July 3, 1956 F. A. TANN 2,752,758

VAPORIZER REGULATOR FOR LIQUEFIED GAS

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Fig. 1

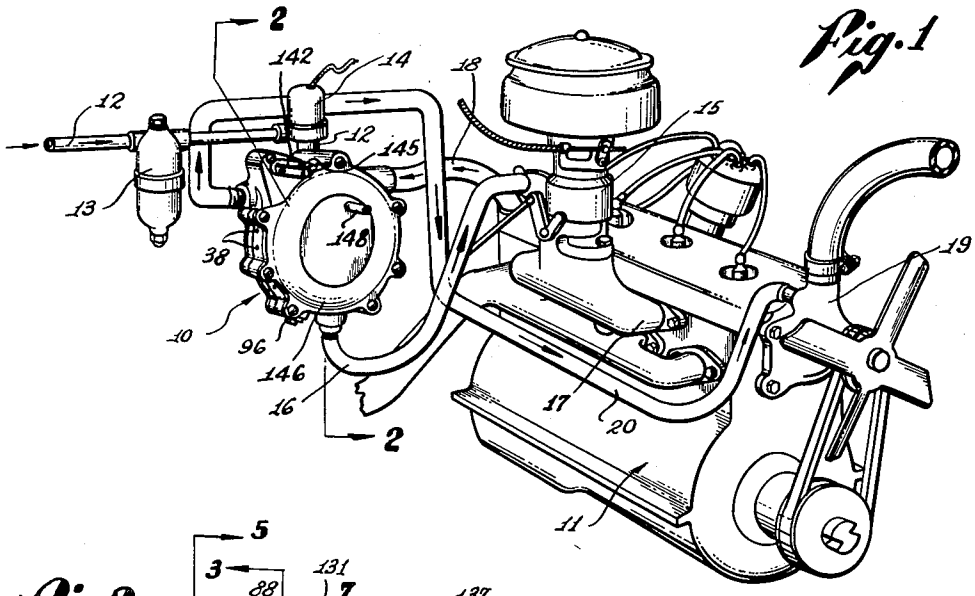


Fig. 2

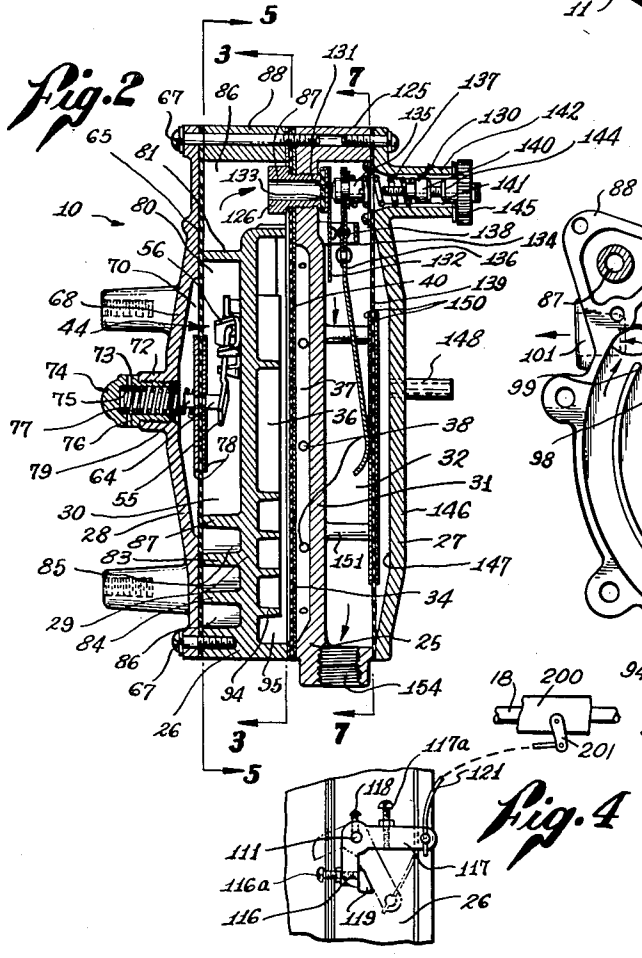


Fig. 3

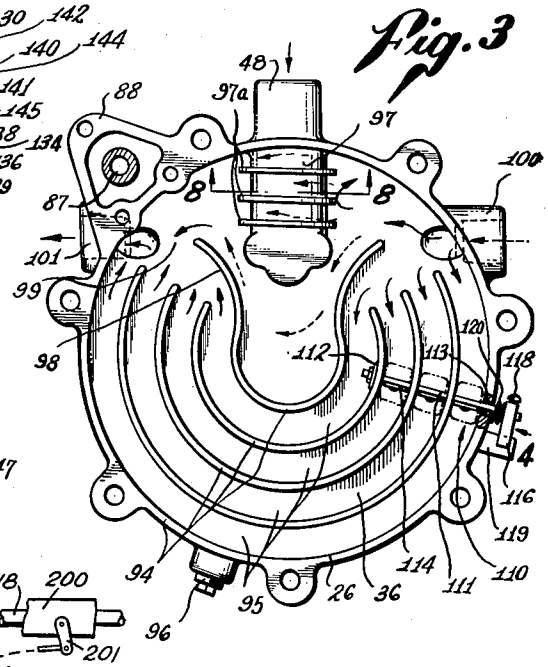


Fig. 4

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Fig. 5

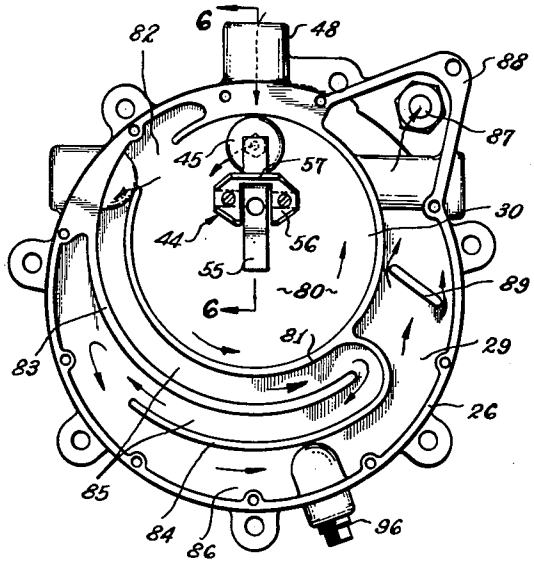


Fig. 6

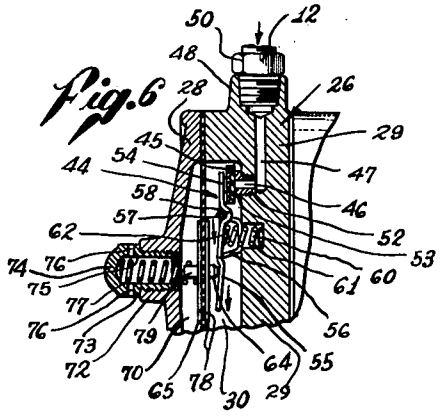


Fig. 7

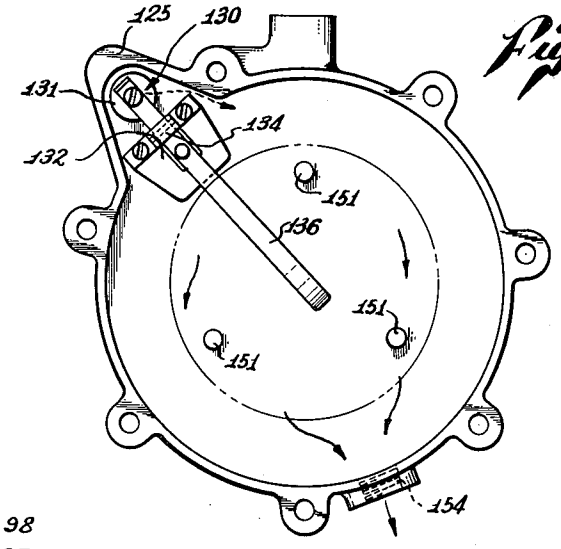
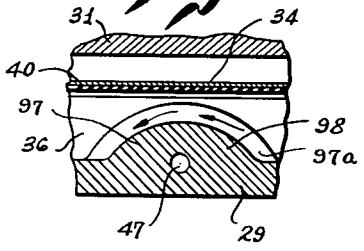


Fig. 8



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VAPORIZER REGULATOR FOR LIQUEFIED GAS

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Application August 21, 1951, Serial No. 242,956

18 Claims. (Cl. 62—1)

My invention relates generally to pressure regulators, and more particularly to a pressure regulator and vaporizer which is adapted to convert a liquefied gas under high pressure into a dry gaseous vapor at uniform temperature and low pressure.

Liquefied petroleum gas as the term is used herein includes butane, propane and similar normally gaseous hydrocarbons, either in a pure state or in such mixtures as are commercially available. Because these fuels have vapor pressures up to approximately 250 pounds per square inch at normal temperatures, they are highly volatile under atmospheric pressure, and cannot be effectively utilized unless they are stored under pressure in a liquid state. This invention is concerned with the problem of reconverting such liquefied fuel gases into a dry gaseous vapor at a low pressure suitable for introduction into a heat engine. While the invention is applicable to any use which requires a supply of gas vapor at uniform temperature and pressure, it is particularly advantageous for use with an internal combustion engine wherein there are varying load requirements. An engine of this type presents severe operating conditions since it requires a dry gas at low delivery pressure for proper carburization, and also requires a variable rate of gas flow.

In the conversion of liquid petroleum gas to a low working pressure, the necessary pressure drop and the accompanying change of state from liquid to gas causes a temperature drop of considerable magnitude in the expanded vapor due both to the pressure reduction and to the loss of the latent heat of vaporization. This cooling or freezing effect impairs the proper operation of the reduction valves and causes the expanded gas to be only partially vaporized unless additional heat is supplied.

