Nov. 25, 1930. F. F. BRUSH 1,782,602

METHOD OF AND APPARATUS FOR VAPORIZING LIQUID FUELS

Filed July 15, 1929

Fig. 1.

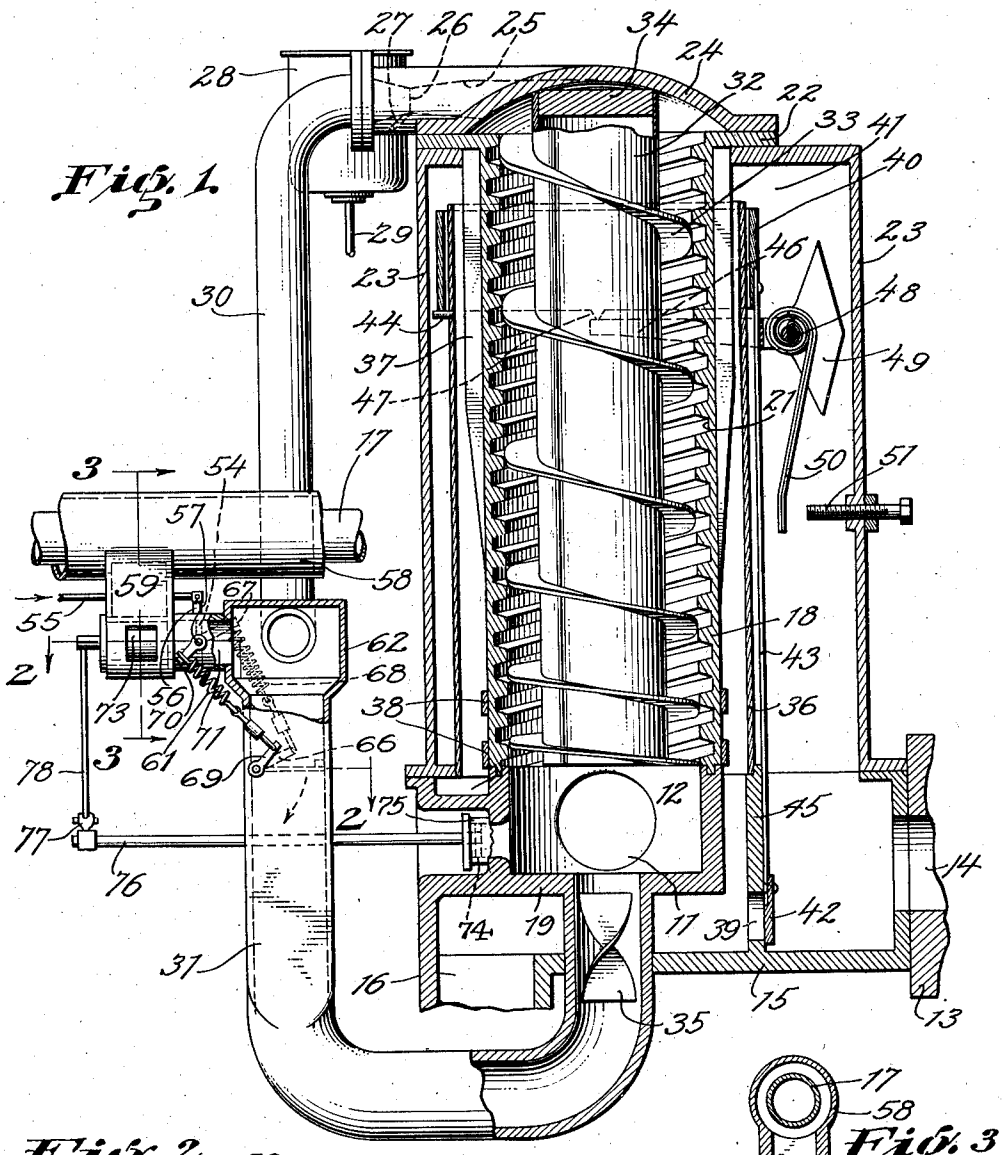



Fig. 2.

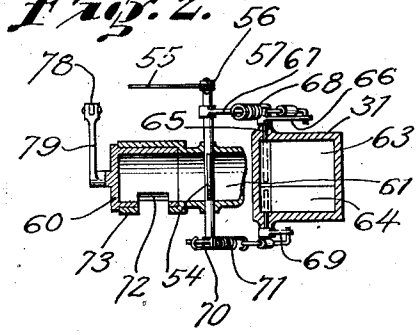
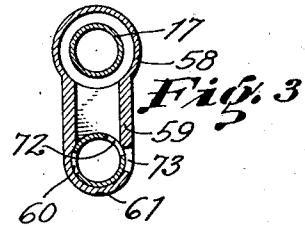



Fig. 3.




