Oct. 31, 1944. G. GERSON 2,361,761

LIQUID FEED CARBURETOR

Filed Dec. 20, 1941 2 Sheets-Sheet 1

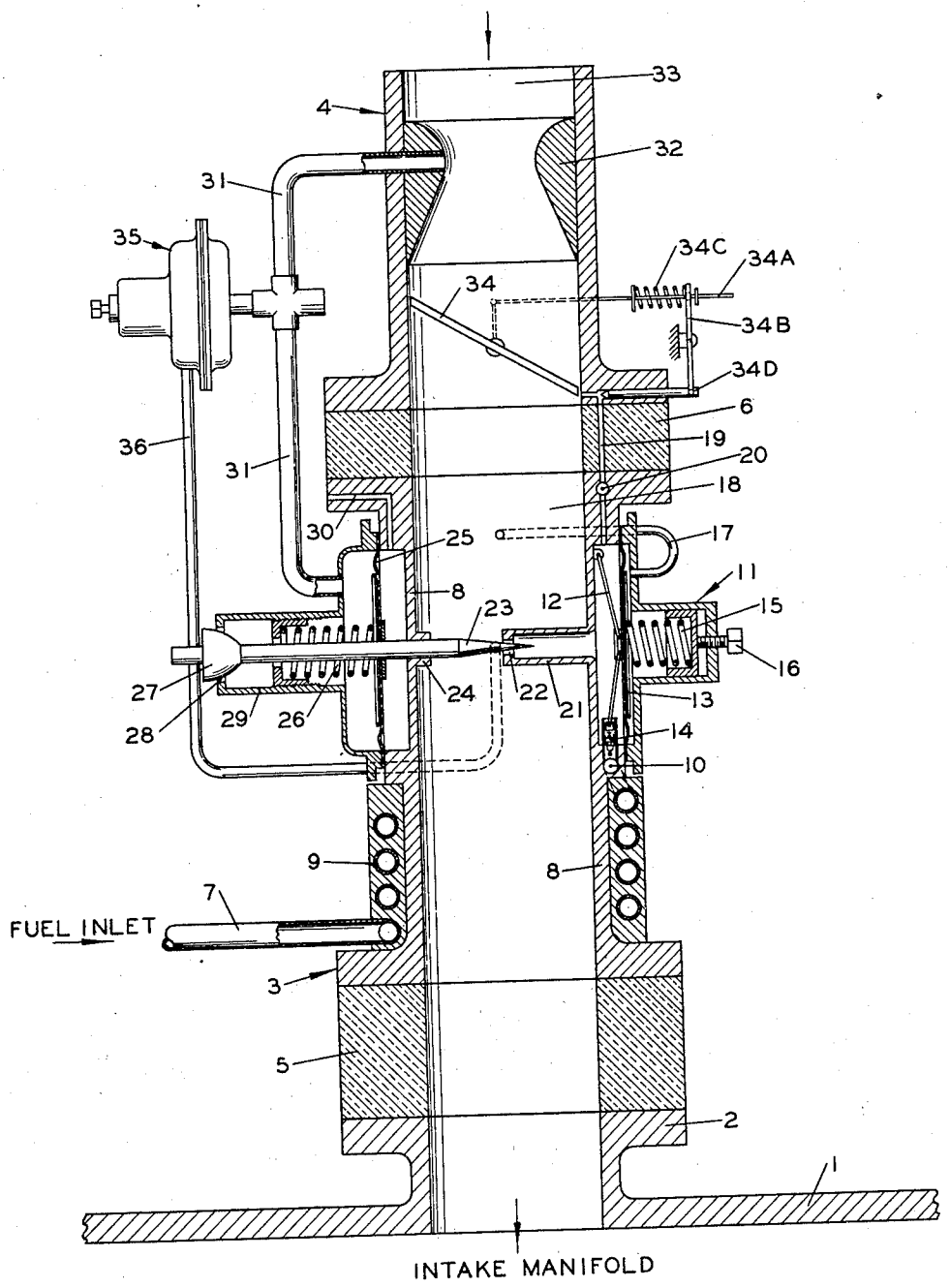


FIG. 1

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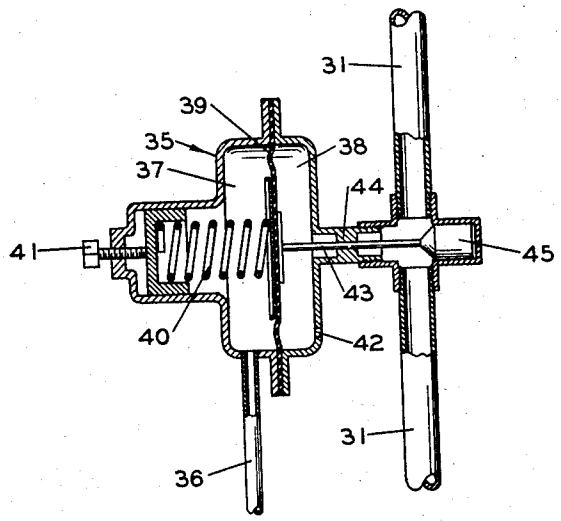


FIG. 2

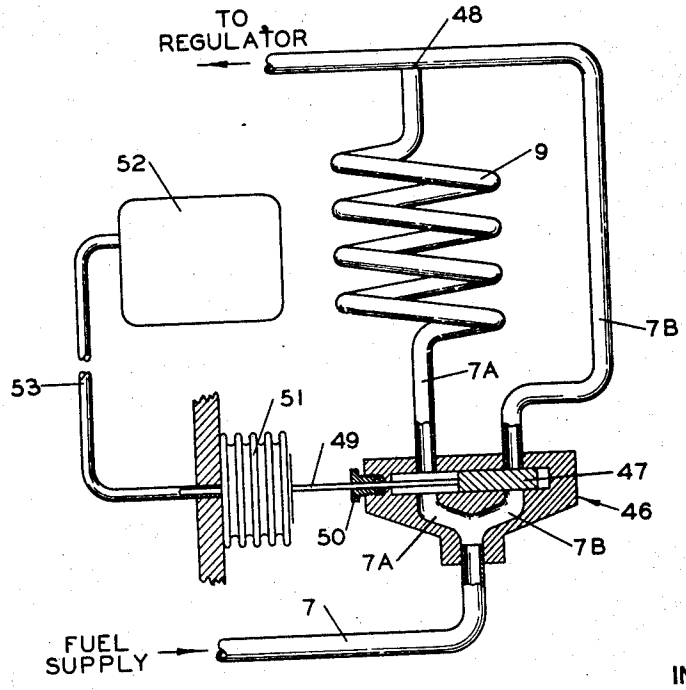


FIG. 3

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UNITED STATES PATENT OFFICE

2,361,761

LIQUID FEED CARBURETOR

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Application December 20, 1941, Serial No. 423,833

6 Claims. (Cl. 261—11)

This invention relates to a device for carbureting various hydrocarbon fuels, which may range in volatility from that possessed by regular gasoline to that of liquid propane, for example. The device here disclosed is designed to accommodate these fuels, or mixtures thereof, without detrimental vapor lock which would result from attempting to use the more volatile ones in a normal liquid carburetor of the types now in wide use.

A definite economic advantage may be realized by utilizing some of the higher pressure hydrocarbons, under certain market conditions. A definite mechanical advantage may always be realized from use of these highly volatile fuels, since their detonation characteristics permit use of high compression ratios with a resultant increase of horsepower for a given engine size.

A primary object of this invention is to provide satisfactory means of carbureting both high and low pressure hydrocarbon fuels without attendant vapor lock.

