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PRESSURE TYPE FUEL SYSTEM FOR INTERNAL COMBUSTION ENGINES

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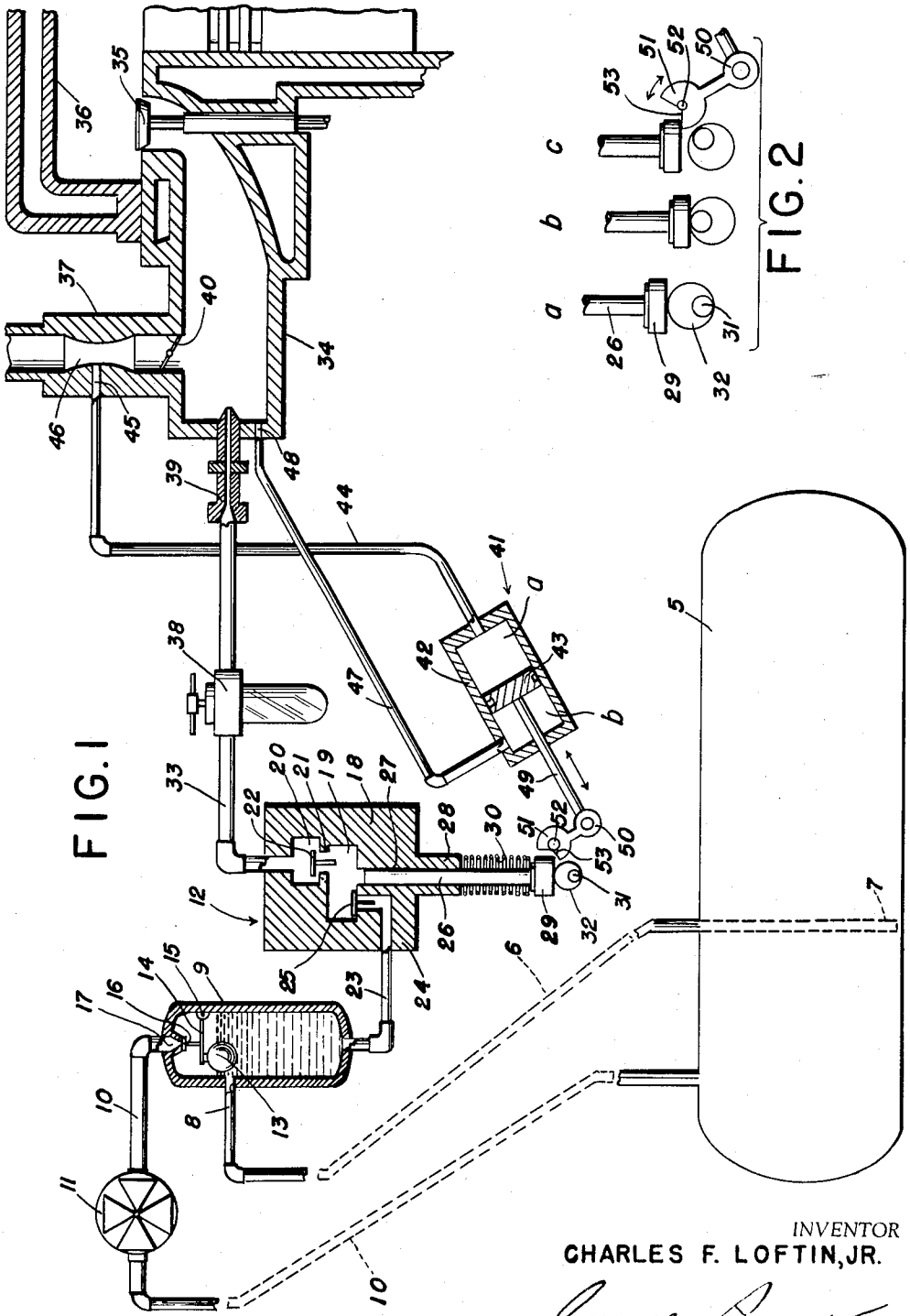


FIG. 1

FIG. 2

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PRESSURE TYPE FUEL SYSTEM FOR INTERNAL COMBUSTION ENGINES

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This invention relates to fuel systems for internal combustion engines and consists more particularly in new and useful improvements in a fuel system of the pressure type for utilizing normally gaseous hydrocarbons such as butane and propane, as fuel for internal combustion engines.

