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VAPOURIZER APPARATUS

This invention relates to a vapourizer apparatus for fuel burning machines.

This invention has particular but not exclusive application to vaporizers for use in liquefied petroleum gas (LPG) or compressed natural gas (CNG) fuelled, internal combustion (IC) powered vehicles, and for illustrative purposes reference will be made to such application.

However, it is to be understood that this invention could be used in other applications, such as fuel delivery generally.

Vaporizers for use in IC engines generally comprise a pneumatically operated valve variably operable as a function of depression of the gas supply line to the mixer. Valves of this nature are generally matched to the demand range of a particular IC engine. The wide range of fuel demands from large and small engines means that specific vaporizer designs must be produced for each engine type.

Since the operation of the valve is generally by means of a pneumatic actuator, there exists a potential for low volume gas leakage when the engine is stopped, establishing a potential explosion risk and thus compromising safety.

The use of a pneumatic demand valve for fuel flow control suffers also from the inherent disadvantage that the valves are slow acting resulting in the gas supply lagging behind the IC engine's instantaneous fuel demand.

The present invention aims to substantially alleviate the above disadvantages and to provide vapourizer apparatus which will be safe, reliable and efficient in use. Other objects and advantages of this invention will hereinafter become apparent.

With the foregoing and other objects in view, this invention in one aspect resides broadly in vapourizer apparatus for a fuel burning machine and including:-

a fuel receiving chamber having a fuel supply inlet and an outlet, the inlet being closable by inlet valve means responsive to the operation of the machine;

a heat exchanger communicating with said outlet and having pressure limiting means, and

adjustable demand valve means controlling flow through a

delivery outlet of said heat exchanger in response to demand from said machine.

Preferably, the apparatus is adapted to the use of LPG fuel and accordingly the fuel receiving chamber is adapted to receive fuel which is a liquid under delivery conditions to the fuel receiving chamber, and wherein the heat exchanger comprises a vaporising chamber for the fuel. However, it is envisaged that the apparatus will be useful in respect of CNG fuels where the high pressure differential between the stored gas and the delivery pressures required lead to a large drop in temperature as the gas expands. In such applications, the inlet chamber is preferably configured to receive fuel as a compressed gas under delivery conditions and the heat exchanger is adapted to warm the gas.

In further describing the invention, reference will be made to compressed fuel gas and liquefied fuel gas interchangeably. However, in the context of the present invention, the term "fuel gas" should be taken to include all fuels which are gases or vaporisable to form gases.

The fuel receiving chamber may take any suitable form and is generally as previously used in vaporizer apparatus. Preferably, the fuel inlet valve means comprises a valve which may only be open whilst the machine is in order for operation. For example, in automotive or other vehicular applications (in which context the invention is hereinafter described), the valve means preferably comprises a valve operable by means of a solenoid connected to the ignition circuit (in the case of spark ignition engines) or alternator field connect circuit (particularly in the case of diesel engines). Alternatively, the valve may be under the control of centrifugal operating means adapted to open the valve in response to the engine turning over at start up.

Preferably, the fuel receiving chamber includes surge limiting means to prevent surges of fuel into the heat exchange means. The surge control means may take any suitable form generally determined by the fuel type. For example, the surge control means may comprise a baffle or the like interposed in the fuel flow path. It has been determined that for the purposes of LPG and CNG fuels, surge



control may be provided by means of a secondary chamber provided in the fuel receiving chamber and located about the outlet thereof, the passage of fuel to the outlet being preferably by means of a plurality of relatively small perforations in the wall of the secondary chamber.

The heat exchange means may take any suitable form and again will generally be determined by the fuel type. For the purposes of LPG and CNG fuels, the heat exchanger means may comprises a chamber having a relatively large interior surface area to volume ratio. Preferably, the heat exchanger is formed of a material of relatively high thermal conductivity and may be provided with interior surface area increasing protuberances such as ribs or the like. For liquid or liquefied fuels in particular it is preferred that a plurality of ribs be at least in part configured to alternately rise from the bottom of the chamber and depend from the top thereof to provide a gas/liquid separator for preventing liquid fuel from passing out of the heat exchanger, although gaseous fuel apparatus is similarly served by such ribs to promote turbulent flow and mixing in the gas stream.

