

March 11, 1958

H. E. SIMONSON
PRESSURE OPERATED VAPOR-LIQUID SELECTOR
VALVE FOR L. P. G. FUEL SYSTEMS

2,826,043

Filed July 28, 1953

2 Sheets-Sheet 1

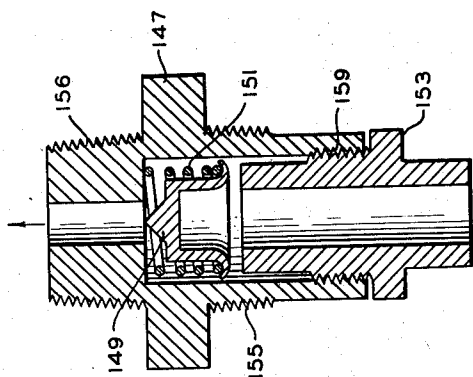


FIG. 6

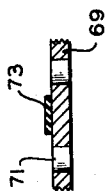


FIG. 3

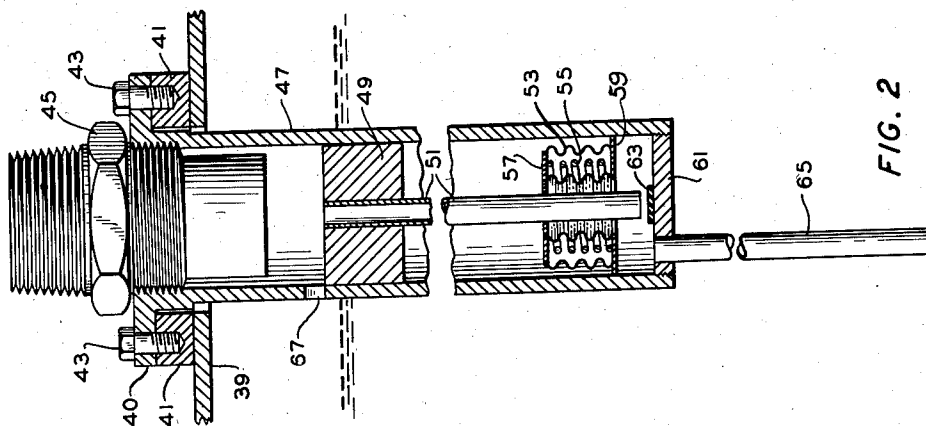


FIG. 2

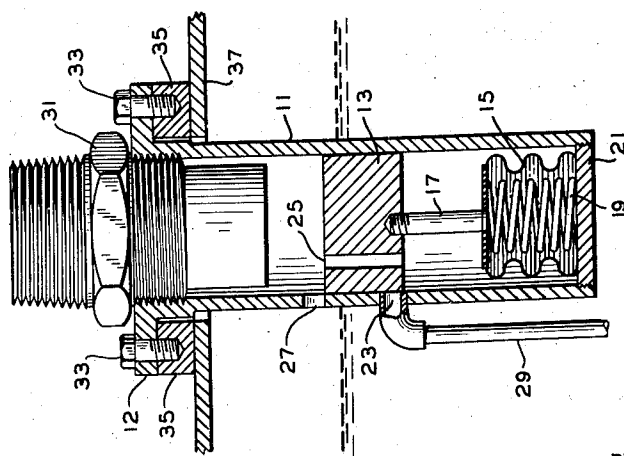


FIG. 1.

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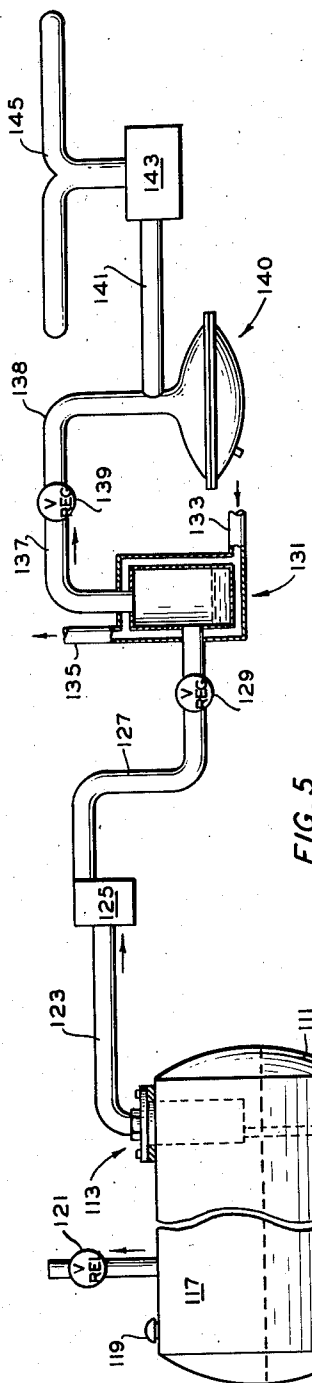


