May 4, 1937. H. V. ATWELL 2,079,586

GAS MACHINE

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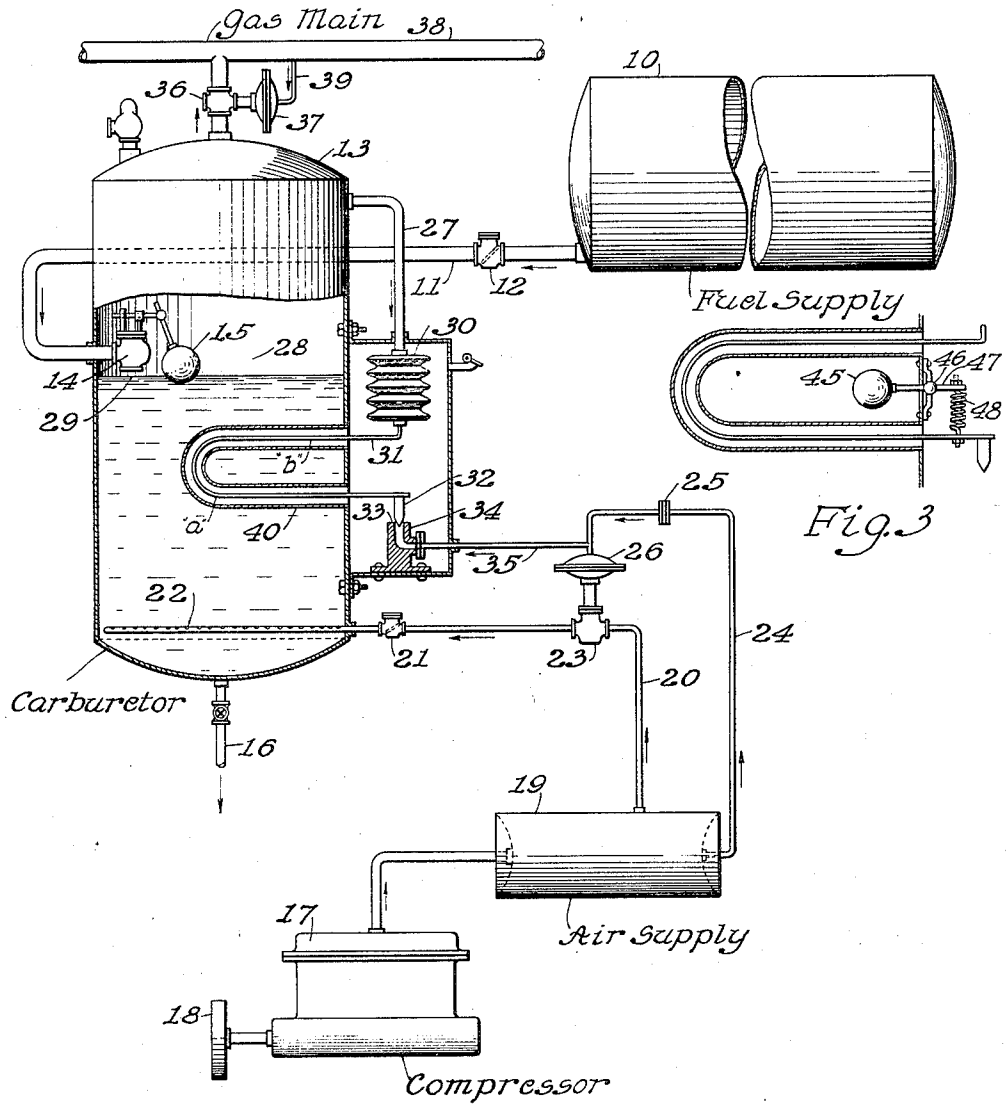