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# UNITED STATES PATENT OFFICE

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## METHOD OF AND APPARATUS FOR VAPORIZING LIQUID FUELS

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This invention relates to a vaporizer adapted to transform comparatively heavy liquid hydrocarbons such as crude oil or coal oil into a gaseous state, so that they can be readily utilized in internal combustion engines.

Attempts have been made in the past to operate internal combustion engines on low-grade fuels such as those mentioned. Although it is possible to do so with ordinary vaporizers, or vaporizers that are now well-known in the art, yet they are objectionable for reasons which will now be outlined.

When an engine is operating on gasoline, this fuel, being more readily placed in mist-like or gaseous form for effective utilization by the engine, can be readily converted into such a usable form without heating the fuel mixture to any substantial degree. An ordinary metering carbureter of any desired form, of proper proportions, can be used, the pumping action of the engine being utilized to draw the fuel mixture into the intake passages of the engine, and also to exert an induction effect upon the liquid fuel into the carbureter. The fuel, even if not thoroughly gasified, can yet remain in the air stream without material danger of condensation at temperatures only slightly higher than ordinary atmospheric temperatures. The engine utilizing such a gaseous fuel operates at high efficiency and power output because for unit volume of the cylinder space the weight of the fuel-air mixture is high as compared with its operation on a fuel-air mixture that has a much higher temperature. In other words, the volumetric efficiency of the engine is high.

In order to provide gasification or vaporization of the heavier or low grade hydrocarbons, it has been attempted in the past to utilize heat sufficient to secure this result; but such heating of the fuel-air mix is disadvantageous for the reasons mentioned.

It is one of the objects of my invention to make it possible to vaporize these low grade fuels or to form a fog-like mixture thereof, without material reduction of the engine efficiency and power; and I accomplish my result by the efficient manner in which heat is applied to the fuel to be vaporized.

Another source of reduction of volumetric efficiency of the engine if vaporizers of the prior art are used, may occur due to the fuel-air stream passing to the engine at a pressure materially lower than atmospheric, which again reduces the amount of fuel-air mixture taken by the engine per unit volume of displacement of its pistons. It is another object of my invention so to organize the vaporization of the fuel and the diffusion thereof in the air stream that the pressure of the fuel-air mix at the intake port is higher than in vaporizers of the prior art. Thus, due to the combination of comparatively low temperature and of the pressure conditions obtained by utilizing my invention, I can duplicate substantially the operation of the engine on gasoline. This is of prime commercial importance, because the cost of such low-grade fuels is only a fraction of that of gasoline.

It is another object of my invention to provide a vaporizer of low grade fuels that works so effectively that a substantially uniformly diffused fuel-air mixture is obtained prior to distribution to the intake ports of the engine. Thus there is an assurance that the engine will operate smoothly, since all of the cylinders thereof will obtain uniform fuel-air charges.

I accomplish these results by providing a heated conduit to which the liquid fuel is passed, which is placed above and directed downwardly to the distributing manifold, in conjunction with the plastering of the fuel by the air stream to be mixed therewith, onto the walls of the conduit, so as to place the fuel into most intimate heat exchange relationship therewith, said plastering of the fuel ensuring that particles thereof, not effectively utilizable by the engine, are automatically urged into contact with the heated surfaces.

In this way, no intense heating of the air stream is required; and due to the downward and straight flow of the mixture, moderate air stream velocities can be used, with an attendant moderately reduced pressure in the intake manifold. However, I find it advantageous in some instances to reduce the temperature of the fuel-air mixture so as

further to increase the efficiency and power output of the engine, as by the provision of a supplemental cooler air stream joining the main stream after the fuel is entrained therein. The cooling however is such that the fuel carried by the stream does not condense.

It may also be advantageous to provide auxiliary heating controls, but in the main, these can be omitted and yet the advantages of my invention may be obtained.

My invention possesses many other advantages, and has other objects which may be made more easily apparent from a consideration of one embodiment of my invention. For this purpose I have shown a form in the drawings accompanying and forming part of the present specification. I shall now proceed to described this form in detail, which illustrates the general principles of my invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of my invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a view, mainly in section, of a vaporizer embodying my invention, some of the elements being shown in diagrammatic form;

Fig. 2 is a detail sectional view, taken along plane 2—2 of Fig. 1; and

Fig. 3 is another detail sectional view, taken along plane 3—3 of Fig. 1.