FIG. 5

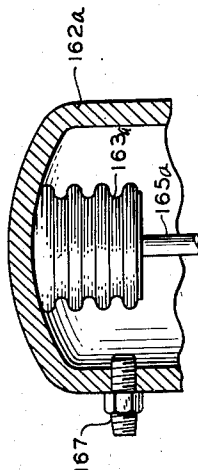


FIG. 8

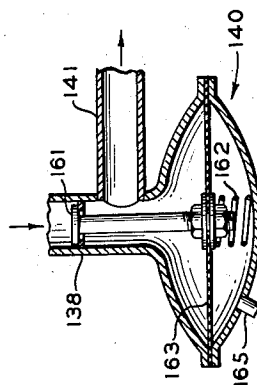


FIG. 7

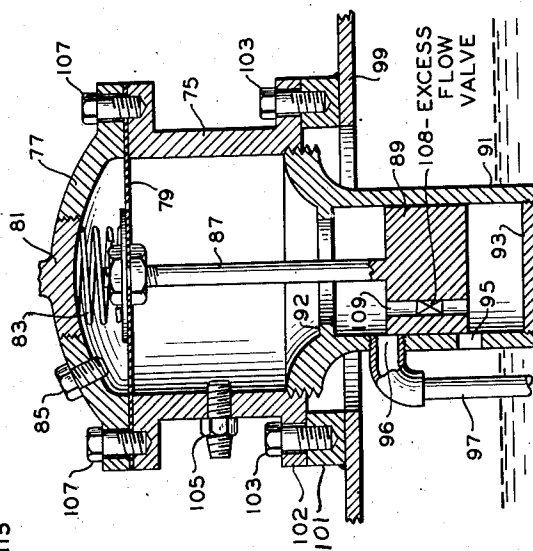


FIG. 4

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1

2,826,043

PRESSURE OPERATED VAPOR-LIQUID SELECTOR VALVE FOR L. P. G. FUEL SYSTEMS

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Application July 28, 1953, Serial No. 370,819

21 Claims. (Cl. 62—1)

This invention relates to internal combustion engine operations. In one aspect it relates to an improved apparatus for use with liquefied petroleum gas as an internal combustion engine fuel. In another aspect it relates to a liquid-vapor selector valve for the selective withdrawal of liquid and vapor in response to tank pressures for maintaining tank pressures at a minimum.

An object of this invention is to provide an apparatus for controlling the pressure of liquefied petroleum gas fuel in internal combustion engine fuel tanks when the engine is powered with liquefied petroleum gas.

Another object of this invention is to provide an apparatus for use in maintaining relatively low pressures in liquefied petroleum gas automotive fuel tanks under atmospheric and road temperatures.

Another object of my invention is to provide an apparatus for use in maintaining relatively low pressures in liquefied petroleum gas fuel tanks under high temperature operating conditions which apparatus is simple and inexpensive to make, and safe and reliable in operation.

Yet another object of my invention is to provide a vapor-liquid selector valve for use with LPG tanks which may be subjected to comparatively wide variations in ambient temperature, such as encountered in the operation of trucks and buses.

Still other objects and advantages of my invention will be obvious to those skilled in the art upon reading the following specification and drawing, which respectively describes and illustrates preferred embodiments of my invention.

The terms "Liquefied Petroleum Gas," and "LPG" as used hereinbelow refer to commercial liquefied petroleum gas, such as commercial propane. Liquefied petroleum gas includes, in addition to propane, such other hydrocarbons as butane, isobutane, isopentane and the like. While one or more of these other hydrocarbons may be present in the commercial propane or liquefied petroleum gas they are ordinarily present in relatively small amounts. However, they may be present in appreciable amounts but ordinarily commercial propane contains largely propane. The presence of any of these other hydrocarbons in propane exerts at least some effect on the vapor pressure of propane, such effect however being small when the concentrations of these other hydrocarbons are small. Such slight effects on the vapor pressure of commercial propane which contains small amounts of these other lower vapor pressure hydrocarbons are negligible and the vapor pressure of commercial propane or liquefied petroleum gas will hereinafter be referred to merely as the vapor pressure of propane or of liquefied petroleum gas.

Since the vapor pressure of commercial propane is about 200 lbs. per sq. in. at 100° F. the use of relatively heavy pressure fuel tanks is necessary. At temperatures higher than 100° F. which temperatures are sometimes encountered during certain seasons of the year, propane has still higher vapor pressures than the above mentioned 200 lbs. Thus, the utilization of this liquefied fuel under

2

such temperature and pressure conditions becomes a problem requiring careful consideration.

According to my invention I have provided a pressure operated liquid-vapor selector valve in which a pressure operated motor actuates a piston for selecting vapor or liquid for withdrawal from the tank. When the pressure in the tank is relatively low the motor operates the piston to close off a port leading to the vapor containing portion of the tank and opening a port leading to the liquid containing portion of the tank for removal of liquid. Complementary to this when pressure in the tank is high the motor operates the piston to close off the port leading to the liquid containing space and opening the port leading to the vapor containing space of the tank thereby permitting withdrawal of vapor, which operation is followed by evaporative cooling and ultimate reduction of pressure. My apparatus can be inserted into an LPG tank through a single opening, and for the most part the major portion of the liquid-vapor selector valve is disposed within the tank thereby minimizing danger from damage to the valve.