In order that the cooling effect be less pronounced, it is desirable to use multiple stages of pressure reduction and expansion. However, to achieve good pressure regulation in a two-stage system, it is necessary to make the second pressure reduction quite small. In a liquefied gas regulator wherein the final working pressures are quite close to atmospheric pressure, I have found that the final pressure reduction should be no greater than five or ten pounds per square inch if uniform regulation is to be achieved. Accordingly, the initial pressure reduction may be as great as 150 to 200 pounds per square inch, and this combined with the loss of latent heat of vaporization requires the addition of considerable heat energy from an outside source. In the second stage of expansion, vaporization has been substantially completed and little or no temperature drop will occure even if no heat is added.

Prior regulator devices of the two-stage type have been designed with a means for heating both the primary and secondary vaporization chambers with a quantity of heat which is calculated to be proper for the maximum rate of gas flow through the device. When a regulator of this type is used to feed an internal combustion engine, operating under variable load conditions, the result is to vary the output temperature of the gas in inverse relationship

to the actual rate of gas flow through the regulator. Thus, when the engine is running at idle or low load, only a small flow of gas passes through the regulator, and the output temperature from the regulator is raised considerably by the heat supplied in the vaporization chambers.

From the standpoint of engine efficiency, it is desirable to supply the fuel at a constant temperature which is just above the vaporization temperature of the gas for the particular working pressure in the carburetor. This can be appreciated by considering that the heating or energy value of the fuel is dependent upon the unit weight of the gas, and accordingly the higher the temperature the less heating value is present within a unit volume. If the engine is to run most efficiently and idle properly, the optimum feed condition is one in which the fuel is supplied at uniform pressure and temperature. From a practical standpoint, this is best achieved by delivering the gas at a uniform pressure and at the temperature of the outside or ambient air. Any higher temperature is undesirable because of the loss of heating value, and a lower temperature cannot be uniformly maintained.

