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VOLATILE FUEL FLOW CONTROL VALVE

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Fig. 1.

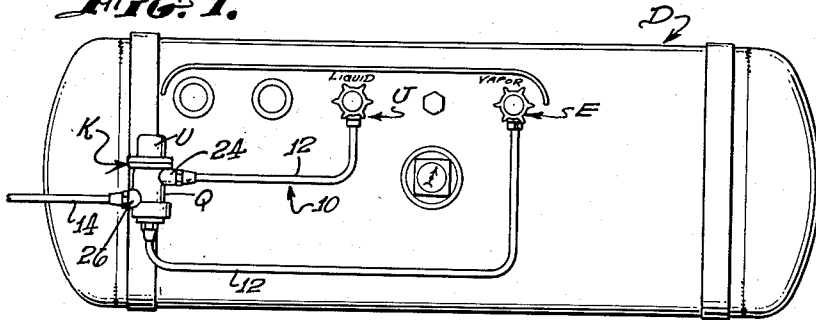


Fig. 2.

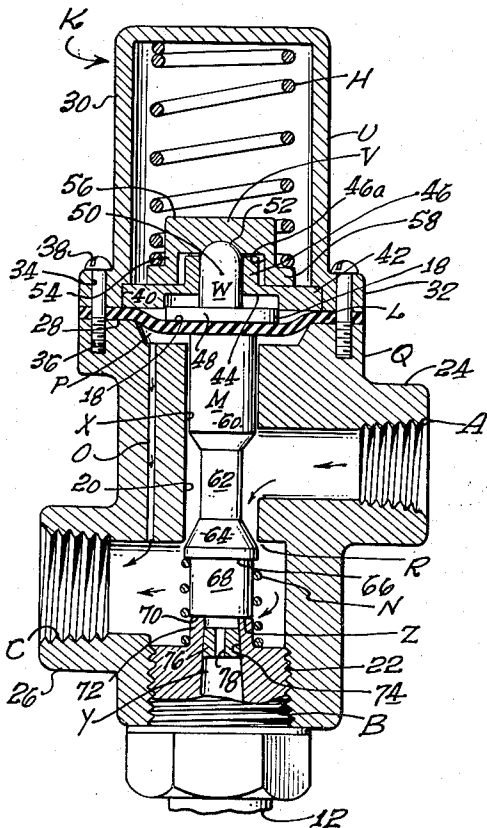
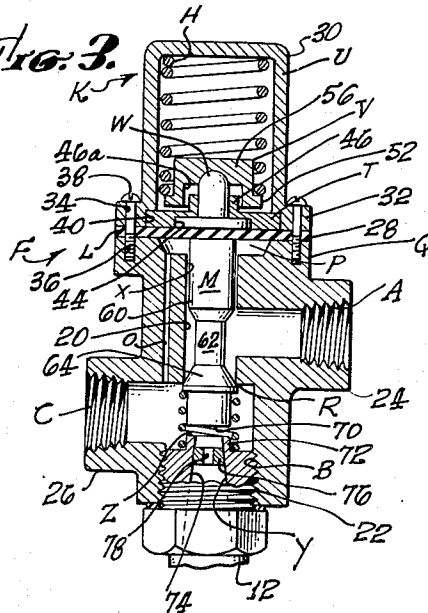


Fig. 3.



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2,996,892

VOLATILE FUEL FLOW CONTROL VALVE

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2 Claims. (Cl. 62-51)

The present invention relates generally to the field of control valves, and more particularly to a novel control valve and method of using same whereby any desired flow of a highly volatile fuel such as butane, propane, isobutane, or a mixture thereof, may be made available to a carburetor at a substantially constant pressure to be mixed with air, although the stored source of the fuel varies widely as to pressure due to the temperature conditions to which it is subjected.

