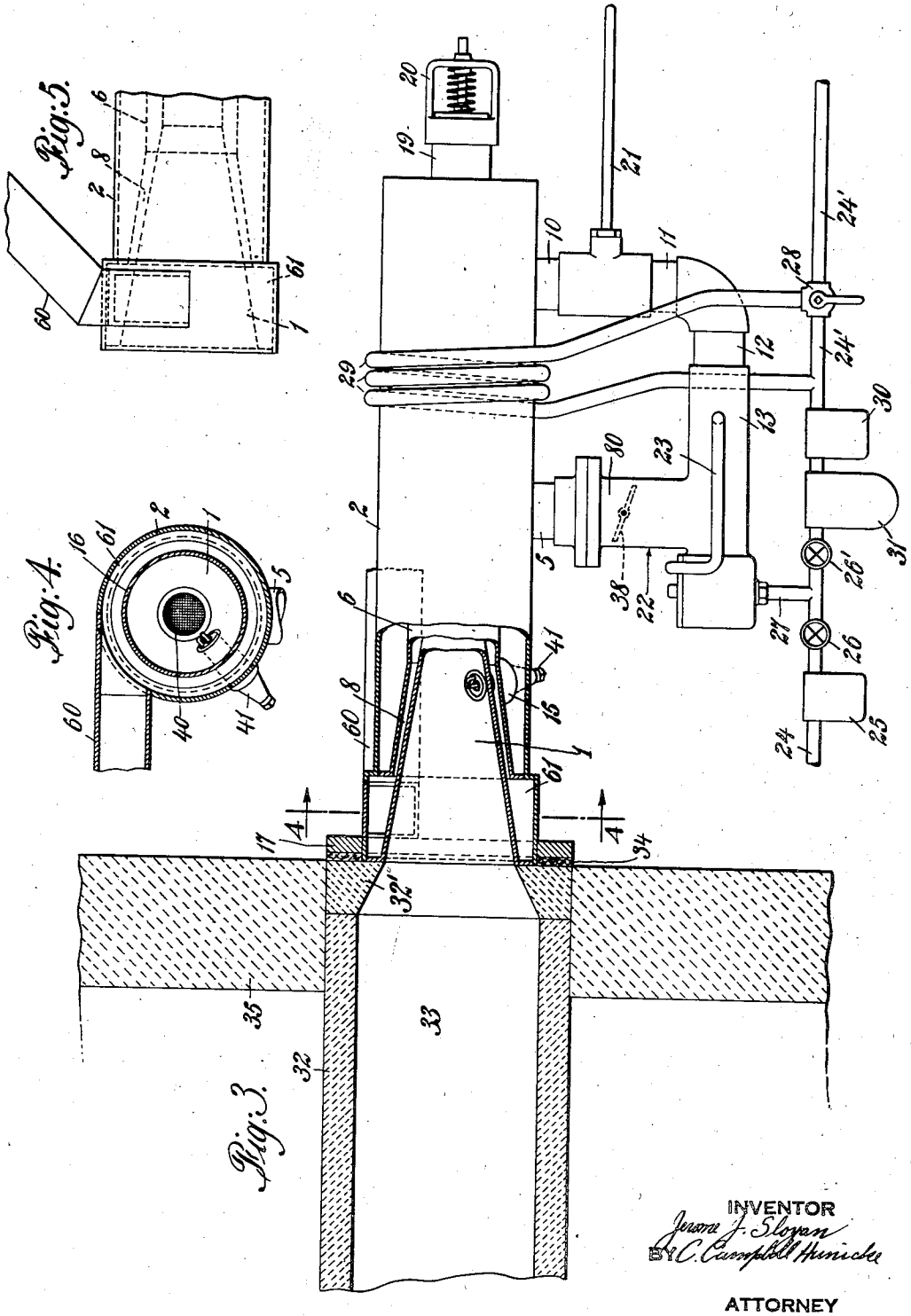
Fig. 2.

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Fig. 9.