In my presently preferred form of regulator, the secondary pressure reduction occurs in a secondary vaporization chamber which is almost totally surrounded by the outside air so that the final working pressure is obtained in a gas which is at substantially the same temperature as the outside air. However, to achieve such a uniform output temperature, it can be seen that it is necessary to use a heating means capable of delivering a variable quantity of heat in the primary vaporization chamber. Otherwise, the variations in the volume flow of gas through the regulator create superheated or underheated gas which cannot be brought to thermal equilibrium with the outside air in the secondary vaporization chamber.

With the foregoing in mind, it is a major object of my invention to provide an improved vaporizer regulator which delivers a liquefied fuel gas in a dry vaporous state at a uniform pressure and temperature.

Another object of my invention is to provide a vaporizer regulator of the character described having heating means delivering a variable quantity of heat in accordance with the volume rate of flow of gas through the regulator.

It is also an object of my invention to provide a two-stage vaporizer regulator in which heat is supplied only to the first-stage vaporizing chamber by the heating means, and in which the second-stage vaporizing chamber is in substantially total surface contact with the outside air so that the gaseous fuel is delivered therefrom at ambient temperature.

It is a further object of my invention to provide vaporizer heating means having a variable area of effective heat transfer surface which is automatically brought into operation in accordance with the speed and load requirements of the engine.

Yet another object of my invention is to provide vaporizer heating means having internal flow regulating characteristics which automatically change the flow path of the heating fluid through tortuous passageways in accordance with the volume and pressure of fluid delivered.

An additional object of my invention is to provide vaporizer heating means having by-pass means adapted to vary the flow path through said tortuous passageways in response to the actuation of a selected external control element, thus allowing a given regulator to be used for a wider range of engine requirements.

A still further object of my invention is to provide the foregoing features in a unit-type vaporizer regulator of compact and simple design which may be economically produced.

These and other objects and advantages of my invention will become apparent from the following detailed descrip-

tion of a preferred form thereof, and from an inspection of the accompanying drawings in which:

Fig. 1 is a perspective view of a preferred embodiment of my invention shown installed for use on an internal combustion engine;

Fig. 2 is a central section of the device taken along the line 2—2 of Fig. 1;

Fig. 3 is a section across the heating chamber taken along the line 3—3 of Fig. 2;

Fig. 4 is an elevational detail taken in the direction of the arrow 4 of Fig. 3;

Fig. 5 is a section taken across the primary vaporizing chamber taken along the line 5—5 of Fig. 2;

Fig. 6 is a cross-sectional detail of the primary regulating valve and diaphragm taken along the line 6—6 of Fig. 5;

Fig. 7 is a section across the secondary vaporization chamber taken along the line 7—7 of Fig. 2; and

Fig. 8 is a sectional detail of the heat regulating dam taken along the line 8—8 of Fig. 3.

Referring now to the drawings and particularly to Fig. 1 thereof, the numeral **10** indicates generally a preferred embodiment of vaporizer regulator shown installed with the necessary fuel and heating fluid lines on a conventional internal combustion engine **11**. Liquefied gas under high pressure is supplied from a storage tank through an intake line **12** to a filter device **13**, and thence through a solenoid operated cut-off valve **14** into regulator **10**. The solenoid valve **14** is held closed when the ignition circuit is broken, and operates to prevent any leakage from the storage tank when the engine is shut down. The regulator **10** may be mounted in any suitable position, but it should be noted for reasons which will hereinafter appear, that it is preferably formed as a thin cylindrical housing standing in vertical or erect position. After conversion to a dry vapor state, the fuel or gas leaves regulator **10** at low pressure and enters a carburetor **15** through output line **16**. In carburetor **15**, the gas is mixed with the proper volume of air and is then drawn into an engine intake manifold **17**. The final working or output pressure of the gas from regulator **10** is dependent upon the particular carburetor installation and to some extent upon the load conditions of the engine, but for purposes of consideration herein, will be taken to be at or around atmospheric pressure.

I prefer to supply heat to the regulator **10** by means of the hot water passing out of the cooling system of the engine, but as can be understood, other heat mediums such as the engine exhaust gases may be used. In the typical installation herein illustrated, hot water from the block of engine **11** enters one side of regulator **10** through a line **18** connected near the top thereof, and is returned to the suction side of a cooling system circulating pump **19** via line **20**. Pump **19** is mounted for drive by engine **11** and the volume of pressure fluid flow through the regulator **10** is increased or decreased in accordance with engine speed.

Regulator **10** as is best seen in Figs. 1–3 comprises a flat cylindrical housing formed mainly by two cylindrical body sections **25** and **26** joined to each other and to front and back cover plates **27** and **28**, respectively. Body section **26** has a transverse dividing wall **29** which cooperates with cover plate **28** to define a first-stage or primary vaporization chamber **30**. The other body section **25** is also formed with a transverse dividing wall **31** which is spaced from cover plate **27** to define a second-stage or secondary vaporization chamber **32**.

Between vaporization chambers **30** and **32**, body sections **25** and **26** join in abutting relationship with a central dividing plate **34** to define adjacent chambers or spaces in cooperation with walls **29** and **31**. The space between plate **34** and wall **29** forms a heating chamber **36** which is adjacent the primary vaporization chamber **30** and is separated therefrom only by wall **29**. The space between plate **34** and wall **31** may be properly designated as a ventilating passageway **37**, and is ventilated peripherally by a series of large ports **38** formed in body section **25**.

Passageway **37** is adjacent the secondary vaporization chamber **32** and serves to insulate the latter from the heating medium chamber **36**, while at the same time conducting outside air into contact with the wall **31**. In order to prevent the loss of heat outwardly from chamber **36**, plate **34** may be covered on each side with a pair of cork discs or gaskets **40**. Thus it can be appreciated that substantially all of the heat within chamber **36** is directed through the wall **29** into primary vaporization chamber **30**.