In the drawing:

Figure 1 is a longitudinal view partly in section of one embodiment of my invention.

Figure 2 is a longitudinal view, partly in section of another embodiment of my invention.

Figure 3 is a sectional view of an end plate useful with the apparatus embodiment of Figure 2.

Figure 4 is a longitudinal view, partly in section, of still another embodiment of my invention.

Figure 5 is a diagrammatic view of the liquid-vapor selector valve assembly of my invention in conjunction with an automotive fuel system.

Figure 6 is a longitudinal sectional view of a portion of the apparatus of Figures 1, 2, 4 and 8.

Figure 7 is a longitudinal view, partly in section, of a portion of the apparatus of Figure 5.

Figure 8 is a longitudinal view, partly in section, of apparatus for use in conjunction with a portion of the apparatus of Figure 4.

Referring now to the drawing and specifically to Figure 1, this vapor-liquid selector valve consists of a cylindrical housing member 11 containing a movable piston 13. To this piston is attached a piston rod 17 which in turn is connected to a pressure operative motor 15. This pressure operative motor in the embodiment of Figure 1 is illustrated as a pressure operative bellows. This bellows is provided with a compression spring 19 for assisting the bellows to expand upon reduction of pressure. This bellows is, as mentioned above, a pressure responsive bellows and it is preferably at least partially evacuated to minimize the effect of temperature changes. This bellows is supported by a base plate 21 which forms the end wall of the cylindrical housing 11. A port 27 is provided in the upper side wall housing 11 for admittance of fuel vapor while another port 23 is provided as shown. To this port 23 is attached a dip tube 29 which is intended to dip into liquid fuel in tank 37. A conduit 25 is disposed throughout the length of piston 13 for passage of liquid from the space below the piston to the space above the piston. The upper end of the housing member 11 is provided with a flange 12 for installation purposes. Bolts 33 hold flange 12 rigidly against a ring 35 which in turn is welded or attached otherwise to the walls of the tank 37. Element 31 is an excess flow valve of more or less conventional type.

In the operation of the apparatus embodiment illustrated in Figure 1 when pressure within the tank increases to a value higher than a preselected pressure the bellows 15 tends to contract thereby lowering piston 13 to close port 23 and open port 27. Vaporous LPG fuel enters the housing 11 by way of port 27 and passes through the excess flow valve 31 for use in the engine. When pres-

sure within the tank 37 decreases to a value below said predetermined pressure the bellows 15 expands with the assistance of the compression spring 19 thereby raising piston 13 to close port 27 and open port 23. Under this condition the source of the vaporous fuel is closed off and liquid fuel may be admitted through dip tube 29 and port 23 into the housing 11 below the piston 13. This liquid then flows upward through conduit 25 and through the excess flow valve 31 to the fuel conduit.

In Figure 2 of the drawing reference numeral 47 identifies a selector valve housing provided with a piston 49. A tubular piston rod 51 is fitted into piston 49 so as to provide a passageway from the space at the bottom of the housing 47 to the space above the piston. An end plate 61 closes the lower end of the housing 47. Centrally disposed on the top surface of this end plate is a resilient sealing member 63, such as a hydrocarbon-proof synthetic elastomer. The bottom end of the tube 51 is intended to act as a valve for seating against the sealing member 63 when the piston is at the lower end of its extent of travel. Tube 65 is provided for dipping into liquid fuel in the tank and through which liquid fuel is drawn into the selector valve. A pressure operative motor is illustrated in Figure 2 as a pressure operative bellows. This bellows is also provided with a compression spring 55 for assisting expansion under reduced pressure conditions. A circular plate 57 is attached to the upper end of the bellows and to the tube 51 in such a manner that as the bellows expands or contracts piston 49 moves respectively upward or downward. An annular plate 59 serves as a base for the bellows 53 and this base is attached rigidly to the housing member 47 as illustrated. A port 67 is provided in the upper side wall of housing 47 for inlet of vapor. A flange 40 is provided for use of bolts 43 for attaching this assembly to ring 41. This ring may be attached rigidly to the tank wall 39 by any method desired, such as by welding. An excess flow valve 45 is provided for controlling the outlet of fuel from this selector valve, i. e., the excess flow valve closes off entirely the flow of fuel in case of breakage of the fuel line.