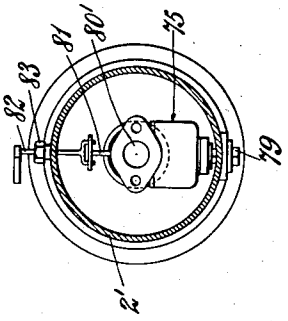
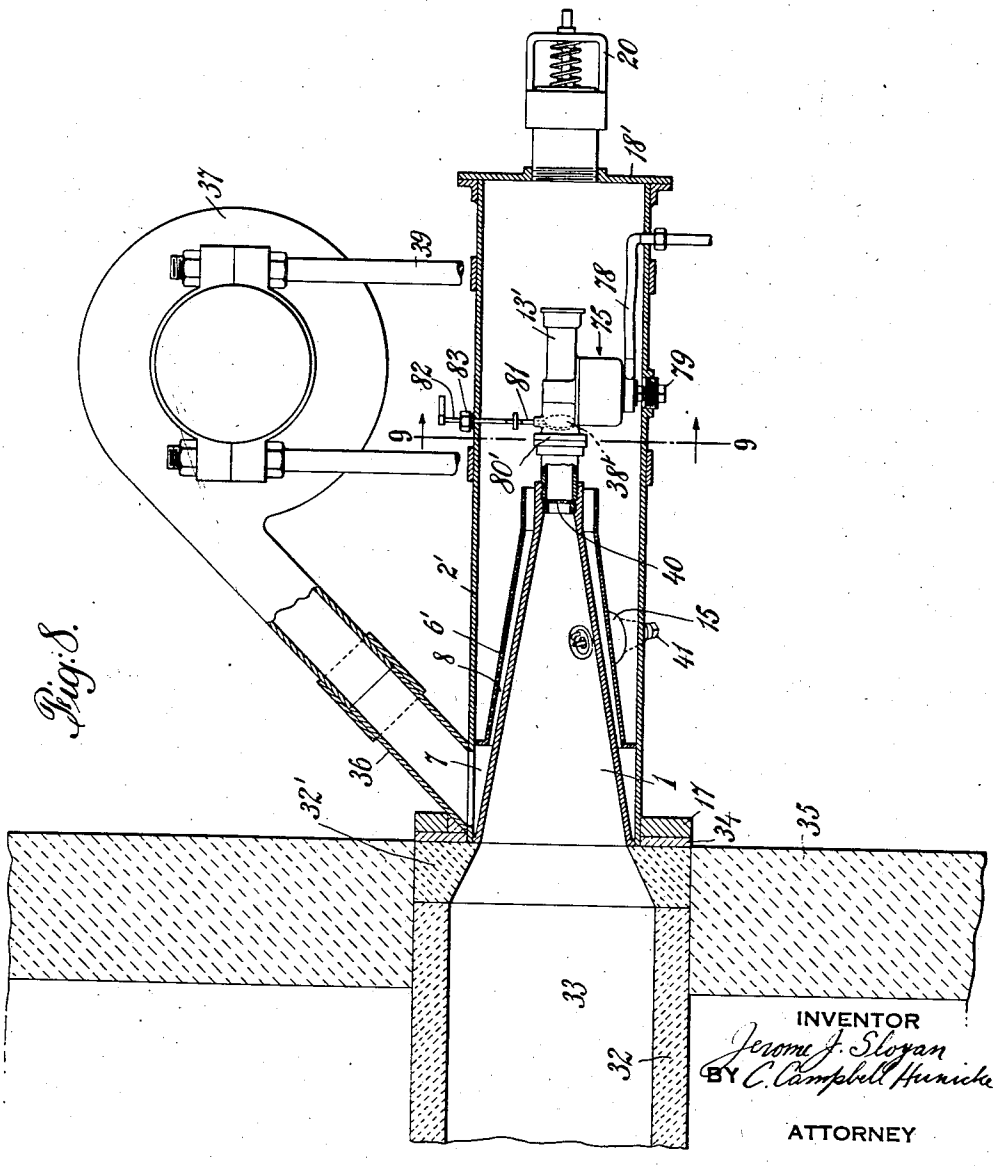


Fig. 8.



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UNITED STATES PATENT OFFICE

1,994,968

HEAT GENERATOR

Jerome J. Sloyan, Red Bank, N. J.

Application October 29, 1930, Serial No. 492,132

2 Claims. (Cl. 158—28)

This invention relates to improvements in heat generators and methods of burning less volatile grades of liquid fuel.

In burning the less volatile grades of liquid fuel the same problems of vaporization, homogeneity of the fuel and air mixture and the maintenance of the proper ratio of fuel and air at all rates of combustion are present as in the case of the more volatile grades of oil but are more difficult of solution. An accurate and sensitive control of the rate of combustion is not only desirable but for certain uses is essenial. In addition there are the commercial requirements of obtaining the maximum temperature from the fuel and the control of the chemical structure of the products of combustion.

The present devices in use for the burning of the less volatile grades of liquid fuel are in the main complicated, difficult to start, of costly construction and are lacking in accuracy and sensitiveness of control of the rate of combustion and of control of the chemical structures of the products of combustion as well as lacking in thermal efficiency, nor are such devices generally of unit construction and yet capable of expansion for increased capacity.

The objects of this invention are:

To provide a heat generator that will satisfactorily burn the less volatile grades of liquid fuel and to make provision to burn the less volatile grades satisfactorily in a relatively short time after the device has been initially started.

To effect a transfer of heat from the flame to air that is to be subsequently mixed with the fuel. The heat thus transferred effecting a rise in air temperature which will in turn thoroughly vaporize the fuel.

To add heat to the fuel and air mixture after it has left the carburetor in order to make up for the temperature drop which occurs due to vaporization of the liquid fuel.

To provide a heat generator having a relatively high overall thermal efficiency by using the heat that must necessarily be removed from certain elements for mechanical reasons in other elements and processes wherein it is essential and by further using the heat thus saved effectively on the material to be heated.

To provide a heat generator which is of simple and unit construction and wherein the desired results are effected by the (natural) physical relation which exists between the various elements and processes, rather than by a complicity of manually or automatically operated moving members.