The high pressure liquefied gas entering regulator **10** passes through a primary reduction valve **44** mounted in the top portion of body section **26** before entering vaporization chamber **30**. The structure of valve **44**, as is best seen in Figs. 5 and 6, includes an upper closure member **45** which is adapted to seat against an entrance port **46**. An intake passageway **47** leads to port **46**, and is bored internally in an outwardly projecting cylindrical boss **48** formed integrally with body section **26**. The outer portion of boss **48** is internally threaded to receive a coupling connector **50**, which is in turn joined to the high pressure feed line **12**. Body section **26** is preferably formed as a pressure resistant casting of aluminum or other lightweight material, and in order that port **46** may be protected against erosion, port **46** is defined by a hardened replaceable valve seat **52** threadedly engaged with the body casting and formed with a flat outer head **53**, as is best seen in Fig. 6. Valve closure member **45** has a shallow pocket therein to take a replaceable neoprene disc **54** that seats in tight sealing engagement with head **53** to insure proper closure of entrance port **46** at all times.

Closure member **45** is carried on the upper end of an arm **55** which is pivotally supported by means of a bifurcated bracket or stirrup **56**. Bracket **56** is securely mounted against body wall **29** and is formed with an outwardly spaced central bar or pivot rod **57** which bears inwardly against a suitable channel **58** formed in the arm **55**. Below the pivot rod **57**, a coil spring **60** is confined between body wall **29** and arm **55** to urge the latter outwardly and force closure member **45** against entrance port **46**. The inner end of spring **60** is held in position by a recess **61** formed in body section **26**, and the outer end of the spring is held by a detent button **62** formed on arm **55**. The lower end of arm **55** extends downwardly to ride against the right end of a stem or plunger **64** which is adapted to pivotally move arm **55** against the compression of spring **60** for opening closure member **45**. Plunger **64** is mounted centrally on a diaphragm **65** which will later be described, and, moving with the diaphragm, regulates the pressure within chamber **30** in accordance with the differential between the pressure existing therein and the atmospheric pressure. As can be understood, movement of diaphragm **65** towards the right as viewed in Fig. 6 causes closure member **45** to move away from port **46** and to permit the entrance of gas into chamber **30**.

Diaphragm **65** extends completely across chamber **30** and is held between the rim of body section **26** and cover plate **28** by a series of bolts **67** which secure the cover plate in position. As can best be seen in Fig. 2, cover plate **28** has an outwardly bulged central portion **68** defining a flat circular reference pressure chamber **70** outwardly of diaphragm **65**. At the center of section **68** is an outwardly projecting hub **72** which is bored through into chamber **70** and internally threaded to take a large adjustment plug **73** formed with an outer wrench head **74**. Plug **73** is centrally counterbored to provide an elongated cylinder **75** which is communicated to air pressure surrounding the regulator through radially directed vent ports **76** at the outer end thereof. Thus, chamber **70** is directly vented to the outside and will at all times carry atmospheric pressure therein to exert force against the outer face of diaphragm **65**. If it is desired to communicate a different reference pressure into chamber **70**, modification of plug **73** may be easily made for connection to an external pressure line.

A coiled spring 77 is carried in cylinder 75 and extends inwardly from plug 73 to bear against the outer side of diaphragm 65. To stiffen the central portion of diaphragm 65, inner and outer plates 78 are placed thereon and held in position by an outer stud 79 which extends through the diaphragm and engages plunger 64. Spring 77 encloses stud 79 and bears against the outer plate 78 with a force dependent upon the effective length thereof which is adjusted by axial movement of plug 73. The total force exerted on the outer side of diaphragm 65 is composed of the force of spring 77 and atmospheric pressure force, and this reference force acts to regulate the opening pressure of valve 44.

The particular pressure maintained in the primary vaporization chamber 30 will vary for different installations, but will normally be set at a pressure of five or ten pounds per square inch above atmospheric pressure. As aforementioned, the liquefied gas under storage is maintained at a high pressure and upon entrance through valve 44 expands sufficiently to change from the liquid to vapor state. This expansion is accompanied by a substantial temperature drop, and in order to overcome the freezing effect and produce a dry vapor, it is necessary to supply a quantity of outside heat. Before considering the heating means, it is best to follow the detailed path of the vaporized gas through the primary chamber 30.

As seen in Fig. 5, gas entering chamber 30 through primary reduction valve 44 is expanded into a circular upper chamber 80 defined by a raised circular rib 81, the chamber being completely closed with the exception of an upper side discharge port 82. The rib 81 together with a series of fragmental concentric ribs 83 and 84 form a tortuous extended passageway 85 through which the expanded gas is directed outwardly and downwardly as is shown by the flow arrows to an outer peripheral passageway 86 enclosed by the rim of body section 26. From the bottom of chamber 30, the gas then flows upwardly through passageway 86 to an upper discharge port 87. Discharge port 87 is formed in a triangular hub or boss 88 extended from body 26 and communicates directly into the secondary vaporization chamber 32. The arrangement of the ribs or baffles within chamber 30 is designed to facilitate the complete vaporization of gas and to prevent the creation of a pressure head at the output port 87 due to the velocity of flow. That is, since the velocity flow head is dependent upon the volume of gas passed through the device, it has been found that a more uniform regulation of pressure in the secondary chamber can be achieved if the flow path of the gas through the primary vaporization chamber 30 is quite restricted. Also, the use of tortuous passageways tends to break up any drops of liquid fuel and achieve a more uniform vapor. To further prevent the creation of a velocity head at the output port 87, I provide a short baffle or fin 89 which is disposed generally transversely across the flow path through passageway 86 to absorb a substantial part of the impact velocity of the outgoing gas.

The relationship of heating chamber 36 to the primary vaporization chamber 30 is such that they are separated only by the common transverse wall 29 and are of substantially coextensive area. Thus, wall 29 may be designated as a heat transfer surface, and the quantity of heat transferred into chamber 30 will depend on the amount of wall 29 in contact with a heating fluid circulated through chamber 36. As is seen in Fig. 2, the wall 29 has formed integrally therewith the ribs or baffles 81—84 of chamber 30 to increase the heat transfer surface. It should also be noted that the ribs 81—84 are raised to such a height as to seat outwardly against the diaphragm 65 which serves as a cover plate and forces all of the vaporized fluid to travel through the complete flow path previously described.