Fig. 1

Fig. 3

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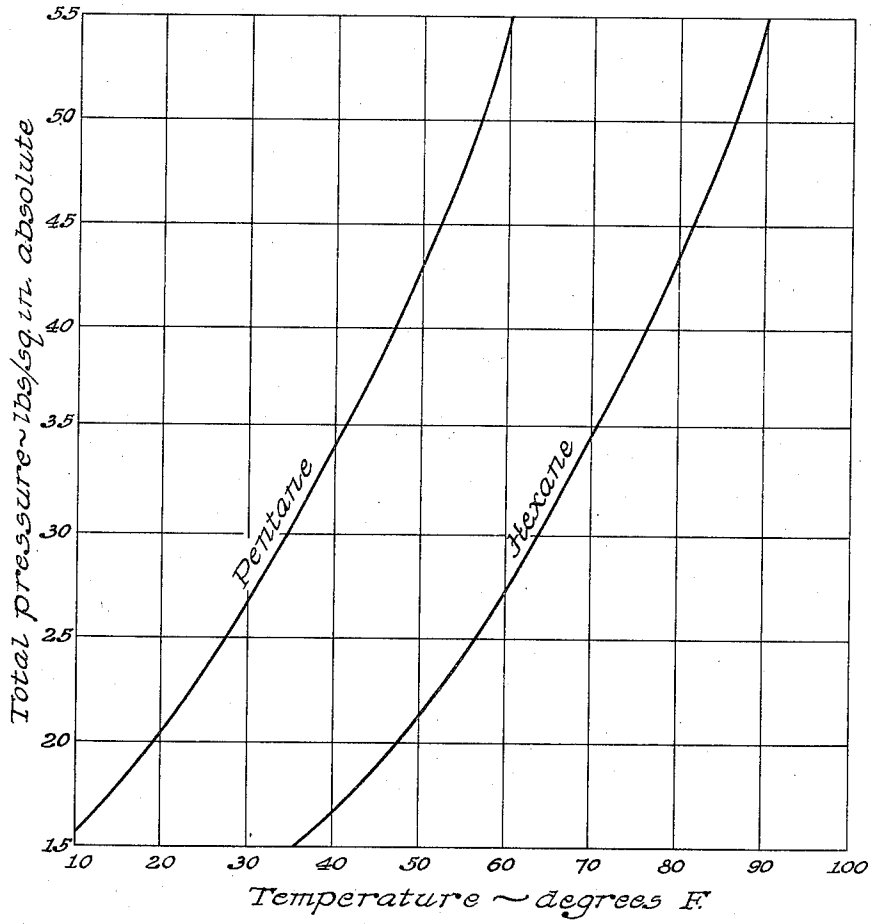


Fig. 2

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UNITED STATES PATENT OFFICE

2,079,586

GAS MACHINE

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15 Claims. (Cl. 261—121)

This invention relates to a process and apparatus for carburetting air with hydrocarbons, and the invention is particularly adapted for preparing a gaseous fuel, from liquid hydrocarbons, of predetermined fuel value per unit volume. Heretofore, it has been the practice to gasefy liquid hydrocarbons for fuel purposes by bubbling air through said liquid in order to obtain a mixture of hydrocarbon gases and air. However, such mixtures were too rich for commercial combustion purposes and, in order to prepare a domestic fuel, it was necessary to add secondary air to the vaporized hydrocarbons to adjust the heating value. This practice has proved to be very hazardous because, inadvertently, too much secondary air was frequently added and the resulting mixture contained air and gas in explosive proportions.

Therefore, one of the objects of my invention is to provide an apparatus and process for carburetting air with normally liquid hydrocarbons to produce a gaseous fuel of constant B. t. u. value per unit volume and eliminate the step of adding secondary air to the gas main.

Another object is to produce a gas machine that operates without attendance and one that is adapted to automatically adjust itself under different climatic conditions so that the carburetted gas will always have a constant heat value per unit volume of gas.

Further objects and advantages of my invention will become apparent from the following disclosure when read in connection with the following drawings, in which:

Fig. 1 of the drawings shows an elevational view of the gas machine partly in section.