Referring to the drawings:

Figure 1 is a view partly in section and partly in elevation of a device embodying the principles of my invention. Figure 2 is a sectional view along the line 2, 2, of Figure 1 looking in the direction of the arrows. Figures 3 is a view of a modification of the device partly in section and partly in elevation with the blower and lead removed and a portion of the housing broken away. Figure 4 is a sectional view of Figure 3 along the line 4, 4, looking in the direction of the arrows. Figure 5 is a detail plan view of Figure 3. Figure 6 is a view in side elevation, partly in section, of a modified form of device wherein the cooling of the antechamber is accomplished through the passing of the cooling air over and around fins thermally connected to the ante combustion chamber wall. Figure 7 is a plan view, partly in section and parts broken off, of a modified form of device wherein a spiral fin directs the passage of the cooling air around the antecombustion chamber wall. Figure 8 is a view in longitudinal section wherein the vaporizing and mixing means is within the housing. Figure 9 is a sectional view of Figure 8, along the line 9, 9, looking in the direction of the arrows.

In carrying out my invention, I propose to provide a construction of the casing assembly which is both unique and simple. Antecombustion chamber 1, has a conically shaped interior and exterior, its smallest end extending into housing 2, so that the end of larger diameter is flush with the end of the casing. The end of larger diameter is either threaded or welded to the end of housing 2 to insure an air-tight joint. That end of smaller diameter which extends into housing 2 is air-tightly connected through pipes 3, 4, 5 to the carburetor discharge 80. Pipe 5 is welded to housing 2, where it passes through housing 2 to make a joint that is air-tight. Sheath 6 is of such shape and dimension and so located within housing 2 with reference to antecombustion chamber 1, as to form a circumferential air passageway 7, having a predetermined transverse cross sectional area (transverse with relation to its circumference) and a longitudinal air passageway 8, having a predetermined transverse cross sectional area (transverse with relation to its longitudinal axis). As clearly shown in the drawings, sheath 6 is progressively spaced further from antecombustion chamber 1 over the air passageway 8 from the larger toward the smaller end of antecombustion chamber 1, so as to make air passageway 8 approach an equal cross sectional area throughout. Extending further backward

from the antecombustion chamber through housing 2, sheath 6 is connected with T, 9, which in turn is connected through pipes 10, 11, 12, to the carburetor inlet 13. Between antecombustion chamber 1 and T, 9, sheath 6 envelopes pipes 3 and 4, which convey the fuel and air mixture from the carburetor to the antecombustion chamber. Pipe 10 is welded to housing 2 where it passes through the casing to prevent the leakage of air to or from housing 2. The outer perimeter of the end of larger diameter of sheath 6 is a snug fit in housing 2 but does not of necessity have to be air-tight because the only exit for air that is delivered into air passageway 8 is through pipe 10 leading to the carburetor inlet, all other possible exits being made air-tight. Sheath 6 acts merely as a directing means and is surrounded by immovable air (immovable because it has no exit) hence the possibility of leakage of air from within sheath 6 to the space 14 between sheath 6 and housing 2 is negligible. For the same reason it is unnecessary that pipe 4 or spark plug housing 15 form air-tight joints with sheath 6 where they pass through it.

Spark plug housing 15 extends through the wall of housing 2 through sheath 6 and through the wall 16 of antecombustion chamber 1. The joints formed by itself, and the antecombustion chamber 1, and housing 2 are made air-tight.

End plate 18 is air-tightly secured to housing 2. Pipe 19 connecting sheath 6 and relief valve 20, passes through end plate 18. The joint formed by the end plate 18 around pipe 19 is made air-tight.

Thermometer 21 is conveniently located in the pipe line from sheath 6 to the carburetor inlet 13, to register the temperature of the air as it enters the carburetor.

The carburetor 22 used is an air sealed carburetor as more fully described in my patent application filed September 13, 1928, Serial Number 305,832. Its inlet 13 is air-tightly connected through pipe connection 10, 11, and 12, to sheath 6, and its discharge is air-tightly connected through pipe connections 3, 4 and 5 to the antecombustion chamber 1.

The more volatile fuel used for initial starting is conveyed from a source of supply (not shown) through pipe 24, to fuel pump 25 wherefrom it is delivered through valve 26 and pipe 27 to the carburetor. The less volatile fuel used for continuous operation is conveyed by pipe 24′ from a source of supply (not shown) through valve 28 then either through heating coil 29 or through pipe 24′ to fuel pump 30, wherefrom it is delivered through fuel filter 31, through valve 26″ and pipe 27, to the carburetor 22. Valve 28 is a three way valve.

Fuel pumps 25 and 30 are the magnetic bellows type and automatically cease to function when the fuel in the carburetor has reached a predetermined level.

Integral with housing 2 is flange 17 which is secured to rear wall 32′ of main combustion chamber 33 by bolts or clamps so that antecombustion chamber 1 and main combustion chamber 33 are joined to form substantially a single chamber. Housing 2 extends a short distance through flange 17 to protect from flame impingement the heat insulating gasket 34 which is located between flange and main combustion chamber rear wall 32′.

Pipe 36, which conveys air to the casing from a source of supply, shown as blower 37 in Figure 1, enters the top of housing 2 adjacent to flange 17. It is important that the air passing through pipe 36 absorb as little heat as possible prior to its coming in contact with the surface of the wall 16 of antecombustion chamber 1 otherwise it will not have the cooling effect on said wall that is intended. In order that pipe 36 shall absorb as little radiant heat from flange 17 or housing 2 as possible it is led in obliquely to housing 2 and flange 17 and is also disposed in a vertical plane (see Figure 5).