The wall 29 is also formed with a plurality of heat transfer ribs or baffles 94 projecting into the heating chamber 36, as is best seen in Fig. 3. These ribs 94 are

arranged in spaced concentric order around the lower portion of the heating chamber 36 and define a series of circular passageways 95 which are of increasing length in outward sequence, and accordingly each passageway offers more flow resistance to the passage of fluid therethrough than the adjacent inner passageway. At the bottom of body 26 is a drain plug 96 which is used to drain chamber 36 as necessary. The upper portion of chamber 36 is open except for a central heat dam 97 which projects downwardly a substantial distance from the top and is raised outwardly a considerable height from wall 29. The dam 97 is preferably formed with ribs 97–*a* to promote transfer of heat and to guide the liquid flow. The innermost concentric baffle 94 is formed with a pair of upwardly divergent arcuate extensions 98 which are closely spaced to heat dam 97 to provide an upper passageway 99 extending across the top of chamber 36 and of selected cross-sectional area.

Near the top of chamber 36 are oppositely spaced side ports 100 and 101 which are connected to the hot water circulating lines 18 and 20 leading into the engine cooling system. Since the normal operating range for the water within the engine cooling system is 140° to 180° F., it forms an effective heating fluid for use in chamber 36. The ports 100—101 can be connected for circulation in either direction, and as illustrated, port 100 is the intake port directing water inwardly into chamber 36. As the fluid enters, it is above the ends of the lower passageways 95 and has a normal tendency to flow directly across the heating chamber. Water impinging against the heat dam 97 is directed either outwardly around the dam, or downwardly through the passageway 99 to flow across a relatively short path in reaching the discharge port 101 at the opposite top side of the chamber. Assuming a condition in which the engine is running at idle or low load, it can be understood that the volume and pressure of water circulated by the cooling system pump 19 will be relatively small. Under this condition, the area of passageway 99 is sufficient to accommodate the entire volume flow of fluid and there is little or no motion of the fluid through the lower passageways 95. Thus, the upper portion of wall 29 in contact with the heated fluid will be active as a heat transfer surface, while the lower portion of the wall in contact with cold fluid will be inactive as a heat transfer surface and the quantity of heat transferred into primary vaporization chamber 30 is therefore limited.

As seen in Fig. 8, the heat dam 97 is formed as a raised semi-circular block which is spaced sufficiently from the dividing plate 34 to permit the flow of a portion of the hot fluid thereacross. This relationship is particularly desirable because dam 97 lies immediately adjacent intake port 47 and the primary reduction valve 44. As the gas expands through valve 44, the lowest temperature occurs immediately adjacent the valve and within upper chamber 80. By directing some of the fluid across heat dam 97 and the remainder through the upper passageway 99, all of the heat transfer under low load conditions takes place around the valve 44 and the tendency of the latter to freeze and operate improperly is overcome.

When the engine speed is increased, the cooling system pump 19 delivers an increased volume of fluid at higher pressure, and it is no longer possible for passageway 99 to accommodate the entire volume of flow. Therefore, some of the heating fluid is directed downwardly through the passageways 95 to displace the cold fluid, and force hot fluid around the lower portion of chamber 36. As each concentric passageway 95 has increased length and frictional resistance, it can be understood that the volume of flow through each passageway will be in inverse proportion to its relative resistance to flow, until a condition is reached in which all of the passageways are substantially full of heated circulating fluid. Thus, the quantity of heat transferred through wall 29 will increase in

direct proportion to the volume of fluid circulated, and more heat will be available for transfer to vaporization chamber **30**. Since the volume of gas flowing through chamber **30** is directly controlled by the speed with which engine **11** is running, it can be seen that I have increased or decreased the quantity of heat available for transfer in accordance with the load condition on the engine. Referring back to the fundamental consideration of volume and temperature, the device can therefore be said to maintain a uniform output temperature of the gas flowing through chamber **30** regardless of the volume rate of flow.

As can be understood, the particular proportions of the heat dam **97** and baffles **94** can be varied to change the flow areas through the device in accordance with the needs of particular installations. However, I have found that it is possible to design a single size regulator which will be properly adapted for use on any size of engine by the provision of additional flow regulating means **110** interposed in the lowermost flow passageways **95**. An additional use of flow regulating means **110** is to provide compensation for variations in a selected load factor other than the speed of the engine **11**. For example, if flow regulating means **110** be actuated by a load responsive element sensitive to manifold pressure, or water temperature, the rate of heat transfer may be varied independently of the normal fluctuation due to pressure and rate of flow of the heated fluid to take into account the effect of high load and low speed operating conditions, such as exists upon acceleration. Under these conditions, of engine operation a richer mixture is required by carburetor **15** and accordingly it is desirable that there be a higher volume of flow through primary chamber **30**. This is accomplished by reducing the heating effect whereby the fuel is supplied at a somewhat lower temperature than otherwise and the gas is therefore denser, providing thereby a higher effective flow volume.

In the embodiment of my invention herein illustrated, flow regulating means **110** comprises a plurality of butterfly valves which are adapted to close one or more of the passageways **95**. A radially extending shaft **111** passes rotatably through baffles **94** and extends outwardly through the wall of body section **26**. The inner end of shaft **111** is held against axial movement by a collar **112**, and an O-ring seal or gland **113** is mounted around the shaft in the rim of body **26** to prevent outward leakage of fluid. Securely mounted to shaft **111** are a series of flat discs or plates **114** which are shaped to conform to the opening through passageways **95**, and are adapted to block the travel of fluid therethrough when held in a perpendicular or closed position. When shaft **111** is rotated, valve discs **114** permit partial or full flow through the passageways in accordance with the rotational position of shaft **111**.