While the use of gasoline as a fuel to power conventional internal combustion engines is generally well known, a less familiar form of fuel for this purpose is that of liquefied petroleum gases, which is rapidly gaining recognition and acceptance. Such fuels are generally butane, propane, isobutane, or a mixture thereof. The virtue of these fuels, generally referred to in the trade as L.P.G. fuels, is that they are considerably less expensive than gasoline on a gallon-for-gallon, as well as on a mileage basis. In contrast to gasoline which remains in the liquid state for a relatively long period of time even out in the open and at elevated temperatures, liquefied petroleum gas fuels are exceedingly volatile. Propane, for instance, boils at -42° F.

It will be readily appreciated that when L.P.G. fuels are used to power internal combustion engines, strong storage tanks must be used therefor due to the high vapor pressures developed thereby, which can rise to as much as 250 lbs. per square inch when a storage tank containing same is exposed to the summer sun. This is in distinct contrast to the relatively low vapor pressures developed by gasoline when stored in a confined space and subjected to the same elevated temperatures. However, the differences between gasoline and liquefied petroleum gases when used as fuel for internal combustion engines is not merely that of storage, but extends to different methods of delivery to the carburetor for mixing with air to provide an explosive mixture which is subsequently employed in powering the engine.

Provision of a constant flow of atomized gasoline from a jet or jets to a carburetor for mixture and vaporization with an incoming stream of air to provide an explosive mixture of a desired fuel/air ratio is relatively simple. Gasoline in the storage tank is at atmospheric pressure. The pressure on the gasoline from the fuel pump is held constant by a calibrated spring, and the gasoline inlet valve in the float bowl of the carburetor is controlled by a sealed float of unchanging buoyancy. It will be apparent that there is nothing in the gasoline fuel supply system to cause variation in the rate of gasoline discharge from the fuel supply jets, and metering of the fuel is constant. When metering of gasoline from the supply jets is correct, and all other operating factors of the engine are likewise correct, engine performance will be at a peak. Peak performance of an internal combustion engine powered by L.P.G. fuels may also be attained if there is uniformity of pressure at the fuel supply jets at the carburetor where the fuel is mixed with air.

Attainment of uniform pressure with resultant uniformity of flow of liquefied petroleum gases at the discharge jets of a carburetor is not the simple operation possible by use of gasoline as fuel. The added difficulties encountered in attaining uniform pressure with uniform flow of L.P.G. fuel at the discharge jets is readily apparent when it is recalled that these gases are not stored at atmospheric pressure, but are under a pressure of as little

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as 20 lbs. per square inch on a cold winter morning and as high as 250 lbs. per square inch on a hot summer day.

In utilizing liquefied petroleum gases as fuel, it has been common practice to withdraw the fuel from the storage tank, cause it to flow through at least one, and sometimes two pressure-reducing valves, then through a heat exchanger, and ultimately delivered to the discharge jets of the carburetor. However, due to the wide pressure fluctuations of L.P.G. fuel in the storage tank caused by external temperature conditions, no pressure-reducing valve or series of valves has been available heretofore that could efficiently respond to such fluctuations, together with the varying fuel demands of an engine when change in load occurs, to constantly provide uniform pressure of fuel at the discharge jets.

Due to the lack of a device or method that assured constant pressure of liquefied petroleum gas at a discharge jet or jets in a carburetor, internal combustion engines in the past have not attained the economy theoretically possible by the use of such fuels, countless millions of gallons of L.P.G. fuel are wasted each year because of incorrect fuel/air ratio, and the poor results attained on some liquefied petroleum gas installations have been so bad as to create considerable discontent amongst the owners or operators thereof.

A major object of the present invention is to provide a method and an automatically operated control valve that carries out this method to supply liquefied petroleum gas fuel to the discharge jet or jets of a carburetor under substantially constant pressure, irrespective of the varying load demands of the engine of which the carburetor forms a part, or fuel pressure variations in the storage tanks caused by external temperature changes over which the operator of the vehicle has no control.