By the use of the liquid dip tube 29 of Figure 1 and dip tube 65 of Figure 2 the respective valve housings may be relatively short since the dip tubes are intended to be sufficiently long to extend substantially to the bottom of the fuel tanks. Under some conditions it might be desirable not to use a liquid dip tube. The end plate 69 of Figure 3 can be inserted into the lower end of housing 47 of Figure 2 in place of end plate 61. This end plate 69 is provided with one or more openings 71 for admission of liquid into the housing. A resilient hydrocarbon-proof seal 73 is provided for sealing the bottom end of tube 51 against inlet of liquid when piston 49 is at the lower end of its extent of travel. When using the end plate 69 of Figure 3 in place of end plate 61 and dip tube 65 the cylindrical housing member of the selector valve must be sufficiently long that the end plate 69 is positioned at a level very near the bottom of the tank. The openings 71 merely replace the dip tube 65 of Figure 2 for inlet of liquid. Otherwise the construction and operation of the selector apparatus with end plate 69 is similar to a construction and operation of the embodiment of Figure 2.

In Figure 4 of the drawing this embodiment of selector valve includes a housing member 91 intended to be installed within the tank 99. A housing member 75 is disposed outside of the tank and a flange 102 integral with housing 75 is held by bolts 103 to ring 101 which in turn is fastened, for example, by welding to tank wall 99. To the outer end of the exterior housing 75 is provided a diaphragm 79. This diaphragm is held in place by a bonnet 77 and bolts 107. An excess flow valve is provided in the bonnet 77 for closing off this apparatus to the escape of fuel in case of rupture of diaphragm 79. 75

This excess flow valve 85 is also intended to serve as a pressure equalizing vent to maintain the space under the bonnet and above the diaphragm at atmospheric pressure. However, in case of rupture of diaphragm 79 and admission of high pressure gas to the space under the bonnet this excess flow valve prevents escape of combustible fuel. A compression spring 83, adjustable by a spring adjuster 81, is provided for assisting movement of piston rod 87 and piston 89. A shoulder 92 is provided in the upper part of the housing 91 to prevent expulsion of piston 89 in case of accidental breakage of the exterior housing member 75. An excess flow valve 105 is also provided for controlling outlet of LPG from this selector valve to the engine.

An end plate 93 is provided in the bottom end of interior housing 91. Piston 89 is provided with a conduit 109 for passage of liquid from the space below the piston to the space above the piston. An excess flow valve 108 is disposed in conduit 109 for closing off fluid flow in case of accidental rupture of the exterior housing 75. In case of accidental breakage of housing 75 piston 89 will be immediately forced upward against shoulder 92 and excess flow valve 108 will then operate to close off all flow of fluid from the tank to the rupture area. A port 95 is provided in the inside housing member 91 as shown. A liquid dip tube 97 is provided for passage of liquid from the liquid containing space of the tank into the selector valve as shown.

In the operation of the selector valve of Figure 4 when the pressure within the tank has been decreased to a value below a predetermined pressure the diaphragm 79 with the aid of spring 83 forces the piston 89 downward to close the vapor inlet port 95 and open port 96 for inlet of liquid fuel. Under these conditions liquid will be admitted through dip tube 97 into the space above the piston 89 and this liquid will then flow upward into the housing 75 and outward through the excess flow valve 105 to the fuel conduit.

When the pressure in tank 99 increases to some predetermined pressure the diaphragm 79 will be forced upward to move piston 89 upward to close the liquid admission port 96 and to open the vapor inlet port 95. Under this condition vapor is admitted through port 95 to the space below the piston. This vapor will then flow upward through conduit 109 and excess flow valve 108, that is, through the piston, and out through excess flow valve 105 to the engine. Removal of vapor in this manner continues until the liquid contents of the tank have been sufficiently cooled by evaporation that the pressure decreases to operate the diaphragm and piston assembly to close off the vapor and open the valve for removal of liquid.

In the embodiments of my invention the several pistons may under some conditions remain in an intermediate position allowing removal of both vapor and liquid simultaneously from the tanks.

In the embodiment of my invention illustrated in Figure 4 the pressure responsive motor is illustrated as a spring loaded diaphragm. A spring loaded bellows, responsive to pressure, may be used in place of the spring loaded diaphragm. In Figure 8 of the drawing is illustrated a bonnet member 162a provided with a pressure operative bellows 163a. To the lower end of this bellows is attached a piston rod 165a which is equivalent to piston rod 87 of Figure 4. An excess flow valve 167 is provided in bonnet member 162a for control of fuel to the engine. In this case when pressure under bonnet 162a decreases to below a predetermined value bellows 163a, which is spring loaded, expands to lower the piston, not shown, and admit liquid for passage through valve 167 to the engine. When pressure under bonnet 162a increases to above a predetermined value bellows 163a contracts raising a piston, not shown, thereby closing off liquid and opening the valve to the inlet of vapor.