Mounted on the outer end of shaft **111** is an actuating lever **116** formed with a perpendicularly extending arm **117**, and locked against rotation on the shaft by an adjustment screw **118**. Adjacent lever **116** is a stop member **119** which is mounted on body **26** and interposed between lever **116** and arm **117** so as to permit movement through an arc of approximately 90°, until either of the members abuts thereagainst. Inwardly of lever **116** is a coiled spring **120** which is positioned to urge lever **116** against stop **119** as is seen in Fig. 4. As can be understood, with lever **116** in this position, valve discs **114** may be partially or completely closed across passageways **95** depending upon the relative angular position in which the lever is locked on shaft **111**. To operate lever **116** a mechanical linkage such as a cable **121** is secured to arm **117** for movement either by manual or automatic actuating means. To permit further adjustment and flexibility of action, lever **116** is provided with a limit-screw **116–*a*** and lever **117** with a limit-screw **117–*a***.

If cable **121** is connected to a sensitive element such as a thermostat or diaphragm valve, it can be appreciated that the movement of lever **116** may be responsive to a change in a selected engine load condition such as the temperature of the output gas, or the vacuum existing in the engine manifold. As shaft **111** is rotated, the heat transfer area of chamber **36** is varied by the opening or closing of passageways **95**. The relative angular position of actuating lever **116** upon shaft **111** is determined in accordance with the size of the engine upon which the device is installed to permit partial or complete opening of the valve discs **114** by the external actuating means. Thus one size of regulator may be properly installed upon many different sizes of engines by a simple adjustment of the movement of actuating lever **116**.

In Fig. 4, a schematic diagram of one method of actuating lever **116** is shown. A thermostatic device **200** having an external lever **201** connected to cable **121** is controlled by the temperature of the fluid flowing in line **18**. When the temperature of the heating fluid in line **18** is low, lever **201** will position cable **121** and lever **116** so that the valve discs **114** will be at the maximum opening and the maximum area of chamber **36** is open to the heating fluid. As the temperature of the heating fluid rises, lever **201** will be moved by the thermostatic device **200**, thereby actuating lever **116** to move the valve discs **114** toward the position of minimum opening so that less fluid or no fluid at all may flow through the passageways **95**.

After the gas has been heated and vaporized in chamber **30** it passes through discharge port **87** into secondary vaporization chamber **32**. A triangular boss **125** is formed on body section **25**, co-extensive with boss **88** of body section **26**, and port **87** is defined within a hardened insert or valve seat **126** which is threaded into boss **125** and may be easily replaced. Seat **126** cooperates with a secondary valve means **130** mounted within chamber **32** to reduce the pressure of the gas to the lower desired working pressure.

Valve **130**, as is best seen in Fig. 2, has an upper closure member **131** supported adjacent the right end of seat **126** by an upstanding spring plate **132**. Mounted in closure member **131** is a neoprene disc **133** which is adapted to seal tightly with seat **126**. Plate **132** is supported by a lower bracket **134** fixed to body wall **31** and tends to hold disc **133** against seat **126** with a very slight closing pressure which is sufficient to prevent valve chattering. Adjacent the outer face of member **131** is a short plunger or stud **135** that is carried by a pivotally mounted lever arm **136**. The outer end of plunger **135** is engaged with a compression spring **137** which tends to resist outward movement of the plunger and closure member **131**.

Arm **136** is supported on a pivot rod **138** carried by bracket **134** and has a downward extension which engages a diaphragm **139** extended transversely across chamber **32**. Movement of diaphragm **139** inwardly within chamber **32** forces plunger **135** outwardly against the pressure of spring **137** and permits opening of member **131** from valve seat **126**. The outer end of spring **137** bears against an adjustable stop member **140** slidably mounted for axial movement along a cylinder **141** defined by a boss **142** that is formed integrally with cover plate **27**. Stop **140** is held in a selected position within cylinder **141** by a threaded adjustment stem **144** which has an exposed outer hand nut **145**.

By rotation of hand nut **145** the position of spring **137** may be shifted longitudinally so that plunger **135** is normally spaced or backed off a slight distance from closure member **131**. This provides an effective idling adjustment for the device by permitting the leakage of a small amount of gas through secondary chamber **32** under idling conditions of the engine. When the engine speed picks up, further opening of closure member **131** is controlled by the movement of diaphragm **139** to maintain correct pressure regulation.

Cover plate **27** holds diaphragm **139** in place, and is

formed with a central outward bulge **146** to define a reference pressure chamber **147** outward of the diaphragm. A vent port **148** communicates atmospheric pressure into chamber **147** to bear against the outer face of diaphragm **139** and maintain a uniform pressure within chamber **32** by control of the valve **130**. Fine adjustment of the desired working pressure can be controlled through the rotation of hand nut **145** to adjust the effective length of spring **137**.

To prevent wear of diaphragm **139** through contact with arm **136**, a pair of stiffening plates **150** are mounted thereon in a central position. The inner plate **150** is also adapted to bear against a plurality of studs **151** spaced around chamber **32** to limit the inward movement of diaphragm **139**. This feature is particularly useful when a high temporary vacuum is created in chamber **32** to prevent distortion of the diaphragm. Such a condition may occur when there is a sudden load demand upon the engine, or in starting when carburetor **15** is choked to a full closed position. After passing through chamber **32** the gas then enters a lower discharge port **154** which is connected to output fuel line **16** leading to carburetor **15**.

The pressure reduction and further vaporization of gas within chamber **32** takes place under uniform temperature conditions which correspond substantially to the outside temperature. As will be remembered, chamber **32** is in substantially total surface contact with the outside air. Cover plate **27** is, of course, exposed to the outside air, and the opposite chamber wall **31** is in contact with the air being circulated through ventilation passageway **37**. A condition of thermal balance is therefore reached between chamber **32** and the outside air tending to bring the temperature of the output gas to the temperature of the outside air. Thus, it can be appreciated that the regulator converts the gas into a dry gas at low pressure and uniform temperature to permit optimum efficiency of the engine.

While I have shown and described a preferred regulator which is fully capable of carrying out the objects and advantages of my invention, it is to be understood that modifications of design and construction will be apparent to those skilled in the art. The installation so described is, of course, merely typical of an installation of the device and may be modified for use on different types of engines.