Another object of the invention is to supply a method and device for carrying out that method which not only assures operation of internal combustion engines powered by liquefied petroleum gas with the same peak efficiency attainable with gasoline powered units, but in so doing, maintaining the L.P.G. fuel in the storage tank at a sufficiently refrigerated temperature to prevent fuel blow-off through the pressure relief valve and avoid waste as well as fire hazard.

Yet another object of the invention is to provide a lightweight, compact, inexpensive control valve that is adapted to be calibrated and sealed at the time of manufacture for a particular fuel and for certain operating conditions, and upon installation serve to selectively and alternately withdraw liquefied petroleum gas fuel from the storage tank in which it is situated to maintain the stored fuel at a predetermined temperature and pressure, as well as supply fuel under constant pressure to the discharge jet or jets of a carburetor.

Still another object of the invention is to encourage increased use of liquefied petroleum gases as fuel for internal combustion engines by substantially eliminating the operational difficulties and disadvantages previously encountered in the utilization thereof.

These and other objects and advantages of the present invention will become apparent from the following description thereof, and from the accompanying drawing illustrating same, in which:

FIGURE 1 is a side elevational view of the present invention, showing the piping connection same to a liquefied petroleum gas storage tank;

FIGURE 2 is a vertical cross-sectional view of the invention shown in a position wherein liquefied petroleum gas vapor only is delivered to the outlet line; and,

FIGURE 3 is a second vertical cross-sectional view of the invention shown in a position to deliver liquefied petroleum gas liquid only to the outlet line.

With continuing reference to the drawings for the general arrangement of the invention and the steps by which it carries out applicant's method previously mentioned, it will be seen that a storage tank D is provided which is constructed to hold a substantial quantity of a liquefied petroleum gas such as butane, isobutane or propane. Tank D has a first valved vapor discharge outlet E and a second valved liquid discharge outlet J. Tank D also has filling facilities, and may include additional accessories such as a liquid level gauge, pressure gauge, pressure relief valve, and the like, which form no part of the present invention.

The control valve referred to herein generally and as an integral unit by the letter K, is best seen in detail in FIGURES 2 and 3. Valve K includes a hollow main body or housing Q that defines a circular first valve seat R within the interior thereof, a liquid fuel inlet A above the seat, a vapor fuel inlet B on the lowermost portion thereof, and a fuel outlet C situated below seat R. A resilient diaphragm L extends across the top of body Q and is gripped in a fixed position thereon between the upper surface of the body and the lower surface of a backing plate T and a cup-shaped housing U in which a helical actuating spring H is disposed.

Spring H is at all times in compression and the lower end thereof abuts against a spring guide V which transmits the compressive force of the spring to a valve plunger W. The lower surface of plunger W is in abutting contact with the upper central portion of diaphragm L. An elongate valve member M having an immediately disposed portion that is adapted to effect a fluid seal with seat R is longitudinally movable in housing Q. Valve member M cooperates with housing Q to define an upwardly extending annulus shaped space X of extremely small width that leads to a liquid chamber P formed in the upper extremity of the valve body. A by-pass or bleed passage O, the purpose of which will be explained hereinafter, extends from chamber P to a communicating position with fuel outlet C.

A vapor inlet orifice Y is removably mounted in vapor inlet opening B. The upper surface of orifice Y serves as a second seat Z which the lower surface of valve member M can contact to obstruct the flow of liquid fuel through the orifice. A second helical spring N encircles the lower portion of valve member M, and while only a small fraction of the strength of spring H, spring N still is under sufficient compression at all times to maintain the upper surface of the valve member M in contact with the center portion of diaphragm L.

A tube 10 connects liquid fuel inlet A with valved liquid fuel discharge J on tank D, as best seen in FIGURE 1. A tube 12 extends from orifice Y to outlet E, also shown in FIGURE 1. The fuel outlet C is connected by a tube 14 to a pressure reducing valve (not shown) that in turn is in communication with a heat exchanger (not shown) from which vaporized liquefied petroleum gas fuel is delivered to the carburetor (not shown) under substantially constant pressure for mixing with air to obtain an air/fuel mixture of the desired ratio.