Blower 37 is conveniently mounted by bracket 39 on housing 2.

It should be noted that as the heated air passes from passageway 8 on its way to the carburetor, it passes over and around those pipes which conduct the mixture of fuel vapor and air to the interior of antecombustion chamber 1. As the heated air passes through carburetor 22 it gives up some heat in order to effect vaporization of the liquid fuel and by so doing its temperature is lowered. It is therefore evident that the temperature of the mixture as it passes through pipes 3, 4 and 5 to the interior of the combustion chamber is much below that of the air passing around said pipes, so that the mixture will absorb some heat from the air passing around the pipes and the heat absorbed will aid in retaining the fuel in the vapor state and in a homogeneous mixture with the air until the instant combustion takes place.

By complete combustion of a hydrocarbon such as liquid fuel, we mean that all the carbon is oxidized to carbon dioxide and all of the hydrogen is oxidized to water. If the quantity of air which is known to be required chemically is not supplied, then combustion will be incomplete and some of the carbon will be only partially oxidized to carbon monoxide. In order to approach complete combustion of the fuel in devices now used, more air than is chemically necessary must usually be supplied and even then frequently too much carbon escapes in the monoxide form.

Only that portion of the fuel which is vaporized and in contact with air will combust. When liquid fuel is atomized (broken up into small globules by some mechanical means) only the surface of each globule vaporizes and if sufficient air is present in that vicinity at the time of combustion to mix with the vapor, complete combustion of that fuel which has vaporized from the globules will result. To continue combustion of this globule, the next layer must vaporize, and if air has displaced these gases of combustion resulting from the combustion of the first layer, then combustion of the second layer will occur and so on until the combustion of the entire globule has been completed. But if the original globule were surrounded by only the exact quantity of air chemically required, some of the unused air would be carried away by the combustion gases and the remaining part of the globule although vaporized would not have sufficient air present to combine with it, hence, it would pass away either partially burned to a monoxide or not burned at all. In order then to approach complete combustion of the globule, an excess of air must necessarily be supplied.

It is quite evident that the more minute the globules and the more evenly they are distributed throughout the air the more complete will be the combustion and the less will be the quantity of excess air required. If vaporization of the fuel is resorted to, still better and more rapid combustion will result because particles of fuel vapor are infinitely smaller than the smallest

globule. Vaporization in reality effects a change in state of the fuel from a liquid to a gas.

In my device, vaporization of the globule is accomplished by the addition of heat to the air and means is provided for the thorough mixing of the fuel vapor and air so that practically no excess air is required because each minute particle of fuel vapor will be perfectly surrounded by its chemical air requirement and completely consumed, requiring no air replenishment as in the case of the surface of the fuel globule.

Even though the fuel is thoroughly vaporized and the required quantity of air is present, it need not follow that combustion will be complete. It is imperative that the two be thoroughly mixed, that is, each fuel particle must be surrounded by its requisite quantity of air. This is known as a homogeneous mixture.

Thus far, I have shown what is necessary if complete combustion is to occur and if the quantity of excess air required is to be reduced to a minimum.

To obtain complete combustion without having to resort to excess air is of vital importance. The quantity of air which is in excess is inert and, being present, must be heated and consequently prevents the combustion temperature from rising to a degree to which it otherwise would, were this inert matter not present. The importance of obtaining maximum temperature from the burning of fuel, when air is used as a source of oxygen, should require no comment.

Excess air and lack of homogeneity both lower the rate of flame propagation i. e. the velocity at which the flame propagates itself throughout the mixture, hence, combustion will be more rapid and the flame will be located within the antecombustion chamber when the quantity of air in excess is reduced to a minimum and the mixture produced is homogeneous. Another very important reason for desiring to minimize the quantity of excess air is because of its disastrous oxidizing effect on boiler tubes, metal furnace parts, and metals in the process of their manufacture.

It will be shown in the device I am about to describe that the fuel is first atomized, then vaporized by, and homogeneously mixed with the air, and that the flame resulting from the combustion is so located by the high rate of flame propagation obtained, which is in excess of 16 ft. per sec., that it is made to effect a desirable transfer of heat to the air that is subsequently to be used to support combustion of the fuel; that the device affords a wide but sensitive variation in the control of the combustion rate without sacrificing any of its thermal efficiency.

The operation of my device is as follows: Air from a source of supply such as blower 37 is delivered through pipe 36, thence through passageway 7, formed between antecombustion chamber wall 16 and housing 2, and passageway 8, formed between wall 16 and sheath 6. Conducted further through sheath 6, it passes around the mixing chamber formed by pipes 3, 4 and 5, thence through pipes 9, 10, 11, 12 and 13 through a metering, mixing, and atomizing device 22. Metering, mixing and atomizing device 22 is substantially an air sealed, pressure equalized, constant level, automotive carburetor wherein the liquid fuel is effected to be discharged into the air stream at a metered rate which depends on the velocity of the air stream (rate of air flow). When no air flows, no fuel is caused to flow because if no pressure difference exists in the air stream, no pressure difference exists on the fuel. Because of the small orifices through which the fuel is discharged into the air stream and the comparatively high velocity of the air stream, it is delivered in a minutely atomized spray. On starting, a more volatile grade of fuel is supplied through pipe 24 and valve 26 to the constant level chamber 84 so that the normal atmospheric temperature of this air stream is sufficient to cause a partial vaporization of the globules of the spray just mentioned. The mixture of fuel vapor and air thus produced is then conducted past safety fire screen 40 into antecombustion chamber 1 where initial ignition is effected by a high tension current supplied to spark plug 41. To insure continuance of flame, at starting when the device is cold it is suggested that the spark be left on for a short period of time.