I claim:

1. A vaporizer regulator for liquefied gas conversion which comprises: means defining a vaporization chamber having intake and outlet ports; pressure regulating means operatively associated with said vaporization chamber to control the pressure of gas therein; heating means having an area of heat transfer surface in contact with said chamber and an area in conductive relation to said area of heat transfer surface for receiving heat from a heating medium; means for supplying a heating medium to said heat receiving area and means for varying the quantity of heat transferred by said heating means by varying the area of said heat receiving surface over which heating medium is circulated.

2. A vaporizer regulator for liquefied gas conversion which comprises: a housing defining a vaporization chamber having intake and outlet ports; pressure regulating means associated with said vaporization chamber to control the pressure of gas therein; a heating chamber having an area of heat transfer surface in contact with said vaporization chamber and adapted to be connected for the circulation of heating fluid therethrough; and baffle means for varying in accordance with the rate of flow of said heating fluid the effective area of said heat transfer surface over which said heating fluid is circulated.

3. A vaporizer regulator for liquefied gas conversion which comprises: a housing defining interconnected primary and secondary vaporization chambers; pressure regulating means associated with each of said chambers to control the pressure of gas therein; heating means having an area of heat transfer surface in contact with said primary chamber, said heating means being thermally insulated from said secondary chamber; and means for varying the quantity of heat available for transfer by said heating means to said primary chamber by varying the area of said transfer surface subjected to heating.

4. A vaporizer regulator for liquefied gas conversion which comprises: a housing defining interconnected primary and secondary vaporization chambers; pressure regulating means associated with each of said chambers to control the pressure of gas therein; heating means having an area of heat transfer surface in contact with said primary chamber, and a barrier chamber between said secondary vaporization chamber and said heating means for insulating said heating means from said secondary chamber.

5. A vaporizer regulator for liquefied gas conversion which comprises: means defining interconnected primary and secondary vaporization chambers and a heating chamber adjacent said primary chamber and spaced from said secondary chamber; pressure regulating means in each of said vaporization chambers to control the pressure of gas therein; said heating chamber having a wall of heat transfer surface common to said primary chamber, said wall being formed with a plurality of integral baffles thereon extending into said heating chamber and defining a series of tortuous passageways therethrough; and flow control means cooperating with said baffles to vary the circulation of heating fluid for changing the effective area of said heat transfer surface.

6. A vaporizer regulator for use on an internal combustion engine having a pump driven fluid circulating system, which comprises: a housing defining interconnected primary and secondary vaporization chambers; pressure regulating means in each of said chambers to regulate the pressure of gas therein; a heating chamber formed in said housing and having an area of heat transfer surface in contact with said primary chamber and spaced from said secondary chamber, said heating chamber being adapted for connection to said circulating system to receive heating fluid therefrom; and means within said heating chamber to control the flow path of said heating fluid and vary the effective heat transfer surface in accordance with the volume of fluid circulated therethrough by said pump driven fluid circulating system, whereby to change the quantity of heat transferred.

7. A vaporizer regulator for use on an internal combustion engine having a pump driven fluid circulating system, which comprises: a housing defining interconnected primary and secondary vaporization chambers; pressure regulating means in each of said chambers to regulate the pressure of gas therein; a heating chamber formed in said housing and having an area of heat transfer surface in contact with said primary chamber and spaced from said secondary chamber, said heating chamber being adapted for connection to said circulating system to receive heating fluid therefrom; and flow control means within said heating chamber adapted to control the flow path of heating fluid circulated therethrough and vary the effective heat transfer surface.

8. A vaporizer regulator for use on an internal combustion engine having a pump driven fluid circulating system, which comprises: a housing defining interconnected primary and secondary vaporization chambers; pressure regulating means in each of said chambers to regulate the pressure of gas therein; a heating chamber formed in said housing and having an area of heat transfer surface in contact with said primary chamber and spaced from said secondary chamber, said heating chamber being adapted for connection to said circulating system to receive heating fluid therefrom; fixed means within said heating chamber to control the flow path of said fluid and vary the effective heat transfer surface in accordance with the volume of fluid circulated therethrough under different pump speeds, whereby to change the

quantity of heat available for transfer; and movable flow control means within said heating chamber adapted to further change the flow path of said heating fluid in response to the variations in the selected engine operating condition.

9. A vaporizer regulator for liquefied gas conversion which comprises: a housing defining a vaporization chamber having an upper intake port; a pressure reduction valve mounted in said chamber adjacent said intake port; automatic pressure regulating means connected to said valve to control the pressure of gas in said chamber; a heating chamber of flat circular shape formed in said housing with a transverse wall thereof in heat-transfer contact with said vaporization chamber and said wall having a plurality of baffles projecting outwardly into said heating chamber to define a series of concentric lower passageways around the lower portion of said chamber; a flow regulating dam projecting downwardly in said chamber and defining with said baffles an upper flow path across said chamber; and inlet and outlet ports in the top of said chamber adapted to be connected in a heating fluid circulating system, with said fluid being directed across said upper passageway under a low volume of flow and being selectively diverted through said lower passageways as the flow increases to vary the effective heat-transfer surface of said chamber, said flow-regulating dam being adjacent said intake port and shaped to direct a partial flow of fluid therearound under a low volume flow condition, whereby to maintain the area of said primary vaporization chamber adjacent said reduction valve in a heated condition.

10. A vaporizer regulator for liquefied gas conversion which comprises: a housing defining a vaporization chamber having an upper intake port; a pressure reduction valve mounted in said chamber adjacent said intake port; automatic pressure regulating means connected to said valve to control the pressure of gas in said chamber; a heating chamber of flat circular shape formed in said housing with a transverse wall thereof in heat-transfer contact with said vaporization chamber and said wall having a plurality of baffles projecting outwardly into said heating chamber to define a series of concentric lower passageways around the lower portion of said chamber; a flow regulating dam projecting downwardly in said chamber and defining with said baffles an upper flow path across said chamber; inlet and outlet ports in the top of said chamber adapted to be connected in a heating fluid circulating system, with said fluid being directed across said upper passageway under a low volume of flow and being selectively diverted through said lower passageways as the flow increases to vary the effective heat-transfer surface of said chamber; and valve means extending across said lower passageways to regulate the volume of flow therethrough, said valve means having an external control lever adapted for connection to a load-responsive actuating element.