The graphs in Fig. 2 show the pressures that should be maintained in the gas machine to prepare a gaseous fuel of constant heat value at different temperatures. For example, the pentane curve shows the pressure in pounds per square inch absolute required for a given temperature to give saturation of air with pentane of a composition of about 13.5% pentane, corresponding to approximately 550 B. t. u. per cubic foot of mixture at atmospheric pressure. The hexane curve shows the pressure and temperature conditions to give a saturated hexane air mixture of constant heat value.

Figure 3 is a sectional view of a portion of the apparatus showing in detail a compensating device for variable fuel volatility.

Briefly, the gas machine comprises a storage tank for the liquid hydrocarbons, a carburetor and a means for supplying compressed air to the carburetor. The compressed air is introduced into the bottom of the carburetor and bubbled through the liquid hydrocarbons. A gas space is provided above the level of the carburant to receive the air and hydrocarbon gases. By regulating the pressure above the liquid level through the introduction of the air added to the mixture, the ratio of air and hydrocarbon vapors can be accurately controlled. For example, at a given temperature the vapor pressure of the carburant will maintain a definite and constant amount of hydrocarbon vapor in the gas space above the liquid hydrocarbon. By introducing air into the carburetor, the pressure of the mixture of air and hydrocarbon gases will increase in proportion to the air pressure applied and the ratio of air to hydrocarbon gases will become greater. Therefore, by regulating the air pressure within the carburetor, the ratio of air and hydrocarbon gases, and consequently the fuel value of the mixture, will be controlled. Means, hereinafter explained, are provided for maintaining a predetermined pressure within the gas space and means are provided for adjusting the apparatus in response to temperature so that the fuel value of the gas leaving the carburetor will have a predetermined and constant value.

The carburant, or low boiling hydrocarbon, is stored in the tank 10 and fed through the conduit 11 and check valve 12 to the carburetor 13. A float valve 14 and float 15 command the flow of liquid hydrocarbons and maintain a constant level of liquid hydrocarbons within the carburetor. The carburetor 13 comprises a tank, or other suitable container, adapted to withstand high pressures. A drain pipe 16 is provided on the lowermost part of the carburetor to remove the water and objectionable materials that collect therein.

The compressed air to be mixed with the hydrocarbon vapors is delivered to the air storage tank 19 from the compressor 17, which is operated by a suitable driving means 18. Generally, pressures from 75 to 100 pounds per square inch absolute are adequate for the operation of the carburetor, but the pressure required will depend on the nature and volatility of the fuel employed. Any conventional means may be employed to automatically start the compressor when the pressure within the air storage tank 19 falls below the pressure to be used in the operation of the gas machine. Compressed air from the tank 19 flows through the conduit 20 and check valve 21 to the perforated pipe 22 in the lower part of the carburetor. The diaphragm valve 23 controls

the flow of air from the air storage tank to the carburetor. The check valve 21 prevents liquids from flowing back into the air system. The conduit 24 provided with the pin hole orifice 25 connects the air storage tank 19 with the upper chamber 26 of the diaphragm valve 23. When the pressure within the diaphragm chamber 26 is the same as the pressure within the tank 19, the valve 23 will close. Therefore, a reduction of pressure within the diaphragm chamber 26 will cause the valve 23 to open and permit the compressed air to pass into the carburetor. The apparatus and conditions for causing pressure fluctuations within the diaphragm chamber 26 will be described hereinafter.

A line 27 communicates with the gas space 28 above the liquid level 29 and the bellows 30. The pressure variations within the carburetor 13 cause the bellows 30 to expand or contract a predetermined and constant amount, and when the bellows expand, as a result of an increase in pressure within the gas space 28, the lower portion of the bellows moves downwardly and causes the bi-metallic hairpin 31 to push the valve needle 32 against the valve seat 33, thereby closing the needle valve 34. As long as the pressure within the gas space of the carburetor remains at a predetermined amount, the valve 34 remains closed, that is the valve needle 32 remains on the valve seat 33. The conduit 35 connects the needle valve 34 with the diaphragm chamber 26.