Another object is to accomplish carburetion of the above fuels in such a manner that the marked icing or freezing tendencies noted in other designs will be avoided. My device has a definite advantage over other carburetors in this respect, due to the provisions made for locating the throttle valve above or outside the main fuel orifice. Thus, the air entering the intake is already past the throttle before the cooling effect of fuel vaporization takes place, and there will, therefore, be no tendency to deposit ice on the throttle. The whole interior of the system below the point of fuel admission is free from projections which might otherwise collect ice from the supercooled air-gas mixture.

A further object of this invention is to provide for introduction of a powerful fuel charge to the engine when under heavy load, even at low engine speeds.

A still further object of the invention is to accomplish the above cited ends without the employment of a float mechanism. The device is, therefore, adaptable to use in aircraft, since it will function properly at all altitudes and in all altitudes of flight, including the inverted condition.

Other advantages will be apparent to those skilled in the art from a consideration of the following disclosure.

Figure 1 shows a preferred embodiment of my invention, although several variations from that form may be employed, as will be discussed later. In this figure, a vertical section through the principal parts is revealed.

Figure 2 is an enlarged sectional elevation of the suction compensator which is shown as a part of Figure 1.

Figure 3 shows one manner in which the degree of cooling imparted to the fuel may be automatically controlled.

Referring to Figure 1, the numeral 1 indicates the intake manifold of an internal combustion engine, provided with a flange 2. The lower portion of the carburetor device is indicated generally by 3, and 4 indicates generally the upper section of the carburetor. The whole carburetor assembly is separated from the manifold by a thick heat-insulating gasket 5, and the upper section is insulated from the lower by a similar gasket 6, appropriate flanges being provided at each juncture for bolting the respective elements to each other.

The fuel inlet pipe 7 connects to a source of fuel under pressure, not shown, and its continuation is wrapped around the carburetor mixer tube wall 8 so as to form a heat exchange coil 9. At 10 is located a shut-off valve to prevent flow of fuel while the engine is not operated. The construction of this valve is not illustrated, but it can be of any well known form and can be operated manually, magnetically, by engine oil pressure or by manifold suction.

A fuel pressure regulator is indicated generally by the numeral 11, which is comprised of a linkage 12 which transmits the motion of diaphragm 13 to the valve 14, which may be a tire valve inside or the like. Resilient loading of the diaphragm is provided by spring 15, adjustable through screw 16. The space on the outer side of the diaphragm is vented by means of tube 17 to the interior of the carburetor mixing tube 18. A small passage 19 communicates between the pressured side of the fuel regulator diaphragm and the mixer tube for admission of idling fuel, the amount of which is regulated by an adjustable needle valve 20. A tubular outlet 21 leads from the regulator to the interior of the mixing tube, with respect to which the outlet is located radially, and is fitted with a tapered seat 22.

On the opposite side of the mixing tube, a movable valve needle 23 operates coaxially with respect to the valve seat 22. This needle enters the mixing tube through a closely fitted guide sleeve 24, motion being imparted to the needle by means of a diaphragm member 25, resiliently loaded by spring 26. At the outer end of the

valve needle stem a bleed valve 27 is provided, which variably cooperates with an opening 28 in the needle valve governor bonnet 29. The bleed valve member preferably has the form of a prolate hemispheroid, the determination of which form will be discussed presently.

The space enclosed between the diaphragm 25 and the wall 8 is vented to the atmosphere through channel 30, the space on the opposite side of said diaphragm being ultimately connected, by the tubing line 31, to a Venturi section 32 which is located near the air inlet 33. A throttle valve 34 of conventional form is located between the Venturi section and the fuel control valve. Throttle lever 34A is yieldingly connected to the pivoted lever arm 34B by means of spring 34C, which operates to close the needle valve 34D when the throttle is opened to any degree beyond the idle position. Control of the absolute pressure in the line 31 (normally sub-atmospheric) is provided by the suction compensator which is generally indicated by numeral 35.