Previous systems have been developed for utilizing liquefied petoleum gas as fuel for internal combustion engines, but so far as I am aware, all of such systems have introduced the fuel into the engine in its vapor state, but experience has shown that such systems cannot maintain accurate metering of the fuel due to intensity variations of the gas at various operating temperatures.

It is an object of the present invention to provide a system which will maintain liquefied petroleum gas in a liquid state until it is injected into the intake manifold of an internal combustion engine where it can be mixed with air for combustion.

Another object of the invention is to provide in a system of this type, means for accurately metering the fuel so that the correct proportions are introduced into the intake manifold under varying load conditions.

On certain types of equipment such as farm tractors and stationary engines, the fuel tank can be installed above the pump which delivers fuel to the internal combustion engine, so that a positive liquid head can be maintained without the necessity of a compressor. However, because liquefied petroleum gas has a tendency to return to its vapor state if there is a slight pressure reduction, with certain other types of equipment it is necessary that some means be provided to keep the fuel in a liquid state until it is drawn into the fuel pump. Thus, on mobile equipment such as trucks, automobiles and buses, where it is difficult to locate the storage tank in a position which will maintain a positive head on the liquid metering pump, the use of a compressor in connection with the vapor eliminator tank is desirable.

It is therefore a further object of my invention to provide a system embodying a series of units of conventional design which can be assembled in a manner to accomplish these desired novel results.

Still another object of the invention is to provide a fuel system of this nature wherein the air fuel ratio is controlled both by the quantity of air passing through the carbureter venturi and by the manifold vacuum, thereby facilitating a more positive and accurate control of the proportion of air and fuel introduced into the engine.

With the above and other objects in view which will appear as the description proceeds, my invention consists in the novel features herein set forth, illustrated in the accompanying drawings and more particularly pointed out in the appended claims.

Referring to the drawings in which numerals of like character designate similar parts in both views,

Figure 1 is a vertical sectional view diagrammatically illustrating the assembly of elements which go to make up my improved system, and

Figure 2 represents a series of diagrammatic views

showing the various relative positions of the control mechanism for the metering pump.

In the drawings, referring first to Figure 1, 5 represents a pressure type fuel tank which may be of any conventional design adapted to accommodate various pressure ranges up to 312 pounds per square inch, working pressure, and provided with any suitable charging opening (not shown). A fuel feed line 6 extends through the wall of the tank 5 with its lower or inlet end 8 connected into a vapor eliminator tank or liquid shut-off trap 9. A return line 10 connects the upper end of vapor eliminator tank 9 with the fuel supply tank 5 and has interposed therein a vapor compressor 11. This compressor may be of any conventional type and may be installed in the system so as to receive its power from the engine through the use of suitable engine belts (not shown in the drawings) or it may be driven by an electric motor.

As will later appear, the purpose of this vapor eliminator tank 9 and compressor 11, is to constantly maintain the fuel in a liquid state up to the time of its introduction into the fuel metering pump generally indicated by the numeral 12. The vapor eliminator tank 9 is preferably provided with an internal float 13 carried by a float arm 14 pivoted at 15 to the inner walls of the tank. To the float arm 14 is connected an upstanding valve 16, preferably provided with a neoprene valve disc adapted to seat on a valve port 17 in the upper end of the tank 9, upon the upward movement of the float arm. The valve port 17 controls the inlet end of the return line 10 as seen in the drawing. Thus, when the liquid level drops in tank 9 the float 13 descends therewith and opens the port 17 whereupon, vapor from the upper portion of the tank 9 enters the return line 10 and is compressed to a liquid state by compressor 11 and returned to the fuel supply tank 5.

This operation continues until the liquid level in the vapor eliminator 9 rises to a point where the float 13 causes the valve port 17 to be closed. Although not shown in the drawing, a pressure switch may be employed in the suction side of the compressor 11, to automatically stop the compressor when the pressure drops, indicating that the vapor eliminator tank 9 is full of liquid. This pressure switch may also be arranged to start the compressor when the suction pressure builds up, indicating that the vapor eliminator tank 9 contains vaporized fuel.