The operation of valve K in maintaining the liquefied petroleum gas fuel in tank D under a subsequent constant pressure, irrespective of the external temperature to which the tank is subjected, as well as variations in the demand for fuel as the engine load changes, is as follows. After tank D has been filled with liquefied petroleum fuel for the first time, the valved outlets E and J are placed in the fully open position and will thereafter so remain until tank D is removed from the equipment on which it is mounted to permit a major repair of the equipment.

Liquefied petroleum gas in tank D under high vapor pressure immediately flows through tube 12 to enter valve body Q through inlet A thereof. This L.P.G. fuel will normally be under sufficient pressure to move valve

plunger W and spring guide V upwardly against the compression offered by spring H from the position shown in FIGURE 3 to that shown in FIGURE 2. Although resilient, diaphragm L is stretched so little when occupying the position shown in FIGURE 2 that it has no appreciable effect in counterbalancing the tendency of compressed spring H to expand. The sole function of diaphragm L is to provide a pliable, resilient barrier between the interior of valve body Q and the interior of housing U.

The pressure on the liquefied petroleum gas as it enters valve body Q is transmitted to spring H to further compress same solely through that portion of diaphragm L directly under the lower flat face 18 of valve plunger W. Upon entering valve body Q the fuel flows upwardly therein through annulus shaped space X to fill chamber P, and from the chamber through by-pass O. By-pass O is of such cross section that liquid can flow there-through at a faster rate than it can enter chamber P through annulus shaped space X. The communication afforded by space X, chamber P and by-pass O at all times assures that the pressure in fuel outlet O will be the same within practical limits as that existing in the interior of tank D. Flow of liquid fuel through space X, chamber P and by-pass O will only take place when the pressure in fuel outlet C is lower than that prevailing in tank D.

Thus, while the pressure on the liquid fuel delivered to valve K, as well as that prevailing in tank D is of sufficient magnitude to compress spring H and permit spring N to lift valve member M to the position shown in FIGURE 2, the pressure in tank D immediately thereafter starts to drop. The reason for this initiation of pressure drop in tank D is that vapor from the liquefied petroleum gas in the tank can flow through orifice Y, through valve K to discharge through outlet C. However, orifice Y is so selected and of such size that the quantity of fuel vapor flowing therethrough will, with what liquid fuel that discharges from by-pass O, just supply the engine (not shown) when it is idling or subjected to a light load.

As fuel vapor in tank D discharges through orifice Y to outlet C, additional vapor must be formed in tank D to replace that withdrawn. Such vapor can only be provided by the transformation of liquid fuel in tank D to the vapor state. Vaporization of the liquid fuel requires heat, which must be supplied either from the liquid fuel or by conductance of heat from the ambient atmosphere through the wall structure defining tank D. Actually, heat comes from both sources.

Thus, it will be seen that even after the engine operates for a prolonged period of time at idling speed, sufficient vaporization can occur in tank D to cause the vapor pressure therein to drop to the extent that fluid in chamber P is insufficient to force valve member W to maintain spring H in maximum compression (FIGURE 3) whereby the spring expands to move valve member M into the position shown in FIGURE 2. Valve member M is then out of sealing engagement with seat R, and liquid fuel can flow from tank D through inlet A, valve body Q, to fuel outlet C without in any way appreciably affecting the temperature of the fuel in the tank. The increased space in tank D created by the normal flow of liquid as above described is so small relative to the already existing space in the tank as to have no measurable effect on the rate of fuel vaporization, with consequent cooling thereof. During the period liquid fuel flows from tank D, heat is conducted from the exterior to the interior of the tank, and when the temperature of the fuel remaining in tank D rises sufficiently, the vapor pressure thereof causes the fuel in chamber P to move valve member M from the position shown in FIGURE 3 to that shown in FIGURE 2.