The manner of construction of the suction compensator 35 is disclosed in Figure 2. The suction compensator is divided into two chambers 37 and 38 by the diaphragm 39, the latter being resiliently loaded by a spring 40 and an adjusting screw 41. The chamber 37 is connected by line 36 to the carburetor mixer tube in the vicinity of the fuel needle valve. The chamber 38 is vented to the atmosphere by means of a hole 42 in the compensator case. To the diaphragm is attached a rod 43 which passes through a gland 44, by which means the diaphragm is made to control a valve 45 located in the line 31, the latter being the same line 31 that is shown in Figure 1. When the engine is under load, particularly at low engine speed, air velocity through the venturi and consequently suction on the diaphragm 25 decreases. This condition may be alleviated by virtue of the compensator 35 which is adapted to increase suction on the diaphragm 25, moving the valve 23 to the left and enriching the air-fuel mixture under load. At this time decreased suction below the throttle valve 34 is communicated to the compensator diaphragm 39 through line 36, moving valve 45, which normally occupies an intermediate position, to the right.

In Figure 3 is shown one method of automatically controlling the flow of fuel either through the cooling coil 9 or not, as different conditions of temperature may require. The fuel line 7 leads from the supply source to a control valve generally indicated by the numeral 46. Here the line is divided into branches 7A and 7B, which branches are alternately or selectively closed, either in part or in full, by the single valve member 47, slidably mounted in the closely fitting bore of the control valve. From the valve, branch 7A proceeds to the cooling coil 9, while branch 7B by-passes the coil, and the two branches come together again at the junction 48. From this point, the fuel flow is led to the pressure regulator 11 as in Figure 1.

The position of the valve member 47 is adjusted by means of the stem 49, which emerges from the valve body via a packing gland 50. To the outer end of the stem 49 is attached a temperature responsive element. I have chosen to illustrate this element as a system comprised of a Sylphon bellows 51, a temperature detecting bulb 52, and inter-connecting tubing 53, the latter three elements being a closed system within which is sealed either a highly volatile liquid, or one having a high coefficient of thermal expansion. The left end of the bellows is rigidly secured to any convenient support common to the valve 46, so that any expansion or construction of the bellows will be translated to longitudinal displacement of the valve member 47. The detector bulb 52 is to be located at any desirable point either under the engine hood, or if requirements warrant it, in the cooling system of the engine.

In operation, my carburetor system performs in accordance with the following discussion. Referring to Figure 1, fuel under pressure is conducted from a tank, not shown, through line 7 to the cooling coil 9. It will be noted that the coil is in such relationship with the fuel discharge nozzle in the mixer tube that an exchange of heat between the two will exist. In other words, the heat required for vaporization of the liquid fuel will be largely obtained from the cooling coil and its contents. Thus, any specific small quantity of fuel, upon vaporizing at the fuel nozzle, will serve to cool succeeding quantities of fuel entering coil 9. A continuous and self-sustaining cooling effect will be maintained by this means. The net result of this process is the elimination of ebullition or vapor lock which would otherwise occur before the fuel orifice when using high vapor pressure fuels, as 26 pounds per square inch Reid vapor pressure gasoline, for example. The ability of this arrangement to prevent vapor lock before the main fuel jet is further enhanced by the fact that the diaphragm 13 is so disposed that it will serve to insulate the liquid fuel on its inner side from the warm air which may prevail at any time on its outer side.

Having passed through the cooling coil, the fuel now enters the pressure regulator via the valve 14. The diaphragm 13 reacts to the admitted fuel under pressure, and as a result the valve 14 is automatically throttled to admit whatever pressure the regulator may be adjusted for. Because of the communication between the outer side of the diaphragm 13 and the carburetor mixing tube 18, via channel 17, the setting of the fuel regulator will automatically be compensated according to the absolute pressure within the mixing tube. In other words, the regulator will tend to maintain a constant pressure differential across the orifice 22, rather than maintaining the fuel at a constant pressure above atmospheric; resulting in a definite air-fuel ratio for any given position of needle 23, regardless of the absolute pressure within the mixer tube. It is obvious that due to the cooling effect imposed on the fuel in the coil, the vapor pressure of the fuel will be lowered sufficiently to preclude vaporization on pressure reduction.