The liquid metering pump 12 is of a positive displacement type and comprises a main body portion 18 having an inlet chamber 19 and an outlet chamber 20, communicating through a valve opening 21 which is adapted to be closed by a check valve 22. A fuel line 23 connects the bottom of the vapor eliminator tank 9 with an inlet passageway 24 in the body of the pump 12, leading to the inlet chamber 19. The discharge end of the inlet passageway 24 is equipped with a check valve 25, similar to the check valve 22.

A pump plunger 26 is mounted for vertical reciprocation in a bore 27, the upper end of which opens into the inlet chamber 19. The step of the plunger 26 projects downwardly through a boss 28 formed on the under side of the body 18 and terminates at its lower end in an enlarged cam abutment or head 29, a coil spring 30 being interposed between the upper side of the cam head 29 and the lower side of the boss 28. The normal tension of the spring 30 forces the plunger 26 downwardly on the suction stroke as will later appear.

The plunger 26 is directly driven by the engine through a series of reduction gears (not shown), operatively connected to a horizontal shaft 31 which has fixed thereto a cam 32. The cam 32 underlies the cam head 29 on the stem of the plunger 26 and as the shaft 31 rotates, the action of the cam 32 causes a reciprocating movement of the plunger 26, against the compression of spring 30.

The reciprocation of the plunger 26 causes liquid fuel to be drawn into the inlet chamber 19 through inlet pipe 23 and check valve 25, on the suction stroke of the plunger, and upon the upward or pressure stroke of the plunger, the check valve 25 closes and a metered quantity of fuel is forced past the check valve 22, into the outlet chamber 20 from whence it is delivered to the feed line 33 leading the intake manifold of the internal combustion engine, as will be later described. This operation is repeated upon each reciprocation of the plunger 26.

The essential parts of an internal combustion engine of conventional design, are illustrated diagrammatically in Figure 1, where 34 represents the intake manifold, communicating through intake valves 35 with the engine cylinder 36, a carbureter 37 being installed in conjunction with the intake manifold in the usual manner.

The fuel feed line 33 may be provided with a suitable filter 38 where foreign substances accumulate and are drawn off through conventional means. From the filter the fuel line leads to the intake manifold 34, into which it is connected by means of a jet injector 39. This injector 39 is of a type wherein liquid fuel under pressure, raises a spring loaded needle valve at a pre-set pressure and liquid fuel is sprayed into the intake manifold, mixed with air and then drawn through the intake valve 35 on the engine cylinder 36, where it is compressed and ignited by the spark plugs in the usual manner. A throttle valve 40 in the air inlet passageway of the carbureter, controls the volume of air introduced into the intake manifold.

As previously stated, the amount of fuel required by an internal combustion engine is proportional to the amount of air required. It is therefore important to so control the quantity of liquid fuel introduced into the intake manifold, that it is accurately proportioned with respect to the air introduced from the carbureter through the throttle valve 40. This is accomplished by the use of a pressure responsive volume control, generally indicated by the numeral 41, which in the form of the invention illustrated, consists of a cylinder 42 containing a reciprocable piston 43. On one side of the piston 43 the cylinder 42 is connected by a line 44 to a transverse passageway 45 in the body of the carbureter 37. The inner end of passageway 45 communicates with the throat 46 of a venturi, located in the air intake passageway of the carbureter, anterior to the throttle valve 40, so that the pressure condition at the throat of the venturi is transmitted to chamber *a* of the cylinder 42. On the opposite side of the piston 43 chamber *b* of cylinder 42, is connected through a line 47 to a passageway 48 in the wall of the intake manifold 34, so that the piston 43 is responsive to pressure differentials between the intake manifold 34 and the venturi 45 in the carbureter.

The movements in either direction of this pressure responsive piston 43, are utilized to regulate the length of stroke of the metering plunger 26, by extending the piston rod 49 from the piston 43 through the end of the cylinder 42 and connecting to its end a pivotally mounted control link 50. The opposite end of the link 50 is provided with an enlarged head 51 which, together with the link is pivotally mounted on a shaft 52, on an axis parallel with the axis of the cam shaft 31. The periphery of the head 51 is notched as at 53 to receive the peripheral edge of the cam abutment 29 on the metering plunger 26, as shown in both Figures 1 and 2 of the drawings.