A weakness ring can be built into the body 75 so that in case of an emergency the housing can be ruptured at a desired point. Figure 6 of the drawing illustrates a longitudinal sectional view of an excess flow valve suitable for use as valve 31 of Figure 1, as valve 45 of Figure 2, as valve 105 of Figure 4 and as valve 167 of Figure 8. The excess flow valve 85 of Figure 4 may be similar to the valve illustrated in Fig. 6 but there need not be an exterior threaded portion for connection to a conduit since valve 85 does not pass fuel to the engine. Excess flow valve 108 of Figure 4 can be similar to the valve illustrated in Figure 6 but there need not be a hexagon shaped section 147 (Figure 6) since valve 108 is threaded to the conduit 109. The valve of Figure 6 is provided with a hexagon shaped section 147 for use of a wrench. This valve is provided with a compression spring 151 and a valve member 149, which members are held in place by a fitting 153 threaded at 159. Threads 155 are for installation of the valve, while threads 156 are for fastening a flow line for carrying fuel from the valve.

Figure 7 of the drawing illustrates in diagrammatic form an atmospheric shut-off valve which is intended to operate in such a manner that when the engine is not running the valve automatically closes the fuel carrying line against continued passage of inflammable fuel. This valve assembly identified by reference numeral 140 contains a diaphragm 163. Space under the diaphragm is vented through a vent 165. Diaphragm 163 is connected to a valve 161 in line 138. This line 138 is the fuel inlet line to the valve while conduit 141 is the fuel outlet line. The fuel outlet line 141 is of course connected to the carburetor and when pressure within line 141 decreases, as by turning over of the motor in starting, pressure above diaphragm 163 decreases and the diaphragm opens valve 161 to permit passage of fuel to the carburetor. Obviously during times when the engine is running pressure in line 141 is below atmospheric and the diaphragm holds valve 161 open. When the engine is stopped pressure in line 141 becomes atmospheric and the diaphragm 163 aided by spring 162 closes valve 161.

In Figure 5 of the drawing is illustrated, diagrammatically, a complete supply apparatus for an internal combustion engine using liquefied petroleum gas as fuel. A pressure storage tank 111 contains the fuel, reference numeral 115 identifying the liquid in the tank and reference numeral 117 the vapor space above the liquid. Element 119 is a valved conduit for filling of the tank. A relief valve 121 is provided in case pressure relief is required. Reference numeral 113 identifies a selector valve assembly of my invention disposed in the tank. Conduit 123 is intended to be connected to the assembly 113 by means of such an excess flow valve as valve 31 or valve 45. Line or conduit 123 discharges into a filter element 125 for removal of foreign matter from the fuel. Fuel free from foreign matter leaves the filter and flows through conduit 127 to a pressure regulator 129. This pressure regulator is intended to reduce pressure from tank pressure to such a pressure that one additional stage of pressure reduction is sufficient. Apparatus 131 is a fuel vaporizer for making certain that only vaporous fuel reaches the carburetor. Conduit 133 conducts water from the automotive cooling system to the vaporizer while conduit 135 conducts used water back to the cooling system. Vaporous fuel leaves the vaporizer through a conduit 137 and passes through a final pressure regulator 139 which is intended to reduce the pressure to substantially atmospheric. From this latter regulator fuel flows through conduit 138 to a valve assembly 140 from which the fuel passes on through conduit 141 to a carburetor 143 and intake manifold 145. This assembly of fuel dispensing and handling apparatus is such as will be used on automotive equipment such as trucks or buses or even automobiles in case these latter vehicles would be powered by liquefied petroleum gas. Also such fuel dispensing and pressure control equipment is suitable for use with perma-

nent internal combustion engines such as those used in power plants, compressor plants and the like.

While the selector valves described hereinafter have been of the top tank outlet type, it is within the scope of my invention to adapt the hereindisclosed selector valve apparatus to bottom outlet type fuel tanks. In this case, the fuel outlet enters the bottom of the tank. Liquid would enter the port next the tank outlet while the dip tube would be a gas dip tube and would extend upward into the vapor space of the tank.

Materials of construction may be selected from among those commercially available and adapted for use in such applications. It is preferable to use materials not easily corroded by oxygen and/or moisture.

While certain embodiments of my invention have been described for illustrative purposes, the invention obviously is not limited thereto.

I claim:

1. A liquid-vapor selector valve assembly for use in liquefied petroleum gas fuel systems comprising, in combination, a valve body member, a portion of said valve body member being adapted to be disposed within a tank, said valve body member defining a first conduit, a pressure operative motor in said first conduit, said pressure operative motor being responsive to externally applied pressure, a movable piston driven by said motor in said conduit dividing said first conduit into two chambers, a second conduit in said piston providing fluid communication between said chambers, a port in the wall of said body member for inlet of vaporous fuel, a port in the wall of said body member for inlet of liquid fuel, said ports being disposed in the portion of said valve body member adapted to be disposed in a tank, said movable piston being disposed in general intermediate said ports and in such a manner that upon movement to one end of its stroke one port becomes closed and the other port opened and at the other end of its stroke said one port becomes opened and said other port becomes closed and an outlet means at least near the outlet end of the valve assembly.
2. In the liquid-vapor selector valve assembly of claim 1 wherein said outlet means comprises an excess flow valve assembly.
3. In the liquid-vapor selector valve assembly of claim 1 wherein said motor is a pressure operative bellows.
4. A liquid-vapor selector valve assembly for use in liquefied petroleum gas fuel systems comprising, in combination, a housing member, a portion of said housing member being adapted to be disposed within a tank, a pressure operative motor in said housing member, said pressure operative motor being responsive to externally applied pressure, a movable piston driven by said motor in said housing member dividing the space within said housing member into an upper chamber and a lower chamber, a conduit throughout the length of said piston providing communication between said chambers, a first port in the wall of said housing member for inlet of vaporous fuel, a second port in the wall of said housing member for inlet of liquid fuel, said ports being disposed at different levels and being in the portion of said housing member adapted to be disposed in said tank, said piston being disposed in general intermediate said ports and in such a manner that upon movement to the upper end of its stroke the upper port is closed and the lower port is opened, and at the lower end of its stroke the upper port is opened and the lower port is closed, and an outlet means in said housing member at least near the upper end thereof for outlet of fuel.
5. In the liquid-vapor selector valve assembly of claim 4 wherein said outlet means comprises an excess flow valve assembly.
6. In the liquid-vapor selector valve assembly of claim 4 wherein said motor is a pressure operative bellows.
7. A liquid-vapor selector valve assembly for use in

7

liquefied petroleum gas fuel systems comprising, in combination, a generally cylindrical, housing member, said housing member being adapted for installation in the top of a liquefied petroleum gas storage tank and so disposed that the axis of said housing is at least approximately vertical, an end plate in the bottom end of said housing member, an opening in said end plate, a liquid dip-tube disposed in said opening in said plate and providing communication from the liquid containing space in said tank to a space above said end plate, a resilient sealing member attached to the top center surface of said end plate, a piston in said housing member adapted for reciprocating movement therein, a pressure operative bellows attached to the lower portion of said housing, said pressure operative bellows being responsive to externally applied pressure, a tubular piston rod connecting said bellows and said piston, a conduit throughout the vertical length of said piston, said tubular piston rod being connected with the walls of said conduit in said piston and extending downward through said bellows to a level adjacent said resilient sealing member, the lower end of said tubular piston rod being adapted to seat against said resilient sealing member at the lower end of the stroke of said piston, a port in the wall of said housing member at a point above said piston when at the bottom end of its stroke, an excess flow valve in the upper end of said housing member, and means for attaching the outer end of said excess flow valve to a conduit for passage of fuel to a point of use.

8. A liquid-vapor selector valve assembly for use in liquefied petroleum gas fuel systems comprising, in combination, a hollow housing member, said housing member being adapted for installation in the upper wall of a liquefied petroleum gas fuel tank and so disposed that the axis of said housing is at least approximately vertical, a non-perforate end plate in the bottom of said housing member, a pressure operative bellows disposed on the top surface of said end plate and within said housing member, said pressure operative bellows being responsive to externally applied pressure, a movable piston in said housing member, a piston rod connecting said piston and said pressure operative bellows, a first port in the sidewall of said housing member at a level just above the top surface of said piston when said piston is at the lower end of its extent of movement, a second port in the sidewall of said housing member at a level just below the bottom surface of said piston when said piston is at the upper end of its extent of movement, a liquid dip tube extending from said second port to a level near the bottom of said tank, an excess flow valve in the upper end of said housing member, said excess flow valve being adapted to control flow of fuel from said tank, and means for attaching said excess flow valve to a conduit for passage of fuel to its point of use.

9. A liquid-vapor selector valve assembly for use in a liquefied petroleum gas fuel system comprising, in combination, a housing member, said housing member being adapted to be attached to the upper wall of a liquefied petroleum gas fuel tank and so disposed that the axis of said cylindrical housing member is at least approximately vertical, a perforate end plate in the lower end of said housing member, said housing member being adapted to extend substantially to the bottom of said tank, a resilient sealing member attached to the top surface of said end plate, a piston in said housing member adapted for reciprocating movement therein, a pressure operative bellows attached to the lower portion of said housing, said pressure operative bellows being responsive to externally applied pressure, a tubular piston rod connecting said bellows and said piston, a conduit throughout the vertical length of said piston, said tubular piston rod being connected with said piston and extending downwardly through said bellows to a level adjacent said resilient sealing member in such a manner as to provide

8

a passage from a level below said bellows to a level above said piston, the lower end of said tubular piston rod being adapted to seat against said resilient sealing member when said piston is at the lower end of its extent of movement, a port in the cylindrical wall of said housing member at a level just above the top of said piston when said piston is at the lower end of its extent of movement, an excess flow valve in the top of said cylindrical housing member, said excess flow valve being adapted to control flow of fuel from said tank, and means for attaching said excess flow valve to a conduit for passage of fuel to its point of use.