A quantity of fuel sufficient for idle running is bled through channel 19, under control of needle valve 20. At the idling condition, the main throttle 34 is closed, and a high degree of sub-atmospheric pressure, which hereinafter will be referred to simply as "vacuum" or "suction," exists in the intake manifold of the engine, and at all points between the engine and the main throttle. The spring 26, meanwhile, is holding the needly valve 23 toward the right, or the "closed" position, and no fuel, therefore, is admitted to the carburetor from the main nozzle 21. Sufficient air for burning the idling fuel is passing the main throttle.

It should be understood that the high suction existent in the mixer tube during idling is not transmitted directly to the right hand side of diaphragm 25. The close fit between the stem of needle 23 and its guide 24 is intended to pre-

vent this. Moreover, even if some leakage around the needle stem should occur, due to eventual wear, the vent channel **30** would offset this leakage so that the suction in the mixer tube could not build up any appreciable vacuum in the chamber enclosed by the diaphragm and the tube wall **8**.

Suppose now the throttle is opened, with the engine free from load. Air passes through the venturi **32** at high velocity, inducing a suction in the line **31**. Disregarding the compensator **35** for the time being, suffice it to say that the suction is transmitted to the needle valve governor, where it acts upon the diaphragm **25** so as to retract the needle **23** against the loading of the spring **26**. Fuel is now entering the carburetor from the main nozzle **21**, and the engine accelerates until an equilibrium condition is reached, dependent upon the degree of throttle opening. Meanwhile, upon initial opening of the throttle, the idling fuel supply has been shut off by the operation of the needle valve **34D** and its related linkage, so that fuel is now entering past the main valve **23**, only.

Upon application of a load to the motor, the tendency is to slow the engine as the load is applied. This in turn tends to reduce the air velocity through the venturi, with a further result that the suction is weakened somewhat in line **31**, allowing the needle to move toward the fuel nozzle seat. The fuel flow would thus be reduced, resulting in a partial loss of power. This condition, however, may be alleviated and the power correspondingly increased by operation of the suction compensator to be hereinafter described.

Referring to Figure 2, the suction compensator operates as follows:

Assume that the valve **45** was previously adjusted by the setting of the spring **40** so as to take an intermediate position for ordinary running at moderate load condition and fairly high speed. A heavier load is applied, and the engine tends to slow down as just above described. At the same time that the air velocity tends to decrease at the venturi, it also tends to decrease at the point where line **36** enters the carburetor, below the throttle valve. A decrease in suction occurs in line **36**, which so reacts upon the diaphragm **39** that the valve **45** is opened further. Thus the effect of decreased suction in line **31** is offset by an adjustment of the restriction in that line. The result is that the fuel needle does not close in response to the reduced air velocity, and the resulting richer and more powerful mixture enables the engine to cope with the additional load imposed upon it, regaining or maintaining speed according to the degree of throttle opening.

Three major features and functions of my device have been disclosed and described, consisting of: (1) a means of preventing vapor lock by cooling the high vapor pressure fuel and reducing its pressure after cooling, just previous to admission to the mixer; (2) a means of proportioning the fuel, responsive to variations in rate of air intake; and (3) compensating means which serve to maintain full engine power when additional load is imposed at low speed or when the load so imposed tends to reduce engine speed.

Certain other refinements are desirable and are held to be vital to and within the scope of my invention, albeit certain elements of the refinements are well known devices per se.