In a short time some of the heat from the flame in antecombustion chamber 1 will be transferred through wall 16 of said chamber to the air passing through passageways 7 and 8 causing said air to rise in temperature. As this heated air, passing through the metering, mixing, and atomizing device 22, comes in contact with the fuel spray, the globules are thoroughly vaporized and the resulting vapor is homogeneously mixed with the air as the two pass through the mixing chambers and safety fire screen 40, so that when the mixture is now delivered into antecombustion chamber 1, it is in condition for complete combustion at a higher rate of flame propagation than when the device was cold at the time of starting. As soon as the air has been heated to a predetermined temperature, at which it is known that the lower grade of fuel, on which the device is intended to operate continuously, will properly vaorize, valve 26′ may be opened and valve 26 supplying the more volatile fuel closed.

The rate of flame propagation increases as the homogeneity of the mixture. Homogeneity of the mixture will continue to increase with an increase in the air temperature until a temperature which effects complete vaporization of the fuel spray has been attained. Thereafter, raising of the air temperature will not increase homogeneity and will not cause an increase in the rate of flame propagation. I have found when the fuel is thoroughly vaporized, that the flame propagation rate is unchanged by a change in the combustion rate, provided the mixture ratio is maintained constant, and that an increase in the fuel percentage increases the rate of flame propagation.

It should be noted that the flame was initially ignited on the antecombustion chamber side of safety fire screen 40 and that said screen prevents the pre-ignition of the mixture prior to its passage therethrough, even though the velocity of the mixture through the screen is less than the rate of flame propagation. The reason for using the screen should be so evident that discussion of its function should not be necessary.

Let it be supposed that the rate of flame propagation is 16 ft. per sec. and let it be assumed that butterfly valve 38 is only slightly open permitting a quantity of mixture to be delivered that will flow through screen 40 at a velocity of 8 ft. per sec. The rear of the flame will be located at the screen and the entire flame, because of being small, will only contact with a part of the surface area of wall 16. Heat will be transferred through that part of the surface of wall 16, with which the flame contacts, to the small quantity of air passing over the outer surface of said wall as the air passes through passageways 7 and 8.

Now as valve 38 is further opened, permitting of the mixture velocity to increase to 16 ft. per sec. through fire screen 40, the rear of the flame will still be located at the screen but the flame will be larger and will therefore contact with a greater surface area of wall 16, effecting a greater transfer of heat to the air and a corresponding increase in air temperature, even though the quantity of air being heated is greater than before. Suppose, now, valve 38 is further opened and the mixture is delivered through screen 40 at the rate of 24 ft. per sec. the flame will then be removed from the screen because the mixture velocity exceeds the rate of flame propagation by 8 ft. per sec.

If no envelope such as wall 16, of antecombustion chamber 1, existed, the flame would assume a certain natural shape of its own, but just where it would start to form at various combustion rates would be difficult to ascertain and to cause an accurate or rather definite rate of transfer of heat, from it, to the air, would be difficult. If, on the other hand, walls 16 are made sufficiently close together to cause some confinement to the flame, then the rear of the flame may be accurately located and a definite rate of heat transfer effected.

Given the rate of flame propagation for a given mixture and the quantity of mixture delivered per sec., location of the rear of the flame may be ascertained by the following formula:

$$A=\frac{144Q}{V}$$

When V is rate of flame propagation in feet per sec. Q quantity of mixture in cu. ft. per sec. delivered into antecombustion chamber. A cross section of antecombustion chamber in square inches at which rear of flame will occur.

Or if we refer to the last position of butterfly valve opening discussed, which permitted a mixture velocity past screen 40, of 24 ft. per sec. then the rear of flame will occur in that cross section of antecombustion chamber 1, which is 1½ times the cross sectional area of the screen, because it is at this location that the mixture will have dropped in pressure and the correspondingly lowered velocity will equal the rate of flame propagation, i. e. 16 ft. per sec.

To go further, if the butterfly valve is further opened, permitting the mixture to be delivered through the screen at 32 ft. per sec. the cross sectional area whereat the rear of the flame will occur will be twice that of the cross sectional area of the screen. And so, on further opening of the butterfly and corresponding increase in the rate of combustion and increase of mixture velocity through the screen, the rear of the flame is further disposed into larger antecombustion chamber cross sections, until full opening of valve 38, might cause the flame to be entirely removed from the antecombustion chamber, provided the pressure and capacity of the blower was sufficiently great to cause such an extreme quantity of air and subsequent quantity of mixture to be delivered.

It should be evident from the foregoing, without having to resort to mathematics, after the maximum surface area of wall 16 has been contacted by flame, that further increasing the rate of combustion causes a decrease in the surface area with which the flame contacts—for the simple reason that the flame is being disposed out of antecombustion chamber 1 as the combustion rate is increased.