From the above description it will be seen that the operation of the valve K is automatic as valve member M alternately moves from and to the positions shown

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in FIGURES 2 and 3 to refrigerate and then permit heating of the liquid fuel in tank D to maintain the liquid under substantially constant pressure.

When valve member M is in the position shown in FIGURE 3 where vaporized fuel is supplied to outlet C from orifice Y, and the load on the engine (not shown) is suddenly increased, the response of valve K to an increased demand of fuel is extremely fast. This sudden increased demand for additional fuel momentarily lowers the pressure in fuel outlet C and establishes a differential in pressure that quickly drains the liquid fuel from chamber P through by-pass O. Inasmuch as liquid fuel can flow out of chamber P through by-pass O at a faster rate than it can enter the chamber through annulus shaped space X, the pressure on valve plunger W is reduced, and valve member M moves from the position shown in FIGURE 2 to that shown in FIGURE 3. Liquid fuel then flows from inlet A through valve body Q to fuel outlet C to meet this sudden increased demand.

In detail, it has been found convenient to cast, or otherwise form, the body Q in a generally tubular shape in which a bore 20 is formed that extends a portion of the length thereof and terminates at the seat R. Vapor inlet B is preferably a tapped bore 22 that is coaxially aligned with bore 20, and of sufficient transverse cross section to permit threaded removable engagement thereof by the orifice-defining vapor inlet member Y. Removability of member Y is highly desirable in order to permit interchange and substitution of members having various orifice sizes formed therein, each of which is adapted for use with a particular liquefied petroleum gas, as well as a particular range of operating conditions. Liquid fuel inlet A and fuel discharge outlet C, as can be seen in the drawings, are defined by oppositely disposed, outwardly extending tubular bosses 24 and 26, respectively. Each of the bosses 24 and 26 is tapped to permit easy connection thereto of tubes 12 and 14 respectively. The upper extremity of body Q terminates in a flat ring-shaped surface 28 that contacts the outer circumferentially extending lower face of diaphragm L. A recess 27 is formed in the body Q within the confines of surface 28, and recess 27 is in communication with bore 20 and bypass O.

Spring housing U is preferably formed as an integral unit and comprises an inverted cup-shaped portion of a suitable rigid material 30, the lower end of which terminates in an outwardly extending ring-shaped flange 32 in which a number of circumferentially spaced bores 34 are formed. Bores 34 are alignable with a like number of tapped bores 36 that extend downwardly into body Q from face 28. When bores 34 and 36 are engaged by a number of screws 38 they cooperate to removably maintain housing U on body Q with diaphragm L gripped therebetween. The lower interior portion of housing U defines a ring-shaped recess 40 that engages the outer circumferential edge portion of backing disc T.

Backing disc T includes a circular plate 42 having a centrally disposed recess 44 extending upwardly therein from the lower face thereof. A tubular guide 46 extends upwardly from plate 42. A bore 46a formed in guide 46 is in communication with recess 44. The valve plunger W is defined by a plate 48 disposable in recess 44, and a rigid protuberance 50 that extends upwardly therefrom to terminate in a convex end portion 52.

Spring guide V is preferably formed as an integral unit to define a short cylindrical side wall 54 which is closed on one end by a heavy wall 56, and on the opposite end portion has a circular flange 58 projecting therefrom. The lower surface of flange 58 rests on the upper surface of plate 42 when valve member M is in the position shown in FIGURE 2. The upper end of compression spring H abuts against the interior end surface of housing 30, and the lower end thereof presses against the upper surface of flange 58.

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Valve member M is generally elongate in configuration, and includes a first portion 60 of circular cross section that is slidably movable within bore 20 but is slightly less in transverse cross section to provide annulus shaped space X. The first portion 60 tapers downwardly and inwardly to an intermediately disposed section 62, which on its lower end develops into an enlarged conical portion 64 that is adapted to effect a fluid-tight seal with seat R when valve member M is in the position shown in FIGURE 2.