It will be apparent that a reciprocating motion of the pressure responsive piston 43 will be transmitted through piston rod 49 to the end of the pivoted link 50 which in turn causes the control head 51 to rotate upon the shaft 52. A variation in the radial position of the notch 53 will correspondingly vary the angle of inclination of the lower side of the notch, thereby vertically adjusting the point of contact of the abutment 29 with the inclined edge of the notch 53. In other words, on the down stroke of the piston rod 49 the head 51 is rotated in clockwise direction, thus elevating the point of contact between the abutment 29 and the notch 53 and reducing the down stroke of the plunger 26, while on the upstroke of the piston rod 49 the head 51 is rotated in counterclockwise direction to lower the point of contact and lengthen the stroke of the plunger 26. Thus, the plunger stroke and consequently the volume of fuel ejected thereby, can be varied to any extent within the limits of the reciprocation of the plunger by the cam 32.

The various relative positions of the plunger abutment and control cam are shown diagrammatically at *a*, *b* and *c* of Figure 2. At *a* the plunger 26 and the cam 32 are shown in their extreme upward positions while at *b* these same elements are shown at their extreme lower positions. At *c* the plunger 26 is shown at a restricted intermediate position where its downward movement or suction stroke has been limited by contact of the abutment 29 with the lower edge of the notched head 51 which has been rotated to this position by the action of the pressure responsive piston 43.

In operation, liquid fuel from tank 5 enters the lower end 7 of feed line 6 and is conducted to the vapor eliminator tank 9 where a positive liquid head is maintained. From the tank 9 the liquid fuel passes through feed line 23 to the inlet end of the metering pump 12. The metering plunger 26, driven by the rotating cam 32 causes successively measured volumes of liquid fuel to be introduced into the intake manifold 34 through the jet injector 39, where it is mixed with air drawn into the intake manifold through the carbureter, and the mixture introduced into the engine cylinder through the intake valve 35 where it is compressed and ignited.

As the load on the engine increases, air entering the intake manifold through the carbureter, passes through the venturi 46, creating a drop in pressure which is transmitted through line 44 to chamber *a* of the volume control cylinder 42. The resulting low pressure area in chamber *a* causes piston 43 to move toward the lower pressure area or to the right in Figure 1, which movement is transmitted by piston rod 49 to the pivoted link 50 which is then rotated in counterclockwise direction to increase the length of the suction stroke of the plunger 26 and correspondingly increasing the volume of fuel per stroke.

When the throttle valve 40 is closed, the pressure in the intake manifold 34 is reduced and this low pressure is transmitted through line 47 to chamber *b* of the control cylinder 42. This low pressure area causes the piston 43 to move toward chamber *b* or to the left in Figure 1, thus rotating the link 50 in clockwise direction to raise the point of contact between abutment 29 and the notch 53 of head 51 to limit the suction stroke of the plunger 26 and consequently reduce the quantity of liquid fuel metered.

It will be apparent that when the engine has reached normal operation, the pressure in chambers *a* and *b* of control cylinder 42, are balanced by air travelling through the venturi 46 and by the pressure in the intake manifold 34 and the position of the throttle valve 40 governs the amount of fuel and air entering the engine.

At any point in the operation of the engine where vapor becomes present in the vapor eliminator tank 9, the float 13 is lowered, opening the valve 17 and permitting the vapors to pass to the compressor 11 where they are returned to their liquid state and reintroduced into the supply tank 5. As previously indicated, since the compressor and vapor eliminator tank are used to maintain a constant liquid head on the fuel pump, when the storage tank can be located above and close to the pump, the compressor and vapor eliminator tank may be dispensed with.

By enabling the use of a fuel which is liquified under pressure, I have provided greatly increased engine efficiency. When the pressure on the fuel is relieved it immediately turns to a gaseous state so that as the fuel

leaves the injector nozzle it vaporizes at once, drawing heat from the surrounding air and thus lowering the temperature of the incoming charge of air which decreases the density of the air and allows a larger quantity of air and gas to enter the cylinder for combustion. This increase in volumetric efficiency improves the power output of the engine. By accurately metering the liquid fuel and regulating its relative proportion with respect to the air introduced, any variation in air fuel ratio due to temperature change will be minimized.