A pressure control valve 36, operated by a diaphragm in the chamber 37, regulates and controls the flow of gases from the carburetor to the gas main 38. A reduction of pressure in the gas main is transmitted to the diaphragm through the line 39, thereby causing the diaphragm to open the valve 36 and maintain a predetermined and constant lower pressure within the gas main independent of the pressure of the gas within the carburetor.

In operating the gas machine, the compressor 17 is started and air passes through the air storage tank 19, line 20, valve 23, and is bubbled through the liquid carburant. In this example, pentane will be used as the carburant, but other low boiling hydrocarbons, such as butane, hexane, heptane, casinghead gasoline or mixtures of these, may be used. The air, saturated with pentane at the prevailing temperature, collects in the gas space 28 above the liquid level 29 of the pentane, and the air continues to enter the carburetor until the pressure of the gas mixture within the gas space has built up to a pressure that gives the desired ratio of gas and air. In this particular example, I will describe the operation of my invention at 50° F. and it will be observed from the curve in Fig. 2 that a pressure of 43 pounds per square inch absolute will be required in the vapor space 28 to produce a saturated pentane-air vapor having a composition of about 13.5% pentane which corresponds to approximately 550 B. t. u. per cubic foot measured at atmospheric pressure. Therefore, when the pressure within the vapor space 28 has built up to 43 pounds per square inch absolute, the bellows 30 will have expanded and closed the needle valve 34. When the needle valve 34 closes, the pressure within the diaphragm chamber 26 builds up to the same pressure as in the tank 19 or line 20, thereby causing the valve 23 to close and stop the flow of air to the carburetor 13. At this state of the operation, the gases within the carburetor are under 43 pounds pressure per square inch absolute and the flow of air to the carburetor has ceased.

As the gas is withdrawn from the main 38, the pressure therein is reduced and the valve 36 is then opened to permit gas to flow from the carburetor 13 to the main 38. As the pressure within the carburetor begins to decrease, the bellows contract a proportional amount and open the needle valve 34 and permits air to escape through said needle valve, thereby reducing the pressure in the diaphragm chamber 26 and causing the valve 23 to open by action of the spring mechanism which it contains, and permit more air to bubble through the pentane in the carburetor. As long as the pressure within the vapor space 28 is below 43 pounds per square inch absolute, the bellows 30 will be sufficiently contracted to hold the needle valve 34 open. Consequently, the air in the diaphragm chamber 26 can escape through the needle valve 34 and reduce the pressure within said diaphragm chamber 26, thereby causing the valve 23 to remain open. It should be understood that the air can escape through needle valve 34 faster than the air enters the chamber 26 through the orifice 25.

Throughout the description of the above operation, the temperature was assumed to be at 50 F. at which temperature the vapor pressure of the pentane remained constant, giving a gas of constant fuel value. Where wide variations in temperature occur as between winter and summer and between day and night, I have found it necessary to employ means for compensating for lowered fuel vapor pressure at low temperatures and vice versa. For this purpose I may employ various thermally responsive devices and in the drawings, Fig. 1, I have shown a bimetallic coil or hairpin 31 for this purpose. This hairpin passes through the U-shaped conduit 40 that projects into the liquid within the carburetor providing a sensitive temperature shield for the bi-metallic hairpin. When the temperature of the liquid within the carburetor is increased, for example, to 55° F., the volatility or vapor pressure of the liquid also increases, and in order to maintain the desired ratio of air and pentane in the space 28 to give a gas mixture of constant fuel value, it is necessary to compress more air into this space. The increase in temperature causes the bi-metallic hairpin to contract and open the needle valve 34, which in turn permits compressed air to enter the lower part of the carburetor until the pressure of the gases within the gas space has increased to a predetermined amount and caused the bellows to expand sufficiently to close the valve 34. It is apparent that the higher temperatures cause the bi-metallic hairpin to contract, that is, causing the ends of the hairpin that are connected to the bellows 30 and valve needle 32 respectively to come closer together, thereby making it necessary for the bellows 30 to expand to a greater extent before it can push the needle valve against the valve seat 33 and stop the flow of air to the carburetor. From the curve in Figure 2, it will be observed that at a temperature of 55° F., the pressure within the gas space 28 should be maintained at about 49 pounds per square inch absolute in order to produce an air-pentane mixture which has a heat value of approximately 550 B. t. u.'s per cubic foot at substantially atmospheric pressure.