The engine to which fuel is supplied by the vaporizer has an inlet manifold leading to one or more cylinders, and connected to a large port 11 leading from the fuel chamber 12. Its exhaust manifold 13 discharges exhaust gases to heat certain elements as will be explained hereinafter; these gases emerge from the opening 16 and may also serve to heat a conduit or pipe 17 (Figs. 1 and 3).

The fuel chamber 12 receives the fully vaporized fuel with its air admixture. The manner in which this vaporization and mixture occurs will now be described. Above the chamber 12, and in communication therewith, is a conduit 18 along the inner walls of which the liquid fuel is distributed, all as will be explained. This conduit is made from thermal conducting material, such as metal. It is arranged to be heated in order to vaporize fuel located on its inner surface. It can be held in place on the walls 19 of chamber 12 by a tongue and groove joint 20. This conduit 18 is preferably vertical, so that fuel introduced at the top thereof progresses downwardly as it is acted upon by a relatively fast moving column of air.

In order to provide a large heat exchange surface on the inner wall of the heated conduit 18, there are preferably grooves 21 in the inner face of the conduit 18. As explained hereinafter, these grooves provide a heated surface to which that portion of the fuel, not sufficiently vaporized or subdivided, to be effectively used in the engine, is passed laterally from a moving column of a fuel-air mixture. The grooves 21 can be formed as by cutting or casting a helical thread in the interior of conduit 18.

The upper end of the conduit 18 is held in place upon casing 23, as by the aid of the flange 22. This casing 23 envelopes conduit 18, and rests upon the member 15 from which the exhaust outlet 16 extends, and which has an orifice 14 in communication with the exhaust manifold 13. Closing the top of conduit 18 there is a cover 24. This cover has a passageway 25 leading to the interior of the cover and over conduit 18. This passageway can be designed to accommodate a modified standard carbureter or a venturi 26, for delivering the fuel to the vaporizer, said venturi having a port 27 leading to a fuel float chamber in casing 28. A fluid fuel supply pipe 29 is shown as connecting to the float chamber. It is now well understood that as a stream of air rushes past such a Venturi throat as indicated at 26, fuel can be drawn through the aperture 27 to be carried along by the air stream. This air flow is caused by the pumping of air by the engine when in operation, and is conducted to the intake manifold by way of aperture 11.

The passage 25 connects to a conduit or tube 30 opening into a larger conduit 31. Air may, if desired, be supplied to conduit 31 in a manner hereinafter to be described. For the present, it is sufficient to state that air enters conduit 30, passes through venturi 26, down into conduit 18, and out into the intake manifold of the engine through aperture 11. The air passes through conduit 18 in a downward direction, and it is caused to whirl so that all entrained liquid particles of fuel that are too large to be effectively utilized by the engine will be thrown off laterally from the air stream by centrifugal force, against the inner wall of conduit 18, where it is readily vaporized by the heat trasferred to it from the walls of conduit 18.

For whirling the air in conduit 18, there is formed an annular space therein, between its inner wall and a column 32 extending axially of the conduit. The air stream must pass through this annular space, and is caused to whirl or describe a helical path by the provision of the helicoidal vane or flange 33. This vane may be substantially as wide as the width of the annular space between column 32 and conduit 18. It may, if desired, provide a helicoidal passageway for the air stream that is much larger in effective area at the top, where the air enters the space, than it is at the bottom, where the air leaves the annular space. This is secured by gradually decreasing the pitch of the helix formed by vane 33.

However, the whirl of the air even at the

top is sufficient to impress a considerable centrifugal force upon any liquid fuel particle entrained therein, which is too large to be effectively utilized in the engine. This causes the particles to be thrown laterally against the heated conduit 18, from which it absorbs the requisite heat for its vaporization. The column 32 is closed at the top, as by stopper 34. The entire air stream from passage 25 must therefore pass through the annular passageway. The colmun 32 can be supported in the conduit 18 in any appropriate manner.

Air is passed to chamber 12 to supplement the air stream flowing through conduit 18 by way of the conduit 31, and up through the optional spiral vane 35. This vane serves to induce efficient commingling of the two air streams in space or chamber 12.