As before stated butane and propane, the preferred fuels for use with this system, are very high octane fuels and therefore higher compression ratio engines can be used, thus increasing the efficiency. Since the fuel has such a low boiling point it is completely vaporized before it enters the engine cylinder thereby eliminating dilution. Furthermore, oil life is extended three or four times and the engine life is extended several times.

Because of the swirling action of the injector, a more thorough mixing of fuel and air is accomplished, insuring more complete combustion. Furthermore, by maintaining a positive liquid head on the pump at all times, the possibility of a vapor lock is completely eliminated.

From the foregoing it is believed that my invention may be readily understood by those skilled in the art without further description, it being borne in mind that numerous changes may be made in the details disclosed without departing from the spirit of the invention as set forth in the following claims.

I claim:

1. In combination with the intake manifold of an internal combustion engine, a closed, pressure type fuel delivery system comprising a fuel supply tank, a feed line leading from said tank to the intake manifold, a jet injector connected to said feed line and directed into said manifold, a fuel metering pump interposed in said feed line, a carburetor having an air inlet passageway, a venturi throat in said passageway, a throttle valve in said passageway posterior to said venturi throat, for controlling the volume of air introduced into said manifold, means for maintaining a constant liquid head on the inlet of said metering pump, comprising a liquid receiving chamber connected into said feed line, a compressor and means controlled by the liquid level in said chamber for returning vapors through said compressor to said supply tank, and means responsive to the pressure differential between said venturi throat and said manifold, for controlling the volume of fuel injected by said pump.

2. In combination with the intake manifold of an internal combustion engine, a closed, pressure type fuel delivery system comprising a fuel supply tank, a feed line leading from said tank to the intake manifold, a jet injector connected to said feed line, and directed into said manifold, a fuel metering pump interposed in said feed line and having a displacement plunger, means anterior to said pump for maintaining a positive liquid head in said system, a carburetor having an air inlet passageway, a venturi throat in said passageway, a throttle valve in said passageway posterior to said venturi throat, for

controlling the volume of air introduced into said manifold, a volume control for said metering pump, including a cylinder, a reciprocable piston dividing said cylinder into two chambers, a line connecting one chamber to the air inlet passageway of said carburetor, adjacent said venturi throat, a line connecting the opposite chamber to the intake manifold, whereby the piston is reciprocated in response to the differential pressures between said throat and manifold, means for correspondingly regulating the length of stroke of said piston, including an abutment carried by said piston, a peripherally notched rotatable head mounted adjacent said abutment with its notch arranged in the path of movement of the latter, and means actuated by said piston and operatively connected to said rotatable head for adjusting the position of said notch with respect to said abutment, whereby the length of stroke of said plunger may be adjusted in response to movement of said piston.

3. In combination with the intake manifold of an internal combustion engine, a closed, pressure type fuel delivery system comprising a fuel supply tank, a feed line leading from said tank to the intake manifold, a jet injector connected to said fuel line and directed into said manifold, a fuel metering pump interposed in said feed line and including a reciprocable positive displacement plunger, a carburetor having an air inlet passageway, a venturi throat in said passageway, a throttle valve in said passageway posterior to said venturi throat for controlling the volume of air introduced into said manifold, means anterior to said pump for maintaining a constant pressure on the liquid entering said metering pump, a volume control for said metering pump, including a cylinder, a reciprocable piston dividing said cylinder into two chambers, a line connecting one chamber to the air inlet passageway of said carburetor adjacent said venturi throat, a line connecting the opposite chamber to the intake manifold, whereby the piston is reciprocated in response to the differential pressures between said throat and manifold, a piston rod connected to said piston and projecting from said cylinder, a rotatable stroke-control head actuated by said piston rod and located adjacent the stem of said plunger, an abutment on said stem, in line for engagement with said stroke-control head, and a peripheral notch in said head adapted to engage said abutment, the point of abutment contact with said notch being variable upon rotation of said head, to correspondingly vary the length of stroke of said plunger.

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