Just what decrease in antecombustion chamber surface area will be effected by various increases in the combustion rate will naturally depend on the contour of the chamber wall. In an antecombustion chamber having the contour of a straight sided cone, as illustrated, the surface area will decrease almost in direct ratio to an increase in the combustion rate, whereas, if the contour is that of a tulip the decrease in surface area will not be as great as the increase in the combustion rate. If the contour is that of a morning glory, the decrease in surface area will be greater than the increase in the combustion rate.

Although it has been shown that a decrease in antecombustion chamber surface area does accompany an increase in the combustion rate, it should be borne in mind that this only holds true when the combustion rate which causes the flame to contact with the maximum surface area has been exceeded. If the antecombustion chamber is abnormally long, and the mixture is not subjected to a pressure which will deliver a sufficient quantity to cause a rate of combustion that will in turn produce a flame large enough to contact with the available antecombustion chamber surface area, this condition would not obtain, but rather, the surface area would increase with the combustion rate, which is not necessary nor desirable.

The conditions which I have found to be desired are these:

1. The design of an antecombustion chamber and the use of an air pressure, which will cause a sufficient surface area to be contacted by the flame at the maximum combustion rate desired, in order to effect a sufficient transfer of heat to the air so that the air will be raised to a temperature which will produce good vaporization of the fuel and the production of a thoroughly homogeneous mixture and thereby effect complete combustion of the fuel with the least quantity of air in excess.

2. An antecombustion chamber, the maximum surface area of which, when contacted by flame at a certain combustion rate will not be so great as to permit of a quantity of heat to be transferred to the air that will raise the air to a temperature that would prove harmful to the device, or cause pre-ignition.

3. A sufficient surface area of the antecombustion chamber to be contacted by a small flame, so that the temperature to which the air will be heated, at the minimum combustion rate desired, will be sufficient to cause a thoroughly homogeneous mixture to be produced.

4. That the maximum temperature to which the air will be heated should be attained at a combustion rate about three or four times the minimum combustion rate and that further increases in the combustion rate should be accompanied by decreases in air temperature.

The conventional type of automotive carburetor (which has been air sealed and pressure equalized to function at pressures in excess of atmospheric because the pressure of the air supply is in excess of the atmosphere) has been used in conjunction with my device because of several desirable functions which it so well performs, which are,

1. Fuel is not discharged from the constant level chamber (whether float or overflow) into the air stream unless air is flowing in said stream.

2. The rate at which the air flow controls the rate of fuel flow.

3. A butterfly valve is the means employed for

controlling the air flow and subsequent quantity of mixture produced.

4. Its adaptability to effect a constant ratio of mixture over a wide range of air velocities (capacity) and the simplicity with which the capacity may be varied by the movement of only the butterfly valve.

5. Atomization, vaporization, homogeneity of mixture and a high rate of flame propagation are so well obtained with the more volatile grades of fuel, at normal atmospheric temperatures, that the use of heated air causes similar conditions to exist with the less volatile grades of fuel.

6. After such settings are made as give the mixture ratio desired, no further manual adjustment is necessary. The butterfly valve may be operated by thermostat or other means to effect whatever variation or constancy of combustion rate that is desired without further attention from the operator.

By my having adapted such a means as the conventional automotive carburetor to the device which I have described for the transfer of heat from the flame to the air, I have perfected a novel method for the combustion of liquid fuel which embodies the following salient features:

1. Rapid and complete combustion of the less volatile grades of liquid fuel.

2. Maximum temperature from the combustion of liquid fuel when air is used as a source of oxygen. Because of a perfectly homogeneous mixture being produced, the quantity of excess air required is reduced to a minimum.

3. The automatic heating of air, to a predetermined maximum temperature which it is definitely known will not be exceeded in a given unit, by a natural physical means without the need of having a resort to a complicity of mechanical devices.

4. Entire control of combustion rate in a single and simple butterfly valve.

5. The wide variation in the rates of combustion which can be obtained in a given unit, and the sensitive control of the variation in the combustion rate afforded.

The unique but natural physical co-relations and their interdependence which exist, between rate of combustion, flame location, surface area contacted by flame, velocity of air passing over the surface area and temperature to which the air is heated, should be understood, because no other device yet disclosed suggests that any thought was given to their existence.

The effect of vaporization on homogeneity and the subsequent increase in the rate of flame propagation are discussed heretofore. It should be stated here that after complete vaporization of the fuel and the homogeneous mixing of the fuel vapor and air have been attained, further increase in the air temperature will not increase the rate of flame propagation. In other words, superheating the vapor will not increase the homogeneity of the mixture and having reached so called maximum homogeneity no increase in the flame propagation rate will result. It is realized that increasing the percentage of fuel in the mixture will increase the rate of flame propagation, but increasing the fuel percentage beyond that which the air percentage will completely consume is outside of this discussion, although use is made of it on starting, by temporarily supplying a slight excess of fuel.

That flame location is the result of the rate of flame propagation and the velocity of the mixture entering the antecombustion chamber, and that surface area contacted by flame is the result of flame location are discussed in detail heretofore.