When the temperature of the liquid in the carburetor is decreased, for example to 40° F., the

volatility of the liquid therein decreases accordingly and in order to maintain the desired ratio of air and pentane in the vapor space 28 above to give a gas mixture of constant fuel value, it is necessary to reduce the amount of air added to the carburetor. Consequently, a pressure of about 34 pounds per square inch absolute must be maintained in the space above the liquid level in order to produce an air-pentane mixture which has a heating value of 550 B. t. u. per cubic foot at substantially atmospheric pressure. The decrease in temperature causes the bi-metallic hairpin to expand, thereby making it necessary for the bellows to contract to a greater extent than in the case of higher temperatures, before the contraction of the bellows will open the needle valve 34.

It should be understood that the temperature changes come about slowly and the bi-metallic needle adjusts itself to each increment of temperature change. The thermostatic element or bi-metallic hairpin comprises two strips of metals having widely different coefficients of expansion, for example, brass and steel, silver and nickel, copper and nickel. The longest strip of metal, or the one on the outside, designated "*a*" should have a higher coefficient of expansion than the strip of metal designated "*b*." Other thermostatic devices may be used instead of the embodiment herein described. For example, the bi-metallic thermostatic element described in U. S. Patent 1,813,122 may be connected between the bellows 30 and the valve needle 32. Also if the gas machine herein described is maintained at substantially constant temperature, it will not be necessary to employ the aid of a thermostatic element. In such case, the lower end of the bellows 30 may be directly connected to the valve needle 32.

From the curve in Figure 2 it will be observed that different pressures in pounds per square inch absolute must be maintained in the vapor space 28 for different temperatures in order to deliver a gas of constant B. t. u. value per cubic foot at atmospheric pressure. The pentane curve shows the total pressure required for any given temperature to give saturation of air with pentane vapor at a composition of 13.5% pentane and corresponding to approximately 550 B. t. u. per cubic foot of mixture at atmospheric pressure. By adjusting and calibrating the bellows and bi-metallic hairpin, my device can produce a gas mixture of constant B. t. u. value for all temperatures. The hexane curve shows the temperatures and pressures that must be maintained in order to produce a gas mixture of constant B. t. u. value.

It should be understood that my gas machine may be adapted to operate at any predetermined pressure for the prevailing temperature, thereby producing gas mixtures with any predetermined heat value. For example, if the prevailing temperature is 50° F., the pressure in pounds per square inch absolute to be maintained within the carburetor may be above or below 43 pounds or square inch absolute, and if the pressure is above 43 pounds per square inch absolute, the B. t. u. value of the fuel per cubic foot will be proportionately less than 550 B. t. u. per cubic foot at atmospheric pressure. If the pressure is below 43 pounds per square inch absolute, the B. t. u. value of the fuel per cubic foot at atmospheric pressure will be proportionately greater than 550 B. t. u. per cubic foot at atmospheric pressure. Therefore it will be noted that I can determine and control the B. t. u. value of the gas mixture discharged from the gas machine by regulating the partial pressure of air within the gas space above the liquid level of the carburant.

While I have described my invention with reference to specific examples, it is not intended that the invention shall be limited thereto except as included in the appended claims.

Under certain conditions it is desirable to use liquid fuels having a relatively wide boiling range chiefly because of their lower cost to manufacture. When using fuels of this type and fuels having substantially different boiling ranges and specific gravities, it is desirable to compensate for differences in vapor pressure exerted by fuels of high and low gravity. It is also desirable to compensate for changes in the vapor pressure of the fuel in the carburetor as the more volatile constituents are evaporated therefrom.