For example, in Figure 3, a means of thermostatic control of fuel cooling is illustrated. It is conceivable that under certain conditions of cold weather and high humidity ice formation may occur in the vapor intake tube. Therefore, it may be desirable to control the cooling function when a low atmospheric temperature sufficiently cools the fuel to prevent vaporization in the pressure reducing regulator, thereby eliminating ice formation in the intake tube. The arrangement shown in Figure 3 in effect accomplishes the delivery of the liquid fuel to the carburetor jet at a constant temperature when the temperature responsive bulb is secured to the outside of the intake tube in the vicinity of the fuel nozzle.

Numeral **52** in Figure 3 indicates a temperature detector or thermostat bulb of the liquid-filled variety, and may be located under the engine hood near the engine manifold on the fuel cooling coil itself or anywhere it is subjected to the vapor temperature in the intake tube. By its influence upon the Sylphon bellows **51**, adjustment of the flow through the cooling coil and/or the by-pass will be so proportioned as to result in the desired degree of cooling under various conditions of atmospheric temperature etc. The by-pass **7B** functions as a heat exchanger, being subjected to under-the-hood temperature, and may be formed of metal having a high heat conductivity or provided with fins. As shown in Figure 3, the flow would be entirely through the cooling coil. During extremely cold weather the valve would occupy the extreme left position. The fuel would then flow entirely through the heat exchanger **7B** until the temperature of the incoming fuel is sufficiently elevated to avoid icing difficulties. At ordinary atmospheric temperatures the valve **47** occupies an intermediate position.

Another refinement which appears in Figure 1 pertains to the air bleed valve **27** on the outer end of the needle valve stem. By experimental means, it is possible to so form the bleed valve that a substantially constant air/fuel ratio can be obtained using a straight tapered needle valve. Without this provision, a valve needle of special contour would be required, due to the non-rectilinear relationship between rate of air flow at the venturi and the resultant displacement of the diaphragm. Since the valve needle must necessarily be of small diameter, the machining of the required corrective contour upon the needle proper would be extremely difficult, if not impossible. Therefore, it is my intent that calibration of the fuel needle movement be accomplished by providing a variable air bleed in the section chamber of the diaphragm **25**, in the manner shown in Figure 1.

In a foregoing detailed description of Figure 1, reference was made to an automatic shut-off valve **10**, the details of which are not shown in the figure, since it may take any one of several already known forms. Its purpose is to shut-off the fuel flow at the location indicated during periods of non-operation of the engine. The valve could be a simple stop-cock, manually operated, or an automatic valve, maintained open during running by means of the engine oil pressure, by a solenoid in series with the ignition circuit, or by any other known means. This accessory is not necessary to the operation of my carburetor, but would be desirable from the standpoint of safety and economy to prevent escape of fuel through the idling jet when the engine is not in operation.

It is apparent that accurate metering of the fuel at the inlet nozzle would be impracticable

at high or fluctuating pressures. The cooling means allow pressure reduction to from 1 to 4 pounds per square inch or higher without the occurrence of vapor lock. The variable opening needle valve then may accurately meter the liquid fuel as a function of the air flow. The needle valve **23** is normally closed when the engine is not running, and therefore, no additional protection is needed to prevent inadvertent escape of fuel through the main nozzle. Therefore, the valve **10** in Figure 1 would serve only to shut off idling fuel, and could, therefore, be located in channel **19**, if desired.

It is not my intent to limit the scope of my invention to the specific form illustrated by the figures. Many variations in mechanical details could be made without departing from the spirit and the basic principles of my device. For example, pistons might be substituted for diaphragms, and a Pitot tube might be employed in the place of the venturi **32**. Other substitutions would doubtless occur to those skilled in the art without deviating from the principles illustrated.