If the mixture ratio of fuel and air is constant for all combustion rates then the velocity and quantity of air flowing between the sheath and the outer surface of the antecombustion chamber wall must vary directly as the combustion rate.

I have already discussed the relative surface areas of the antecombustion chamber which are contacted by flame at various combustion rates.

Starting with the lowest combustion rate practicable, we have this condition; a small flame starting at the fire screen and spending itself before its exit from the mouth of the antecombustion chamber. Consequently, only the rear of the chamber wall surface is contacted by the flame, the forward portion of the chamber wall receiving heat only from the hot gas after combustion is complete. A quantity of air, proportional to the combustion rate, is flowing over the relatively small surface with which the flame contacts, and heat is transferred to it, raising its temperature.

If now the combustion rate is doubled, the flame is enlarged, a greater surface area is contacted, and twice the amount of air is flowing over the surface.

The air is now heated to a higher temperature than before because the surface area contacted by flame has increased more rapidly than the quantity of the air passing over this surface. Whether or not the flame has been removed from the screen at this point is of little concern, the fact is a greater surface area is contacted.

As the combustion rate is further increased, a point will soon be reached where the maximum surface area will be contacted by flame. At this point, the air will be heated to a maximum temperature.

Further increasing the combustion rate is now accompanied by a decrease in the surface area contacted by flame but the quantity and velocity of air contacting with the other side of the wall are of course increasing in direct ratio with the combustion rate. The net result being that the final air temperature now decreases as combustion rate is increased.

It is very evident, therefore, that the final temperature to which the air is heated is closely related to the surface area contacted by flame and the quantity and velocity of air passing over said surface.

It will be seen from the foregoing and from the previous discussion that the final temperature to which the air is heated at various combustion rates is dependent on the size and contour of the antecombustion chamber. Other factors which have been found to have an effect on final air temperature are, the relative diameter of the main combustion chamber as compared to the mouth of the antecombustion chamber and the method employed for joining both chambers.

So far mention has only been made of final air temperature, for in fact, it is this which effects vaporization of the fuel. However, final air temperature is only the result of the quantity of heat transferred and the weight of air to which the heat is transferred.

Knowing the weight of air flowing per hour, the initial and final temperatures, the heat absorbed by or transferred to the air may readily be computed by the formula

$$Q=CW(t_1-t)$$

Where Q=B. t. u. absorbed or transferred per hr.
C=Specific heat of air
W=Weight of air flowing per hr.
t_1=Final air temperature
t=Initial air temperature

From the above, it is seen that if the same quantity of heat was absorbed by a lesser quantity of air, the final air temperature would be higher and vice-versa. But the quantity of heat absorbed by the air must be equal to the quantity of heat transferred to it from the flame through the surface of the antecombustion chamber wall. Lucke's formula for heat transfer is—

$$Q=Ko\ A\ h_m$$

Where Q=B. t. u. transferred per hr.
A=Area in square feet through which transfer is in process (the area contacted by flame.)
h_m=Mean temperature difference for the process which in this case would be the mean temperature difference existing between the flame and the initial and final air temperatures.
K_o=Coefficient of heat transfer, which is the conductance of the antecombustion chamber wall and fluid film of which the latter is of greater importance. The velocity at which the air passes over the wall has a marked effect on the fluid film. According to the experiments of Hinlein the value of K_o varies approximately as the square root of the air velocity. However, tests which I have made lead me to believe K_o varies almost directly as the air velocity. In fact, if Hinlein's values for K_o were used it would be found that the air temperature would drop so rapidly with increase of the combustion rate that the maximum capacity of a given burner assembly would be materially reduced by lack of sufficient air temperature to effect proper vaporization.

The size and contour of the antecombustion chamber, the annular cross section of the passageway between the sheath and the antecombustion chamber and the method of joining the chambers are all factors which have a direct bearing on the final temperature to which the air, that is subsequently to vaporize the fuel, will be heated.

Although I have shown the blower as forcing the air through the device I do not desire to be limited in this respect as it can be located between the device and the intake of the carburetor or between the carburetor discharge and the device.

In Figures 3, 4, 5, a modified form of my invention is illustrated. Pipe 60, delivers air into passageway 61 tangentially and in so doing causes the air to have an unidirectional course therethrough.

In other matters of construction and operation this modified form approximates that of the preferred form in Figures 1 and 2.

In describing the operation of the device, relief valve 20 was considered to be made inoperative. In some applications its use may be very desirable, for instance, where the heat generator is to be installed in batteries of two or more, it may at times be desirable not to operate all of the units in the battery. Where this is done it is possible that those units not being operated may become overheated due to radiation from their respective main combustion chambers. The use of relief valve 20, located as in Figure 1, permits of air being circulated as a cooling medium around the antecombustion chamber and said air to be discharged into the atmosphere without having to pass through carburetor 22. To furnish a supply of compressed air from a single source to a battery of heat generators described herein is entirely feasible and nothing herein is meant to be construed otherwise.

In Figure 6 is shown another modified form of my invention wherein the outer surface of antecombustion chamber 1 is equipped with fins 62 to expose a greater surface area to the air which is effected to pass over said surface on its way to the carburetor from a difference in pressure creating device. If desired the fins could be replaced by pegs.