The upper end of spring N abuts against a ring-shaped surface 66 formed below conical portion 64, from which a second valve portion 68 depends that defines a flat lower face 70 adapted to provide a fluid-tight seal with seat Z within contact therewith. The lower end of spring N rests against the orifice defining member Y. Seat Z is defined by an upper ring-shaped surface formed on a boss 72 comprising a part of orifice defining member Y. Member Y has an upwardly and inwardly tapering bore 74 formed therein in which an insert 76 can be removably disposed. A plurality of inserts 76 may be provided, each of which have a bore 78 of different transverse cross section extending therethrough. By experimentation, the proper insert 76 having a bore 78 of correct size suitable for a particular liquefied petroleum gas fuel and known operating conditions can be determined.

The method of using the above described invention has been previously described in detail and need not be repeated.

From an operational standpoint the above described valve has the advantage that diaphragm L serves solely as a sealing medium and as a means to transfer the force of the compressed spring H to the plate 48, as well as the force exerted by fuel in chamber P to plate 48. A further advantage of the invention is that the plate 48 at all times moves on a longitudinal axis extending through the body Q and spring H, and at all times normal thereto.

It will be obvious to those skilled in the art that various changes may be made in the invention without departing from the spirit and scope thereof, and therefore the invention is not limited by that which is shown in the drawing and described in the specification, but only as indicated in the appended claims.

I claim:

1. A valve for use in automatically supplying fuel to an engine at a substantially constant pressure from a storage tank that contains liquefied petroleum gas fuel and is subjected to varying ambient temperatures above that temperature at which said liquefied fuel would boil at atmospheric pressure, comprising: an elongate valve body having liquid and vapor inlet passages formed therein that are in communication with said liquid fuel and the vapor thereof in said tank, as well as a common outlet for said liquid and vapor fuel that is in communication with said engine; a valve member sealingly and movably mounted in a first bore in said body, said member being capable of occupying either a first position wherein communication is effected between said liquid inlet and said outlet or a second position wherein communication is effected between said vapor inlet and said outlet, with a portion of said valve member being so shaped that it cooperates with said first bore to define an annulus-shaped space that extends from a communicating position with said liquid inlet to a recess formed on the exterior of said body, which body has a second bore formed therein that extends from said recess to said outlet, together with liquid bypass means therein that includes said annulus-shaped space, said second bore, and said recess, with said means at all times connecting said inlet and said outlet; pressure-receiving means on said valve member that are at all times subjected to the pressure of said liquid in said bypass means for exerting a first force on said valve member in a direction to move said valve member to said second position where said vapor flows from said outlet and said fuel in said tank is cooled by self-refrigeration as addi-

tional portions of said fuel vaporizes to replace said vapor that flows through said vapor inlet, said pressure-receiving means including a rigid plate affixed to a part of said valve member that extends from said body and a resilient diaphragm sealingly affixed to said plate and that part of said body surrounding said recess; and spring means for exerting a second force on said valve member in a direction to overcome said first force and move said valve member to said first position where said liquid flows from said outlet without cooling when said liquid in said tank has been cooled to the extent that the pressure of the vapor thereof starts to fall below said substantially constant pressure and said first force overcomes said second force to move said valve member to said second position when the pressure on said liquid in said bypass means rises above said constant pressure due to an increase in temperature of said liquid in said tank as a result of absorption of heat from said ambient atmosphere.

2. A valve body as defined in claim 1 wherein a backing disc is provided that has a centrally disposed recess formed therein of such depth and transverse cross section as to permit said plate to fit snugly therein, said disc being provided with a rigid tubular guide in communica-

tion with said plate-receiving recess, said guide having a portion of said valve member slidably disposed therein, with the upper extremity of said valve member projecting upwardly therefrom, with means being provided to hold said backing plate in a position relative to said body that the circumferential surface portions of said diaphragm are gripped therebetween, and said diaphragm being so resilient that said first force is only transferred through that portion thereof in contact with said plate, with said diaphragm lying in a single plane abutting against at least portions of the surfaces of said plate and disc when said valve member is in said second position.

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