The members 15 and 23 form an enclosing chamber for conduit 18. Into this chamber is admitted the hot exhaust gases. These gases must first travel upwardly in member 23; and then downwardly through the tube 36 spaced from conduit 18, and having its top spaced below flange 22. The gases finally emerge from opening 16, and pass out through the conduit 17. The heating of conduit 18 can readily be kept such that it is maintained at a temperature below the cracking point of any fraction in the fuel. In order to secure quick vaporization, the top of conduit 18 may be provided with a greater heat absorbing power but a characteristic lower temperature. For this purpose, there are a series of teeth or ribs 37 arranged longitudinally of the exterior of the conduit. These taper off toward the bottom so that there is less heating effect; further to shield the bottom from excessive heat, I may provide one or more heat insulating rings 38. The ribs 37 being vertical, the passage of the exhaust gases past them will tend to prevent any carbon or soot depositing on the ribs. Due to the provision of heat from exhaust gases, the greater the volume of air and fuel taken in to take care of a greater load on the engine, the more heat is supplied to conduit 18.

I may provide an automatic gate or shutter that limits the amount of exhaust gases that are allowed to pass down through tube 36, as compared with the amount that can pass, as by orifice 39, directly to outlet 16 without taking the tortuous path through tube 36, and that is actuated only when the temperatures obtained are excessive. This control, however, may be omitted for all ordinary engine operation. For this purpose, I provide a sleeve 40, loosely slidable over tube 36. This sleeve, if moved upwardly, will cover the communicating opening 41 between the interior of member 23 and that of tube 36. At the same time, it will lift a gate 42 from orifice 39 to open this by-pass. Gate 42 is shown as mechanically connected to sleeve 40, as by a strip 43. It is evident that as sleeve 40 is moved upwardly, it closes passageway 41 and causes orifice 39 to be uncovered to an extent depending upon the vertical position of the sleeve. A stop pin 44 can be used to serve as a rest for the sleeve in its lowermost position shown. Furthermore, the sleeve 40 is guided in its vertical movement although loose on tube 36 due to the spaced position of gate 42 on the wall 45 of member 15. In this way, the tilting of the sleeve is materially restricted.

The axial movement of sleeve 40 is rendered automatic in response to the attainment of an excessive temperature of the exhaust gases. When an engine is started cold, and in normal operation, the exhaust gases of course are not very hot; and under such circumstances, sleeve 40 should be in its fully opened position shown. However, after the engine becomes highly loaded, the sleeve 40 is moved upwardly and takes a position that reduces the amount of gases passed around conduit 18. In most instances however the exhaust gases do not provide such excessive heat as to be materially harmful even without this automatic regulation.

For the initial heating period, sleeve 40 can be left unmoved. The manner in which this control can de effected will now be described. Sleeve 40 rests upon a fork 46 and may be provided with a pair of diametrically opposite knife edges 47 for this purpose. Fork 46 is fixed to a shaft 48 and has a counterweight 49 which however is not quite sufficient to overcome the weight of sleeve 40. Thus in inactive condition of the engine, the sleeve 40 is in the position shown. A temperature responsive device operates on shaft 48 to turn it in a clockwise direction when the temperature reaches a definite excessive value. This device is shown as a coiled bimetallic element 50 exposed to the temperature of the gases in casing 23. Its inner end is fastened to shaft 48. As the temperature increases, this coiled member tends to unwind. At first this unwinding has no effect upon the shaft 48, for the free end of member 50 merely moves toward the right.

However, after a definite excessive temperature is reached, the free end contacts with an abutment 51, and further unwinding is effective to rotate shaft 48 and fork 46 in a clockwise direction. This serves to raise the sleeve 40 and gate 42, thereby causing less exhaust gases to pass down through tube 36 and more to be by-passed through orifice 39. In this way a definite limit to the amount of heat imparted to the conduit 18 is provided. By making abutment 51 adjustable, the degree of heat attained in operation can be controlled to some extent. Thus I show abutment 51 as a headed screw engaging into a tap in the wall

of casing 23, to provide convenient external manipulation of the abutment.

In order to secure maximum efficiency and power output from the fuel mixture it should be kept as cool without condensation, before entering the engine as possible, whereby the weight of air per unit volume of engine displacement is maintained at a high value. If this condition may not be readily met by the air entering through the carbureting device 26, I cool the mixture after the fuel is vaporized to a usable stage by a colder air stream so proportioned as to give the desired mixture at the lowest permissible temperature. It is for this reason that a supplemental air supply through conduit 31 is provided. A control is so arranged that the volume of air drawn in through conduit 31 is made dependent upon the main throttle position, although in many instances this dependance may be dispensed with, and any usual form of air intake device can be used. The main throttle is indicated at 54 (Figs. 1 and 2) and as capable of manipulation by the aid of a pedal controlled link 55 operating on a lever arm 56, fixed to the throttle carrying shaft 57.