The heat exchanger may provide heat to the fuel by any suitable means. Preferably, the heat exchanger exchanges heat between a fluid provided by said machine and said fuel. In the case of liquid cooled internal combustion engines fuelled by gas fuels such as LPG and CNG it is preferred to provide the heat exchanger means with a coolant jacket such that the fuel is heated off the engine coolant. However, the heat exchanger means may be heated by any suitable means including electrical heating or exhaust gas circulation heating, particularly where vaporization of less volatile fuels such as motor spirit or ethanol is required.

The means for limiting the pressure within the apparatus may take any suitable form consistent with the function of providing a suitable pressure output from the heat exchanger to the demand valve. For example, the pressure limiting means may comprise pressure sensing means such as a transducer adapted to control the opening of the supply line valve. However, it is preferred that the pressure limiting



means include a valve disposed between the inlet chamber outlet and the heat exchanger such that the control is exercised substantially independently of the electrical system.

5 Preferably, in the interests of reliability and simplicity, as well as to provide for variation with demand, it is preferred that the pressure limiting control valve be operable by means of a diaphragm directly responsive to pressure in the heat exchanger. Preferably, the diaphragm is
10 located in a regulator chamber and divides the chamber into a reference chamber held at a reference pressure and a working chamber in fluid communication with the heat exchange cavity, preferably in the vapour-only portion thereof after the preferred gas/liquid separation means.

15 The reference pressure may be ambient atmospheric pressure whereby the pressure limiting control valve is operated as a function of the differential between the heat exchange cavity pressure and atmospheric pressure which can vary. By this means, the apparatus may compensate for high
20 altitude operation by maintaining a lower absolute pressure in the heat exchanger at altitude. Alternatively, the reference pressure may be other than ambient to allow for non standard operation, particularly in forced-aspiration engines, wherein the reference pressure may be derived from
25 the variable-pressure outflow from a turbocharger or supercharger.

The adjustable demand valve means controlling flow through a delivery outlet of the heat exchanger in response to demand from said machine may take any form consistent with
30 the function of supplying fuel gas to the machine at a relatively constant relative pressure compared to a reference pressure over the range of volumes dictated by varying machine demands. Preferably, the adjustable demand valve means comprises mechanical demand valve means responsive to a
35 depression in the machine supply line to increase flow as demand increases. For example, the mechanical demand valve means may comprise a piston or diaphragm having a working surface in communication with the gas supply line to the machine, and a reference surface in communication with the



reference pressure, operating a valve for delivering fuel gas from the heat exchanger to the machine supply line.

Preferably, in order to provide a large working surface at low mass and hence low inertia of the demand valve moving parts, a diaphragm is used. Adjustability of the demand valve may be provided by any suitable means dictated by the selection of operation, with it being preferred both in the case of piston and diaphragm operated demand valves to use adjustable biasing means to vary the differential force required to provide a particular gas flow, thus providing for variability to suit the demand ranges of different machines.

The reference pressure for the demand valve may be any suitable reference pressure determined by the particular machine in question. For example, in applications where the fuel entry point in the machine is subjected to increased pressure as demand increases such as gas turbines, the reference pressure may take the form of a bleed from the pressure side of the radial or axial fan compressor. In conventional piston or radial IC engines, the reference pressure may be ambient atmospheric pressure or accumulator or direct pressure derived from the exhaust side of the engine.

The vaporizer or heater preferably comprises an assembly comprising the liquid-fuel or compressed gas receiving chamber, the heat exchanger, and adjustable demand valve means. Preferably, the assembly comprises alloy castings adapted to be sealable secured together in assembly to define the respective inlet, heat exchange and demand valve cavities.

In apparatus for conventional reciprocating and rotary piston IC engines, and other machines having a start-up fuel demand in excess of its operating requirements and independent of operating combustion stoichiometry, it is preferred to provide bypass valve means for delivering gas fuel directly to the supply line to the machine from the heat exchanger cavity. For safety reasons, it is preferred that the bypass valve means comprise a solenoid operated valve operable in response to operation of the ignition circuit or alternator field connect circuit of a rotary piston,



reciprocating piston, spark ignition or diesel engine. It is envisaged that the bypass valve may also be operable in response to other inputs relating to start up or cold start.

For example, the bypass valve may be a multi-position valve adapted to fully open at start-up in response to the starter motor operation, and to partially close after starting, full closure of the valve being achieved after the engine or machine has reached operating temperature or the ignition or field connect circuit is broken.