In order to achieve this compensation I have made use of the fact that the vapor pressure of the fuel decreases with an increase in its specific gravity. A compensating mechanism which may be employed for operating my gas machine under the conditions of fluctuating fuel volatility described is illustrated in Figure 3, which represents a cut-away section of the bi-metallic temperature regulator shown in Figure 1. 45 is a submerged float whose buoyancy varies with the change in density of the fuel contained in the carburetor 13. The buoy actuates lever arm 47 through the sealed pivot 46. Lever arm 47 in turn is connected to the needle valve member 32 by means of elastic tension member 48 which in this case is illustrated as a coil spring. The manner of gravity compensation is as follows: When the specific gravity of the fuel in carburetor 13 increases, the float 45 is caused to rise and in turn reduces the tension on spring 48, thus permitting valve pin 32 to seat more readily and close off orifice 33. As a result the air pressure is permitted to act on diaphragm valve 26 and partially closed valve 23 supplying air to carburetor 13, as previously described. The pressure of the air in the carburetor is thereby reduced, thus tending to enrich the gas mixture contained in the vapor space thereof, which is the desired compensation for the reduced volatility of the heavier fuel.

I claim:

1. An apparatus for carbureting air with volatile liquid hydrocarbons to produce a gaseous fuel of constant heating value, which comprises a liquid hydrocarbon supply tank, means for passing air through the hydrocarbon contents of said tank, said tank having a gas space above the liquid level thereof for maintaining the carbureted air at a pressure determined by the amount of air admitted to the tank, means for maintaining a super-atmospheric pressure within said gas space, a valve for controlling the admission of air into the tank, and means connected to said first mentioned means and responsive to a decrease in the specific gravity of the hydrocarbon fluid for regulating the valve to increase the amount of air passing therethrough.

2. The method of carburetting air with hydrocarbon gases to provide a gas mixture wherein the ratio between the air and the hydrocarbon gases is a predetermined constant to provide a gas of uniform heating value which comprises, contacting air directly with a volatile liquid hydrocarbon to carburet said air, maintaining said carburetted air in contact with said liquid hydrocarbon under a super-atmospheric pressure pro-

ductive of said desired gas mixture ratio, varying the said superatmospheric pressure by regulating the amount of air directly contacting the liquid hydrocarbon to control the partial pressure of air within said mixture of air and gasified hydrocarbons in response to changes in temperature of said liquid hydrocarbon, and delivering said gas mixture at a lower pressure to a point of consumption.

3. The method of carburetting air with hydrocarbon gases to produce a gas mixture wherein the ratio between the air and the hydrocarbon gases is a predetermined constant to provide a gas of uniform heating value which comprises, maintaining a volatile liquid hydrocarbon in a carburetor, passing air through said hydrocarbons and collecting the air and evolved hydrocarbon gases, maintaining the mixture of air and gaseous hydrocarbon under a super-atmospheric pressure productive of said gas mixture ratio, and regulating the amount of air passing through said liquid hydrocarbon to vary said super-atmospheric pressure of said mixture of air and gasified hydrocarbons in response to changes in the temperature of said liquid hydrocarbon.

4. The method of carburetting air with hydrocarbon gases to produce a gas mixture wherein the ratio between the air and the hydrocarbon gases is a predetermined constant to provide a gas of uniform heating value which comprises, passing air under pressure through a volatile liquid hydrocarbon to carburet said air, maintaining the resultant gas mixture in contact with said hydrocarbon liquid at super-atmospheric pressure, and increasing and decreasing said super-atmospheric pressure by increasing and decreasing respectively the amount of air passed through said liquid hydrocarbon in response to increases and decreases respectively of the temperature of said hydrocarbon liquid to maintain said desired gas mixture ratio.