Having described fully a preferred embodiment of my invention and the manner of its operation, I claim:

1. A device for carbureting high vapor pressure liquid hydrocarbon fuels and feeding same to an internal combustion engine comprising, in combination, an intake tube connected to the intake manifold of the engine and having a venturi and a main throttle therein, a fuel inlet for bringing in liquid fuel at high pressure, a low pressure fuel chamber disposed on one side of said intake tube in parallel relationship thereto, a diaphragm forming a heat-insulating wall of said chamber and located exteriorly thereof, a pressure reducing valve operated by said diaphragm for reducing the pressure on said fuel and discharging it in liquid form into said chamber, means for conveying said fuel from said inlet to said valve, means for cooling said fuel before it passes through said valve to such an extent as to prevent vaporization as it passes through said valve and in said low pressure chamber, a fuel nozzle projecting radially into said intake tube from said chamber for discharging fuel therefrom at the low pressure prevailing therein directly into said intake tube, a needle valve arranged co-axially with said nozzle and projecting radially into said intake tube from the opposite side thereof from said diaphragm for controlling the discharge opening of said fuel nozzle, means for opening said needle valve in direct proportion to the decrease in pressure developed at said venturi, and compensating means for modifying the degree of opening of said needle valve by said last-named means in relationship to the change in pressure in said intake tube in the vicinity of said fuel nozzle.

2. A device for carbureting high vapor pressure liquid hydrocarbon fuels and feeding same to an internal combustion engine comprising, in combination, an intake tube connected to the intake manifold of the engine, a venturi located in said intake tube, a main throttle valve located in said intake tube on the engine side of said venturi, a fuel nozzle located in said intake tube on the engine side of said main throttle valve, a fuel inlet for bringing in liquid fuel at high pressure, a low pressure fuel chamber, a diaphragm forming a wall of said chamber, said fuel nozzle communicating directly with said low pressure chamber, a pressure reducing valve operated by said diaphragm for reducing the pressure on said fuel and discharging it in liquid form into said chamber, conduit means arranged in heat exchange relationship with said intake tube on the engine side of said fuel nozzle for conveying incoming fuel from said fuel inlet to said pressure reducing valve and simultaneously cooling said fuel to such an extent as to prevent vaporization thereof upon passage through said reducing valve and before reaching said fuel nozzle, spring-loading means associated with said diaphragm normally tending to press said diaphragm in a direction such as to open said reducing valve, means fluid-connecting the space on the side of said diaphragm opposite to said chamber with the interior of said intake tube, a needle valve extending into said fuel nozzle for controlling the discharge opening thereof, a second diaphragm operatively connected to said needle valve, second spring-loading means normally tending to move said second diaphragm in a direction such as to cause said needle valve to close said fuel nozzle, means for applying the lowered pressure developed at said venturi to said second diaphragm in such manner that the lower the said pressure the greater the opening of said needle valve, and means for decreasing the application of said lowered pressure developed at said venturi to said second diaphragm in direct proportion to the decrease in pressure in said intake tube in the vicinity of said fuel nozzle.

3. The device of claim 2 including in addition a by-pass conduit around the heat exchange portion of said conduit means, said by-pass conduit being subjected to heat developed by the engine, a valve for controlling the proportions of incoming high pressure fuel passed through said heat exchange portion and said by-pass conduit, and temperature-responsive means subjected to the temperature surrounding the fuel inlet for controlling said last-named valve for thereby controlling the proportioning of the incoming fuel between said heat exchange portion and said by-pass conduit.