11. A vaporizer regulator for liquefied gas conversion which comprises: a housing defining a vaporization chamber having an upper intake port; a pressure reduction valve mounted in said chamber adjacent said intake port; automatic pressure regulating means connected to said valve to control the pressure of gas in said chamber; a heating chamber of flat circular shape formed in said housing with a transverse wall thereof in heat-transfer contact with said vaporization chamber and said wall having a plurality of baffles projecting outwardly into said heating chamber to define a series of concentric lower passageways around the lower portion of said chamber; a flow regulating dam projecting downwardly in said chamber and defining with said baffles an upper flow path across said chamber; inlet and outlet ports in the top of said chamber adapted to be connected in a heating fluid circulating system, with said fluid being directed across said upper passageway under a low volume of flow and being selectively diverted through said lower passageways as the flow increases to vary the effective heat-transfer surface of said chamber; a rotatable shaft extending across said lower passageways and projecting through said housing; a plurality of valve discs mounted on said shaft in said passageways to regulate the volume of flow therethrough in accordance with the rotational position of said shaft; and an external control lever on said shaft adapted for connection to a load-responsive actuating element and movable to change the rotational position of said shaft to thereby vary the effective heat transfer area of said heating chamber.

12. A vaporizer regulator for use on an internal combustion engine having a pump driven fluid circulating system, which comprises: a housing defining interconnected primary and secondary vaporization chambers with said primary chamber having an upper intake port therein; a pressure reduction valve mounted in said primary chamber adjacent said intake port; automatic pressure regulating means in said primary chamber and connected to said valve to control the pressure of gas in said primary chamber; a second pressure reduction valve mounted in said secondary chamber; automatic pressure regulating means in said secondary chamber to reduce the pressure of said gas in said secondary chamber to a low delivery pressure by control of said second reduction valve; a heating chamber of flat circular shape formed in said housing with a transverse wall thereof in heat transfer contact with said primary chamber and spaced from said secondary chamber, said wall having a plurality of baffles projecting outwardly in said heating chamber to define a series of lower concentric passageways around the lower portion of said heating chamber, and said secondary chamber being substantially enclosed by external walls of said housing and a ventilation passageway defined therein; a flow regulating dam projecting downwardly in said heating chamber and defining with said baffles an upper flow path across said chamber; inlet and outlet ports in the top of said heating chamber adapted to be connected to the fluid circulating system, with said fluid being directed across said upper flow path under a low volume of flow and being selectively diverted through said lower passageways as the flow increases to vary the effective heat transfer surface of said chamber, said flow regulating dam being adjacent said intake port and shaped to direct a partial flow of fluid therearound under a low volume flow condition whereby to maintain the area of said primary chamber adjacent said reduction valve in a heated condition; and valve means extending across said lower passageways to regulate the volume of flow therethrough, said valve means having an external control lever adapted for connection to a load-responsive actuating element.

13. In a pressure regulator, a first pressure reduction stage, a second pressure reduction stage connected to said first pressure reduction stage, a heat exchanger associated in heat exchange relation with said first pressure reduction stage, means defining a barrier chamber for thermally insulating said heat exchanger from said second pressure reduction stage and a housing enclosing said first and second pressure reduction stages and said heat exchanger.

14. A pressure regulator comprising a first pressure reduction stage, a heat exchanger associated in heat exchange relation with said first pressure reduction stage, means for supplying a heated fluid to said heat exchanger at varying rates of flow, fluid inlet and outlet ports in the upper portion of said heat exchanger connected to said supply means, a plurality of baffles in said heat exchanger defining a series of concentric passages around the lower portion of said exchanger, and flow regulating means defining with said baffles an upper flow path across said heat exchanger with said fluid being directed across said upper flow path under a low rate of flow and being selectively directed through said lower passages as the rate of flow increases to vary the effective heat transfer surface of said exchanger.

15. A heat exchanger comprising means defining a heat exchanger chamber having a surface adapted to be heated by fluid supplied to said chamber, an inlet port leading to said chamber and an outlet port leading from said chamber, a plurality of baffles in said chamber defining a series of concentric passages around the lower portion of said chamber, and flow regulating means defining with said baffles an upper flow path across said chamber with said fluid being directed across said upper flow path under a low rate of flow and being selectively directed through said lower passages as the rate of flow increases to vary the effective heat transfer surface of said chamber.

16. A heat exchanger comprising means defining a heat exchanger chamber having a wall adapted to be heated by circulation of heated medium thereover, inlet means associated with said chamber for directing heated medium over said wall, a plurality of baffles in said chamber defining a series of concentric passages around the lower portion of said chamber, and flow regulating means defining with said baffles an upper flow path across said chamber with said fluid being directed across said upper flow path under a low rate of flow and being selectively directed through said lower passages as the rate of flow increases to vary the area of said wall over which said heated fluid is circulated.

17. A pressure regulator comprising means defining a pressure reduction chamber having inlet and outlet ports, a valve associated with said inlet port for controlling the pressure of gas in said chamber, heat exchange means having an area of heat transfer surface in contact with said chamber, means for supplying heated medium to

said heat transfer surface, a heat dam in said heat exchanger located adjacent to said valve and in thermal conductive relation thereto for communicating heat to said valve, and means for varying the quantity of heat transferred by said heat transfer surface by varying the area of said surface subject to heat supply.

18. A heat exchanger comprising means defining a heat exchanger chamber having a surface adapted to be heated by fluid supplied to said chamber, an inlet port leading to said chamber and an outlet port leading from said chamber, a plurality of baffles in said chamber defining a series of concentric passages around the lower portion of said exchanger and means defining with said baffles an upper flow path across said heat exchanger with said fluid being directed across said upper flow path under a low rate of flow and being selectively directed through said lower passages as the rate of flow increases to vary the area over which said fluid is circulated in direct ratio to the volume of said heated fluid.

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