10. A liquid-vapor selector valve assembly for use in a liquefied petroleum gas fuel system comprising, in combination, a housing member, said housing member being adapted to be attached to the upper portion of a liquefied petroleum gas fuel tank with at least a portion extending into the tank, said housing member being so disposed that its axis is approximately vertical, a movable piston in the portion of said housing member adapted to extend into said tank, the bottom end of said housing member being closed, a pressure operative motor in the portion of said housing member adapted to be outside of said tank, said pressure operative motor being responsive to externally applied pressure, a piston rod connecting said motor to said piston, an excess flow valve in the wall of said housing member adapted to be outside of said tank and below said motor, means for attaching the end of said excess flow valve outside of said housing member to a conduit for passage of said fuel to its point of use, said excess flow valve being adapted to control the flow of fluid from said housing member to said conduit, a vapor inlet port in the sidewall of the portion of the housing member adapted to be inside said tank and at a level just below the bottom surface of said piston when said piston is at the upper end of its extent of travel, a liquid inlet port in the sidewall of the portion of said housing member adapted to be inside said tank and at a level just above the top surface of said piston when at the lower end of its extent of travel, a liquid dip tube extending from said liquid inlet port into the liquid containing portion of said tank, and a conduit through said piston connecting the space above the piston with the space below the piston.

11. In the liquid-vapor selector valve assembly of claim 10 wherein said pressure operative motor is a pressure operative diaphragm disposed gas-tight against the upper end of said housing member outside said tank, a bonnet disposed gas-tight on the side of said diaphragm opposite said housing member and an excess flow valve in said bonnet to regulate gas pressure in the space bounded by said diaphragm and said bonnet.

12. In the liquid-vapor selector valve assembly of claim 10 wherein said pressure operative motor is a pressure operative bellows.

13. A liquid-vapor selector valve assembly for use in liquefied petroleum gas fuel systems comprising, in combination, a valve body member of generally circular cross-section, means for attaching said valve body member vapor-tight to the wall of a tank, a portion of said valve body member being adapted to be disposed within said tank when said means is attached vapor-tight to said tank, said valve body member defining a first conduit, a pressure operative motor in said first conduit, said pressure operative motor being responsive to externally applied pressure, a movable piston driven by said pressure operated motor in said first conduit dividing said first conduit into two chambers, a second conduit in said piston providing fluid communication between said chambers, a port for inlet of vaporous fuel and a port for inlet of liquid fuel in the wall of said portion of said valve body member adapted to be disposed within said tank, said movable piston being disposed in general intermediate said ports and in such a manner that upon movement to one end of its stroke, one port becomes closed and the

9

other open and at the other end of its stroke, said one port becomes opened and said other port becomes closed, and an outlet means at least near the outlet end of said valve assembly.

14. A liquid-vapor selector valve assembly for use in liquefied petroleum gas fuel systems comprising, in combination, a generally cylindrical housing member, said housing member being adapted for installation in the upper portion of a liquefied petroleum gas storage tank, an end plate in the bottom end of said housing member, an opening in said end plate, a liquid dip-tube disposed in said opening in said plate and providing communication from the liquid containing space in said tank to a space above said end plate, a resilient sealing member attached to the top surface of said end plate, a piston in said housing member adapted for reciprocating movement therein, a pressure operative bellows attached to the lower portion of said housing, said pressure operative bellows being responsive to externally applied pressure, a tubular piston rod connecting said bellows and said piston, a conduit throughout the length of said piston, said tubular piston rod being connected with the walls of said conduit in said piston and extending through said bellows to a level adjacent said resilient sealing member, a lower end of said tubular piston rod being adapted to seat against said resilient sealing member at the lower end of the stroke of said piston, a port in the wall of said housing member at a point above said piston when at the bottom end of its stroke, and means for attaching the outer end of said assembly to a conduit for passage of fuel to a point of use.

15. A liquid-vapor selector valve assembly for use in liquefied petroleum gas fuel systems comprising, in combination, a housing member, said housing member being adapted for installation in the upper portion of a liquefied petroleum gas fuel tank, a pressure operative bellows supported by the inner end and within said housing member, said pressure operative bellows being responsive to externally applied pressure, a movable piston in said housing member, a piston rod connecting said piston and said pressure operative bellows, a first port in the side wall of said housing member at a level above the top surface of said piston when said piston is at the lower end of its extent of movement, a second port in the side wall of said housing member at a level below the bottom surface of said piston when said piston is at the upper end of its extent of movement, a liquid dip-tube extending from said second port to a level near the bottom of said tank, and means for attaching the upper end of said assembly to a conduit for passage of fuel to its point of use.