As indicated most clearly in Figs. 1 and 3, air may be supplied past throttle 54 from a space enclosed between exhaust conduit 17 and a sleeve 58 disposed thereover. Thus warmed air passes through the casing 59 (Fig. 3), through the barrel 60, and into the conduit 61 (Fig. 2) in which the throttle 54 is located, and which leads into the top part 62 of conduit 31. In the present instance, I indicate in Fig. 2, a pair of hinged valves 63 and 64, in conjunction sufficient, if desired, to extend entirely across conduit 31. Valve 63, which is the "running" valve, is shown as fastened to a shaft 65 rotatable by a lever 66. This lever is resiliently joined to lever 67 on throttle shaft 57, as by the aid of an adjustable tension spring 68. The spring tension and lever arms are all so proportioned that the first movement of throttle 54, in a clockwise or opening direction, serves to remove the extreme excess spring tension and allows the spring to return to normal adjusted tension almost at the first stage of movement of the throttle. This slacking of the spring is accomplished very fast at the beginning of the opening movement due to the angular position of arm 67, relative to throttle 54, whereby during substantially the whole period of operation, the effect of valve 63 is not substantial.

Valve 64, which is the idling valve, is operated by the aid of levers 69, 70, and spring 71. Spring 71 is placed strongly under tension right at the start of the opening movement of throttle 54. The relative areas of control of the two valves are determined by trial. This control if utilized thus provides for a functional relation (that is predetermined by the design) between throttle opening and the proportion of the air stream that is permitted to pass through throat 26.

There is also provided a supplemental control for the temperature of the air stream. In order to ensure that the fuel in chamber 12 will be maintained at a temperature above the condensation temperature of the fully vaporized fuel in chamber 12, and yet not very unduly heated, the barrel valve 60 is arranged to be adjusted to permit definite quantities of cold air to be taken into conduit 61. Thus the valve 60 has a peripheral port 72 (Figs. 3 and 4) that can be in partial and variable registry with aperture 73 in conduit 61. The degree of opening thus uncovered of aperture 73 is dependent upon the angular position of valve 60 in conduit 61. This angular position is made responsive to temperature conditions at chamber 12, as by the aid of a coiled thermostat 74 in an extension 75 of chamber 12. This thermostat acts on shaft 76 to rotate it and lever 77 carried thereby. This lever in turn moves a link 78 connected to lever 79 on valve 60. If the temperature in chamber 12 becomes too low for proper operation, the valve 60 is caused to be moved to shut out more of the cold air, whereby more heated air through sleeve 58 is utilized. On the other hand, if the temperature in chamber 12 becomes too high for proper operation, the barrel valve 60 uncovers a greater portion of aperture 73 to permit more cold air to be drawn in.

A recapitulation of the operation of the device can now be set forth. The predetermined proportion of cold and hot air is drawn into conduit 61. The air flowing through conduit 30 takes up the desired amount of fuel at the Venturi throat 26, this being one conventional means for introducing the fuel into the system.

The conduit 18 is kept below excessive temperatures by the operation of thermostat 50. The fuel is substantially entirely vaporized and is carried by the air stream into chamber 12, where the supplemental air supply from conduit 31 reunites with the fuel mix. Thence the mixture continues on through aperture 11 into the intake manifold of the engine.

I claim:

1. In a vaporizer for hydrocarbon fuels for use in internal combustion engines, a pair of air stream conduits, means whereby fuel in liquid form is supplied to one of said pair of conduits, means for heating the mixture in said conduit to vaporize the fuel, means for combining the two streams after said heating is accomplished, and means whereby the air stream in the first mentioned conduit is preliminarily heated in accordance with temperature conditions of the combined streams.

2. In a vaporizer for hydrocarbon fuels for use in internal combustion engines, a pair

of air stream conduits, means whereby fuel in liquid form is supplied to one of said pair of conduits to vaporize the fuel, means for combining the two streams after said heating is accomplished, and means whereby the quantity delivered by one stream is controlled in accordance with the total rate of air delivered to both streams.

3. In a vaporizer for hydrocarbon fuels for use in internal combustion engines, a pair of air stream conduits, means whereby fuel in liquid form is supplied to one of said conduits, means for heating the mixture in said conduit to vaporize the fuel, means for combining the two streams after said heating is accomplished, a throttle for controlling the flow of air to both streams, and means operated in accordance with the throttle position to control the proportion of air passed to each stream.