Preferably, all solenoid valves or other operating means controlling gas flows in and within the apparatus are adapted to be normally-closed in operation such that in the event of failure of the motive power of the valves, the valves are closed or close.

During times of heavy engine demand and consequently heavy fuel demand, the primary pressure in the apparatus may drop to a point where the fuel mixture leans out, resulting in a loss of power under certain conditions of heavy demand. Accordingly, if desired, the apparatus may be provided with additional boost pressure means adapted to provide additional fuel flow at times of maximum demand. For example, there may be provided means adapted to bias the primary valve means to its open position in response to maximum demand. Preferably, the biasing means includes means for sensing pressure developed dynamically as a result of high gas flows being delivered from the apparatus, the developed pressure being preferably directed to assist the preferred spring in maintaining the primary valve in its open configuration.

In order that this invention may be more easily understood and put into practical effect, reference will now be made to the accompanying drawings which illustrate a preferred embodiment of the invention, wherein:-

FIG. 1 is a side view in cross section of apparatus in accordance with the present invention, and

FIG. 2 is an alternate apparatus including a boost port feature.

In the figure, there is provided vaporizer apparatus having a housing assembly 10 formed of cast alloy. The housing assembly 10 encloses a fuel inlet chamber 11 adapted



to receive fuel from a fuel supply line 12 via inlet solenoid valve 13. Disposed within the fuel inlet chamber 11 is a cylindrical filter/baffle 14, the interior of which communicates with a primary delivery passage 15 leading out of the fuel inlet chamber 11.

Disposed within and concentric with the filter/baffle 14 is a valve member 16 adapted to close the primary delivery passage 15 and being biased towards its closed position by means of valve spring 17. Disposed within the housing and adapted to receive fuel passing from the fuel inlet chamber 11 is a heat exchange chamber 20 comprising a primary heat exchange portion 21 and a delivery portion 22, divided by a gas liquid separation portion 23 characterized by interlinking upwardly and downwardly depending baffles 24.

Separated from the heat exchange chamber 20 by a conductive septum 25 is a coolant jacket 26 having a coolant inlet 27 and a coolant outlet 28 and being in circuit with the engine coolant circuit for the purposes of delivering heat to the heat exchange chamber 20. The septum 25 is increased in efficiency as a heat exchange surface by means of surface area increasing ridges 30.

Operation of the valve member 16 in controlling flow through the primary delivery passage 15 is achieved by means of a primary diaphragm 31 which divides a chamber formed in the housing assembly 10 into a reference portion 32 maintained at ambient atmospheric pressure and a working portion 33 communicating with the delivery portion 22 of the heat exchange chamber 20 by means of aperture 34. The diaphragm 31 is partially supported by a diaphragm spring 35, the setting of the control parameters of the valve member 16 being achieved by the selection of the valve spring 17 and diaphragm spring 35 as well as providing adjustability to the compressed length of the valve spring 17 by adjustment through the top of the housing assembly 10 by means of adjustment means (not shown).

The delivery portion 22 of the heat exchange chamber 20 is provided with a delivery passage 36 leading into a demand regulator chamber 37 which in turn has a relatively large bore supply line outlet 40 to the engine. A demand



regulator diaphragm 41 divides the demand regulator chamber 37 into a working portion 42 in fluid communication with the delivery passage 36 and the supply line outlet 40 and a reference portion 43 vented to ambient atmospheric pressure through atmospheric vent 39.

The demand regulator diaphragm 41 operates a primary demand valve operating lever 44 which in turn operates a secondary demand valve operating lever 45, regulation being effected by means of a delivery valve 46 operable by the secondary lever 45 and adapted to regulate the flow through the delivery passage 36. The performance of the demand regulator portion of the apparatus is adjustable by means of a variable length spring 47 supported in the housing assembly 10 and adjusted by means of a threaded plug 50.

To meet start up and idling demands, there is provided a start up/idling assembly 51 comprising a solenoid valve 52 interposed in a passage 53 directly linking for fluid communication the delivery portion 22 of the heat exchange chamber 20 and the working portion 42 of the demand regulator chamber 37.