Figure 7 shows another modified form of my invention, wherein the antecombustion chamber is equipped with an integral spiral fin 73. The air is discharged into casing 72 from a source of pressure and is effected to traverse a spiral path, over the total surface of the antechamber, on its way to the carburetor.

In Figure 8 is shown another modified form of my device wherein the carburetor 75 is located within the housing 2' which surrounds that portion of the combustion chamber 1 adjacent to the entrance of the fuel and air mixture and herein referred to as the antecombustion chamber. Such construction has certain advantages since it reduces to a minimum the distance travelled by the air or the mixture to and from the vaporizing and mixing means; a further advantage is to effect a direct heating of the fuel in the carburetor bowl which is desirable when very viscous fuels are used. Still another advantage is that the housing itself functions to afford equalization of the air pressures in, around and through the carburetor and therefore an air sealed carburetor is unnecessary. In addition such construction is compact, easily transportable and erected and has a neat appearance.

The construction is similar to the preferred and other modified forms in that antecombustion 1 has a conically shaped interior and exterior with its small end extending into housing 2'. Also sheath 6' is provided to direct the air which is subsequently to be used for combustion to come into intimate contact with the outer wall or surface of the antecombustion chamber, to absorb heat from said wall and thereby effect a cooling of the chamber wall and a preheating of the air used in combustion.

Carburetor 75 is located entirely within housing 2' and has its discharge 80' air-tightly connected to the small end or entrance of antecombustion chamber 1 and has its intake 13' located on the same center line as its discharge with the float chamber so located as to supply fuel to the jets which are in said intake and discharge line. Pipe 78 conducts fuel from an external source of supply to the float chamber of carburetor 75. Pipe 78 is preferably flexible to permit of ready assembly and where it passes through housing 2', it is air-tightly secured to prevent leakage of air to or from the housing.

A removable plug 79 may be located as indicated in housing 2' under the carburetor float chamber to permit of flexible pipe 78 being connected to the float chamber. End cap 18' is removably but tightly secured to housing 2' to permit of removal thereof in order to obtain access to carburetor 75 when necessary but must be secured to prevent leakage. Relief valve 20 in addition to its functions as heretofore set forth affords protection should excess pressures arise for any reason and is located at any convenient part of the housing or as shown in end cap 18'.

Carburetor butterfly shaft 81 is flexibly but securely connected to an extension 82 which passes through a stuffing box 83 to the outside of housing 2', permitting of carburetor butterfly 38' being operated from without housing 2' and yet permitting easy removal of carburetor 22' from the housing 2'.

Various changes might be made in the location and construction of certain elements and still fall within the scope of my invention. Certain of such changes I have illustrated in the various modifications.

In conclusion, the device which I have described provides for the metering of liquid fuel and air in constant ratio irrespective of the rate of combustion, the thorough vaporization of the less volatile grades of liquid fuel and the homogeneous mixing of the fuel vapor and air. Heating of the air to a temperature which will effect this thorough vaporization and homogeneity is accomplished by a means heretofore never employed. The method is unique in that it is thermodynamically balanced and requires no mechanical or manually operated contrivances to positively prevent overheating of the air at any combustion rate. Further, a single unit affords a wide but sensitive variation in the control of the rates of combustion without sacrificing any of the efficiency of combustion because the air is heated to a sufficient temperature over a range to effect good vaporization and homogeneity, and the means provided for metering and mixing the fuel and air does effect constancy of mixture over a similar wide range. Liquid fuel is burned completely with a minimum of excess air resulting in much higher temperatures from the combustion of liquid fuel than have heretofore been obtained. And withal, it is simple and economical to construct, operate and maintain.

Although the burner has been illustrated as operating in a horizontal position, it is to be understood that it is equally adapted to operate at any angle including the positions in which the mouth of the burner would be pointing directly upwardly or directly downwardly.

This application is a continuation of my copending application for Heat generator, Serial Number 318,900, filed November 12, 1928.

Having described by invention it is obvious that many modifications may be made in the same within the scope of the claims without departing from the spirit thereof.

I claim:

1. In a fuel burner of the carbureting type having a combustion chamber that diverges from adjacent the point of admission of the combustible mixture thereto and employing preheated air as the carbureting medium, means surrounding said combustion chamber and forming therewith an air preheating passage of approximately uniform cross-sectional area throughout the major portion of its length and which communicates at one end with the carbureting device, means at the other end of said passage for distributing the air entering said passage uniformly about the entrance thereto, and means for causing air to flow through said passage.

2. In a fuel burner of the carbureting type having a combustion chamber that diverges from adjacent the point of admission of the combustible mixture thereto and employing preheated air as the carbureting medium, means surrounding said combustion chamber and forming therewith an air preheating passage of approximately uniform cross-sectional area throughout the major portion of its length and which communicates at one end with the carbureting device, means at the other end of said passage for distributing the air entering said passage uniformly about the entrance thereto, means for causing air to flow through said passage, means forming a passage for delivering a combustible mixture of fuel and air to said combustion chamber, and means forming substantially an extension of said air passageway and surrounding said mixture delivering passage for transferring thereto a part of the heat of said preheated air prior to the point of entrance of said mixture into said combustion chamber.

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