4. A device for carbureting high vapor pressure liquid hydrocarbon fuels and feeding same to an internal combustion engine comprising, in combination, an intake tube connected to the intake manifold of the engine, a venturi located in said intake tube, a main throttle valve located in said intake tube on the engine side of said venturi, a fuel nozzle located in said intake tube on the engine side of said main throttle valve, a fuel inlet for bringing in liquid fuel at high pressure, a low pressure fuel chamber, a diaphragm forming a wall of said chamber, said fuel nozzle communicating directly with said chamber, a pressure reducing valve operated by said diaphragm for reducing the pressure on said fuel and discharging it in liquid form into said chamber, means for delivering fuel in liquid form from said inlet to said reducing valve, means for applying the pressure in said intake tube between said throttle valve and the engine freely at all times to the side of said diaphragm opposite from said chamber, spring-loading means associated with said diaphragm normally tending to press said diaphragm in a direction such as to open said reducing valve, a needle valve controlling the discharge opening of said fuel nozzle, a second diaphragm operatively connected to said needle valve, conduit means for applying the pressure developed at said venturi to one side of said second diaphragm in such manner as to open said needle valve in direct proportion to decrease in said venturi pressure, means for applying atmospheric pressure freely at all times to the

opposite side of said second diaphragm, spring-loading means normally tending to close said needle valve, and compensating means for modifying the degree of opening of said needle valve by said decrease in said Venturi pressure comprising a third diaphragm, a valve in said conduit means operated by said third diaphragm, spring-loading means normally tending to open said last-named valve, means for applying the pressure in said intake tube in the vicinity of said fuel nozzle to one side of said third diaphragm freely at all times in such manner as to close said last-named valve in direct proportion to decrease in said last-named pressure and means for applying atmospheric pressure freely at all times to the opposite side of said third diaphragm.

5. A device for carbureting high vapor pressure liquid hydrocarbon fuels and feeding same to an internal combustion engine comprising, in combination, an intake tube connected to the intake manifold of the engine and having a venturi and a main throttle therein, said intake tube being cylindrical between the venturi and intake manifold of the engine, a fuel inlet for bringing in liquid fuel at high pressure, a low pressure fuel chamber, a diaphragm forming a wall of said chamber, a pressure reducing valve operated by said diaphragm for reducing the pressure on said fuel and discharging it in liquid form into said chamber, means for conveying said fuel from said inlet to said valve, means for cooling said inlet fuel being supplied under pressure before it passes through said reduction valve and for keeping the fuel under reduced pressure cooled and in liquid form in said chamber to such an extent as to prevent vaporization during the pressure reducing process as it passes through said valve and in said chamber, a fuel nozzle for discharging fuel from said chamber at the low pressure prevailing therein directly into the cylindrical portion of said intake tube, a valve for controlling the discharge opening of said fuel nozzle, means for opening said last named valve in proportion to the variation of pressure developed at said venturi, and compensating means for modifying the opening of said last named valve in proportion to the pressure variations in the cylindrical portion of said intake tube between the venturi and the intake manifold in the vicinity of said fuel nozzle.

6. A device for carbureting high vapor pressure liquid hydrocarbon fuels and feeding same to an internal combustion engine comprising, in combination, an intake tube connected to the intake manifold of the engine and having a venturi and a main throttle therein, said intake tube being cylindrical between the venturi and intake manifold of the engine, a fuel inlet for bringing in liquid fuel at high pressure, a low pressure fuel chamber, a diaphragm forming a wall of said chamber, means for applying the pressure in said intake tube to the opposite side of said diaphragm from said chamber, a pressure reducing valve operated by said diaphragm for reducing the pressure on said fuel and discharging it in liquid form into said chamber, means for delivering fuel in liquid form from said inlet to said valve, means for cooling said inlet fuel being supplied under pressure before it passes through said reduction valve and for keeping the fuel under reduced pressure cooled and in liquid form in said chamber to such an extent as to prevent vaporization during the pressure reducing process as it passes through said valve and in said chamber, a fuel nozzle for discharging fuel from said chamber at the low pressure prevailing therein directly into the cylindrical portion of said intake tube, a valve for controlling the discharge opening of said fuel nozzle, means for opening said last named valve in proportion to the variation of pressure developed at said venturi and compensating means for modifying the opening of said last named valve in proportion to the pressure variations in the cylindrical portion of said intake tube between the venturi and the intake manifold in the vicinity of said fuel nozzle.

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