4. The process of treating hydrocarbon fuels for internal combustion engines, which comprises passing heated air in two streams to the engine, passing liquid fuel to one of the streams, treating said stream to vaporize the fuel, combining both streams after said vaporization, and varying the rate of air flow in one of the streams in accordance with the total rate of air delivered to both streams.

5. In a vaporizer for hydrocarbon fuels for use in internal combustion engines, a conduit into which liquid fuel and air can be supplied, an enclosing casing for said conduit, means providing a by-pass for the exhaust gases, and means for simultaneously controlling the by-pass and the entry of exhaust gases into the casing, including a sleeve extending over the casing, and controlling a passageway into the casing, a gate mechanically connected to the sleeve, controlling the by-pass, and a bimetallic element movable in accordance with temperature changes and affecting the position of the sleeve and gate, said element being in the path of the exhaust gases.

6. In a vaporizer for hydrocarbon fuels for use in internal combustion engines, a main air stream conduit, means for regulating the density of the air stream in said conduit, a pair of air stream conduits leading from said main air stream conduit, means whereby fuel in liquid form is supplied to one of said pair of conduits, means for heating the mixture in said conduit to vaporize the fuel, means for combining the two streams after said heating is accomplished, and means whereby the air stream in the main conduit is preliminarily heated in accordance with temperature conditions of the combined streams.

7. In a vaporizer for hydrocarbon fuels for use in internal combustion engines, a conduit into which liquid fuel, and air can be supplied, an enclosing casing for said conduit, means providing a by-pass for the exhaust gases, and means for simultaneously controlling the by-pass and the entry of exhaust gases into the casing, including a sleeve extending over the casing, and controlling a passageway into the casing, a gate mechanically connected to the sleeve, controlling the by-pass, a bimetallic element movable in accordance with temperature changes and in the path of the exhaust gases, and an abutment normally spaced from the element to cause it to respond to operate the sleeve and gate only upon the attainment of a temperature sufficient to bring the bimetallic member to said abutment.

8. The process of supplying an internal combustion engine having an intake manifold, with a mixture of air and fuel of the heavy hydrocarbon type, which comprises first, inducting the fuel into an air stream; second, passing the said stream through a downwardly directed conduit connected at its lower end with the manifold so that the whole stream of fuel and air is fed to the intake manifold substantially continuously downward; third, heating the wall of the conduit; fourth, urging fuel particles in the stream that cannot be readily utilized by the engine, onto the heated wall of the conduit, where they are vaporized and from which wall the vaporized fuel is remingled with the stream to be used directly in the engine.

9. The process of supplying an internal combustion engine having an intake manifold, with a mixture of air and fuel of the heavy hydrocarbon type, which comprises first, inducting the fuel into an air stream; second, passing the said stream through a downwardly directed conduit connected at its lower end with the manifold so that the whole stream of fuel and air is fed to the intake manifold substantially continuously downward; third, heating the wall of the conduit; fourth, urging fuel particles in the stream that cannot be readily utilized by the engine, onto the heated wall of the conduit, where they are vaporized and from which wall the vaporized fuel is remingled with the stream to be used directly in the engine; and fifth, supplementing the fuel-air stream with another cool stream of air to reduce the temperature of the stream to only slightly above the condensation point.

10. In a device for supplying a mixture of heavy hydrocarbon fuel and air to an internal combustion engine having an intake manifold, an imperforate conduit leading downwardly into the intake manifold, for leading the whole of a fuel-air stream that is directed downwardly in the conduit, to the manifold; means for heating the wall of the conduit; and means for urging fuel particles not readily utilizable by the engine into contact with the wall to vaporize them, and from which wall all of the said fuel is returned to the stream to feed it into the manifold.

11. In a device for supplying a mixture of

heavy hydrocarbon fuel and air to an internal combustion engine having an intake manifold, an imperforate conduit leading downwardly into the intake manifold, for leading the whole of a fuel-air stream that is directed downwardly in the conduit, to the manifold; means for heating the wall of the conduit, means for urging fuel particles not readily utilizable by the engine into contact with the wall to vaporize them, and from which wall all of said fuel is returned to the stream to feed it into the manifold; and means for passing a supplemental cool air stream to said stream to reduce the temperature to a point neighboring the condensation point of the fuel in the stream.

In testimony whereof I have hereunto set my hand.

FREDERICK F. BRUSH