16. A liquid-vapor selector valve assembly for use in a liquefied petroleum gas fuel system comprising, in combination, a housing member, said housing member being adapted to be attached to the upper portion of a liquefied petroleum gas fuel tank, a perforate plate in the lower portion of said housing member, said housing member being adapted to extend substantially to the bottom of said tank, a resilient sealing member supported by the top of said end plate, a piston in said housing member adapted for reciprocating movement therein, a pressure operative bellows attached to the lower portion of said housing, said pressure operative bellows being responsive to externally applied pressure, a tubular piston rod connecting said bellows and said piston, a conduit throughout the vertical length of said piston, said tubular piston rod being connected with said piston, and extending through said bellows to a level adjacent said resilient sealing member in such a manner as to provide a passage from a level below said bellows to a level above said piston, the lower end of said tubular piston rod being adapted to seat against said resilient sealing member when said piston is at the lower end of its extent of movement, a port in the cylindrical wall of said housing member at a level above the top of said piston when said piston is at the lower end of its extent of movement, and means

for attaching the upper portion of said assembly to a conduit for passage of fuel to its point of use.

17. A liquid-vapor selector valve assembly for use in liquefied petroleum gas fuel systems comprising, in combination, a housing member adapted to be attached to the upper portion of a liquefied petroleum gas fuel tank with at least a portion extending into said tank, a movable piston in the portion of said housing member adapted to extend into said tank, a pressure operative motor in the portion of said housing member adapted to be outside of said tank, said pressure operative motor being responsive to externally applied pressure, a piston rod connecting said motor to said piston, means for attaching the portion of said housing member outside said tank and below said motor to a conduit for passage of said fuel to its point of use, a vapor inlet port in the side wall of the portion of the housing member adapted to be inside said tank and at a level below the bottom surface of said piston when said piston is at the upper end of its extent of travel, a liquid inlet port in the side wall of the portion of said housing member adapted to be inside said tank and at a level above the top surface of said piston when at the lower end of its extent of travel, a liquid dip-tube extending from said liquid inlet port into the liquid containing portion of said tank, and a conduit through said piston providing communication between the space above the piston with the space below the piston.

18. In the liquid-vapor selector valve assembly of claim 17 wherein said pressure operative motor is a pressure operative diaphragm disposed gas-tight against the upper end of said housing member outside said tank, a bonnet disposed on the side of said diaphragm opposite said housing member and an excess flow valve in said bonnet to regulate gas pressure in the space bounded by said diaphragm and said bonnet.

19. In the liquid-vapor selector valve assembly of claim 17 wherein said pressure operative motor is a pressure operative bellows.

20. A liquid-vapor selector valve assembly for use in liquefied petroleum gas fuel systems comprising, in combination, a housing member, said housing member being adapted for installation in the upper portion of a liquefied petroleum gas storage tank, a plate in the lower portion of said housing member, an opening in said plate, a liquid dip-tube disposed in said opening and providing communication from the liquid containing space in said tank to a space above said plate, a resilient sealing member supported by the top surface of said plate, a piston in said housing member adapted for reciprocating movement therein, a pressure operative bellows attached to the lower portion of said housing, said pressure operative bellows being responsive to externally applied pressure, a tubular piston rod connecting said bellows and said piston, a conduit through the vertical length of said piston, said tubular piston rod extending downward through said bellows to a level adjacent said resilient sealing member, the lower end of said tubular piston rod being adapted to seat against said resilient sealing member at the lower end of the stroke of said piston, said tubular piston rod and said conduit extending through said piston providing communication from a space below said pressure operative bellows to a space above said piston, a port in the wall of said housing member at a point above said piston when at the bottom end of its stroke, an excess flow valve in the upper end of said housing member, and means for attaching the outer end of said excess flow valve to a conduit for passage of fuel to a point of use.

21. A liquid-vapor selector valve assembly for use in liquefied petroleum gas fuel systems comprising, in combination, a housing member, said housing member being adapted for installation in the upper portion of a liquefied petroleum gas storage tank, a plate disposed vapor-tight in the lower portion of said housing member, an opening in said plate, a liquid dip-tube disposed in said opening

11

in said plate and providing communication from the liquid containing space in said tank to a space above said plate, a resilient sealing member attached to the top surface of said plate, a piston in said housing member adapted for reciprocating movement therein, a pressure operative bellows attached to the lower portion of said housing, said pressure operative bellows being responsive to externally applied pressure, a tubular piston rod connecting said bellows and said piston, a conduit throughout the length of said piston, said tubular piston rod being connected with said piston in such a manner that the conduit of the tubular piston rod communicates with said conduit in said piston, said tubular piston rod extending through said bellows to a level adjacent said resilient sealing member, the lower end of said tubular piston rod

12

being adapted to seat against said resilient sealing member at the lower end of the stroke of said piston, a port in the wall of said housing member at a point above said piston when at the bottom end of its stroke, and means for attaching the outer end of said assembly to a conduit for passage of fuel to a point of use.

References Cited in the file of this patent

UNITED STATES PATENTS

1,450,893	Morrow	Apr. 3, 1923
1,940,090	Hetherington	Dec. 19, 1933
1,962,214	Russell et al.	June 12, 1934
2,226,810	Ensign et al.	Dec. 31, 1940
2,365,423	MacSparron	Dec. 19, 1944
2,543,920	McCabe, Jr.	Mar. 6, 1951