In use, whilst the engine is not running and the ignition is off, the inlet 13 and start-up/idling 52 solenoids are switched off and are in their "normally closed" configuration, eliminating gas leakage and flow from either the fuel supply line 12 to the fuel inlet chamber 11 and the heat exchange chamber 20. When the engine is turned on, solenoids 13, 52 are activated, opening their respective valves.

Solenoid valve 13 allows liquid gas to flow into the fuel inlet chamber 11 and thence to the interior of the filter/baffle 14. From the interior of the filter/baffle 14, liquid fuel decompresses through the primary delivery passage 15 and valve 16 into the primary heat exchanger portion 21 of the heat exchange chamber 20. Reduction of pressure between the inlet chamber 11 and the heat exchange chamber 20 converts the liquid fuel to a gas, the heat of vaporization of the fuel on phase change, or heat of expansion, as the case may be, being taken from the alloy housing material.

The conversion of liquid fuel to gas or expansion of



highly compressed gas absorbs a great deal of heat energy from the housing. To compensate for this loss of heat, the coolant jacket 26 is connected to the engines cooling system by means of coolant inlet 27 and coolant outlet 28 to provide
5 a heating medium for the gas and to prevent freezing of the vaporizer apparatus.

This gas is allowed to pass through the idle/start-up solenoid valve 52 directly into the working portion 42 of the demand regulator chamber 37 and thence to the engine to
10 provide a rich mixture on start up under the positive supply pressure provided by vaporization or expansion of the liquid or compressed gas respectively, and to provide adequate fuel for idling when the demand operated apparatus is closed. This positive supply pressure substitutes for the choke for
15 start and fuel pressure for idle speed provided in conventional motor spirit powered engines.

Pressure build up in the heat exchange chamber 20 will be sensed by the primary diaphragm 31 through the aperture 34 to a degree determined by the nature of the diaphragm 31 and
20 springs 17, 35. Once this pressure overrides the springs 17, 35 the diaphragm 31 will depress, closing the primary delivery passage 15 with the inlet valve member 16. When the engine begins to rotate, the demand of the engine lowers the pressure in the demand regulator working chamber 42. The
25 atmospheric vent 39 allows ambient air pressure to move the demand regulator diaphragm 41 which operates the primary and secondary operating levers 44, 45 to unseat the delivery valve 46 from the delivery passage 36. This allows primary pressure to enter the working chamber 42 and out to the
30 engine. The greater the tendency for pressure reduction in the engine supply line and hence the working chamber 42, the further the delivery passage 36 is allowed to open thus controlling fuel supply through all ranges of operation at close to constant pressure.

35 On switching off the engine, solenoid valves 13, 52 switch off, eliminating gas flow. The loss of vacuum signal on the demand regulator diaphragm 41 allows the spring 47 to reseal the delivery valve 46 closing the delivery passage 36. This ensures no leakage of the heat exchanger contents into



the demand regulator stage.

In the embodiment illustrated in FIG. 2, wherein like numerals are used to designate features described in FIG. 1, there is illustrated a boost pressure circuit for use during times of heavy engine demand and consequently heavy fuel demand, when the primary pressure in the apparatus may drop to a point where the fuel mixture leans out, resulting in a loss of power under certain conditions of heavy demand. The boost pressure means is adapted to provide additional fuel flow at such times of maximum demand.

After the secondary valve 46 opens to its maximum regulated flow rate, and demand continues to increase, the valve 46 contacts a fixed stop 60 adapted to cause the valve 46 to tilt. A boost port 61 is disposed in the housing adjacent the valve 46 and in the region opposite the fixed stop 60 such that the high velocity gas flow through the valve 46 at high demand impinges on the opening of the boost port 61. This increases the pressure in a boost passage 62 which is in fluid communication with the reference portion 32 (in this embodiment not referenced to atmospheric) below the primary diaphragm 31, thereby assisting the spring 35 in opening the primary control valve 16. As a result, more fuel and therefore more pressure is obtained in the primary chamber to act on the diaphragm 31 before forcing it down to close the valve 16.

Apparatus in accordance with the above embodiments have the advantages that they can be fitted to a wide range of engine sizes, the idle fuel and maximum fuel flows infinitely adjustable, and includes positive leakage protection ensuring maximum degree of safety.

It will of course be realised that while the above has been given by way of illustrative example of this invention, all such and other modifications and variations thereto as would be apparent to persons skilled in the art are deemed to fall within the broad scope and ambit of this invention as defined in the claims appended hereto.



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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Vapourizer apparatus for a fuel burning machine and including:-

a fuel receiving chamber having a fuel supply inlet and an outlet, the inlet being closable by inlet valve means responsive to the operation of the machine;

a heat exchanger communicating with said outlet and having pressure limiting means, and

adjustable demand valve means controlling flow through a delivery outlet of said heat exchanger in response to demand from said machine.

2. Vapourizer apparatus according to claim 1, wherein said fuel is a liquid under delivery conditions to said fuel receiving chamber, said heat exchanger comprising a vaporising chamber.

3. Vapourizer apparatus according to Claim 1, wherein said fuel is a compressed gas under delivery conditions to said receiving chamber, said heat exchanger being adapted to warm said gas.

4. Vapourizer apparatus according to any one of Claims 1 to 3, wherein said fuel inlet valve means comprises a valve which may only be open whilst the machine is in order for operation.

5. Vapourizer apparatus according to Claim 4, wherein said valve means comprises a valve operable by means of a solenoid connected to the ignition circuit or alternator field connect circuit of an engine selected from rotary piston, reciprocating piston, spark ignition or diesel engines.

6. Vapourizer apparatus according to any one of the preceding Claims wherein said fuel receiving chamber includes surge limiting means.

7. Vapourizer apparatus according to any one of the



preceding Claims wherein said fuel receiving chamber includes a fuel filter.

8. Vapourizer apparatus according to any one of the preceding Claims wherein said heat exchanger means comprises a chamber having a relatively large interior surface area to volume ratio and is formed of a material of relatively high thermal conductivity.

9. Vapourizer apparatus according to Claim 8, wherein said heat exchanger means includes a gas/liquid separator for preventing liquid fuel from passing out of the heat exchanger.

10. Vapourizer apparatus according to any one of the preceding claims wherein said heat exchanger exchanges heat between a fluid provided by said machine and said fuel.

11. Vapourizer apparatus according to any one of the preceding Claims, wherein said pressure limiting means includes a valve disposed between the inlet chamber outlet and the heat exchanger and operable by means of a diaphragm directly responsive to pressure in the heat exchanger.

12. Vapourizer apparatus according to Claim 11, wherein said diaphragm is located in a regulator chamber and divides the chamber into a reference chamber held at a reference pressure and a working chamber in fluid communication with the heat exchanger chamber.

13. Vapourizer apparatus according to Claim 12, wherein said reference pressure is ambient atmospheric pressure.

14. Vapourizer apparatus according to any one of the preceding Claims, wherein said adjustable demand valve means is a mechanical demand valve responsive to the pressure in a machine supply line in fluid communication with said heat exchanger and adapted to control flow therefrom.





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15. Vapourizer apparatus according to Claim 14, wherein said demand valve means is a diaphragm operated demand valve mounted in a chamber, said demand diaphragm dividing said chamber into a working chamber in fluid communication with said heat exchanger and a reference chamber maintained at a reference pressure.

16. Vapourizer apparatus according to Claim 15, wherein said reference pressure is ambient atmospheric pressure.

17. Vapourizer apparatus according to any one of Claims 15 and 16, wherein said adjustable demand valve means includes adjustable biasing means adapted to bias the diaphragm.

18. Vapourizer apparatus according to any one of the preceding Claims, wherein there is further provided bypass means providing fluid communication between said heat exchanger means and the outlet from said demand valve means, said bypass being closable by means of bypass valve means responsive to the operating condition of said machine.

19. Vapourizer apparatus according to Claim 18, wherein said bypass valve means comprises a solenoid operated valve operable in response to operation of the ignition circuit or alternator field connect circuit of a rotary piston, reciprocating piston, spark ignition or diesel engine.

20. Vapourizer apparatus according to any one of the preceding Claims, wherein there is further provided boost pressure means adapted to provide additional fuel flow at times of maximum demand.

21. Vapourizer apparatus according to Claim 20, wherein said boost pressure means includes biasing means operable to bias said inlet valve towards its open position in response to maximum demand, said biasing means including means for sensing pressure developed dynamically as a result of high gas flows being delivered from the apparatus, the developed



pressure being directed to assist in maintaining the primary valve in its open configuration.

22. Vapourizer apparatus substantially as hereinbefore defined with reference to the accompanying drawing.

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