5. The method of carburetting air with hydrocarbon gases to produce a gas mixture wherein the ratio between the air and the hydrocarbon gases is a predetermined constant to provide a gas of uniform heating value which comprises, passing air under pressure through a volatile liquid hydrocarbon to carburet said air, maintaining the resultant gas mixture in contact with said hydrocarbon liquid at super-atmospheric pressure, and in increasing and decreasing said super-atmospheric pressure by increasing and decreasing respectively the amount of air passed through said liquid hydrocarbon in response to increases and decreases respectively of the temperature of said hydrocarbon liquid and to decreases and increases respectively in the specific gravity of said hydrocarbon liquid to maintain said desired gas mixture ratio.

6. The method of carburetting air with hydrocarbon gases to produce a gas mixture wherein the ratio between the air and the hydrocarbon gases is a predetermined constant to provide a gas of uniform heating value which comprises, passing air under pressure through a volatile liquid hydrocarbon to carburet said air, maintaining the resultant gas mixture in contact with said hydrocarbon liquid at super-atmospheric pressure, and in increasing and decreasing said super-atmospheric pressure by increasing and decreasing respectively the amount of air passed through said liquid hydro-carbon in response to decreases and increases respectively in the specific gravity of said hydrocarbon liquid to maintain said desired gas mixture ratio.

7. Apparatus for carburetting air with hydrocarbons to produce a gas mixture wherein the ratio between the air and the hydrocarbon gases is a predetermined constant which comprises, in combination, means for passing air under pressure through a volatile liquid hydrocarbon to carburet said air, means for confining resultant gas mixture in contact with said hydrocarbon liquid at super-atmospheric pressure, and means connected to said first mentioned means for increasing and decreasing said super-atmospheric pressure by increasing and decreasing respectively the quantity of air passing through the liquid hydrocarbon in response to increases and decreases respectively of the temperature of said hydrocarbon liquid to maintain said desired gas mixture ratio.

8. Apparatus for carburetting air with hydrocarbons to produce a gas mixture wherein the ratio between the air and the hydrocarbon gases is a predetermined constant which comprises, in combination, means for passing air under pressure through a volatile liquid hydrocarbon to carburet said air, means for confining resultant gas mixture in contact with said hydrocarbon liquid at super-atmospheric pressure and means connected to said first mentioned means for increasing and decreasing said super-atmospheric pressure by increasing and decreasing respectively the quantity of air passing through the liquid hydrocarbon in response to increases and decreases respectively of the temperature of said hydrocarbon liquid and to decreases and increases respectively in the specific gravity of said hydrocarbon liquid.

9. Apparatus for carburetting air with hydrocarbons to produce a gas mixture wherein the ratio between the air and the hydrocarbon gases is a predetermined constant which comprises, in combination, means for passing air under pressure through a volatile liquid hydrocarbon to carburet said air, means for confining resultant gas mixture in contact with said hydrocarbon liquid at super-atmospheric pressure and means connected to said first mentioned means for increasing and decreasing said super-atmospheric pressure by increasing and decreasing respectively the quantity of air passing through the liquid hydrocarbon in response to decreases and increases respectively in the specific gravity of said liquid.

10. In an air-gas carburetor wherein air under pressure is intimately contacted with a volatile liquid fuel in a closed chamber maintained at super-atmospheric pressure, the method of controlling the heating value of the gas under changing fuel volatility, comprising varying the amount of air intimately contacted with said liquid fuel to regulate the pressure in said chamber in response to variations in the specific gravity of the liquid fuel therein.

11. An apparatus for converting volatile liquid hydrocarbons into a gaseous fuel of constant heating value, which comprises a container partly filled with liquid hydrocarbons, means for maintaining the liquid level of said hydrocarbons substantially constant, means for introducing air directly into said liquid hydrocarbons, a chamber providing a confined space above the level of said liquid hydrocarbons and in communication therewith for receiving the air and hydrocarbon vapors that collect therein, means for maintaining a superatmospheric pressure within said confined space, means connected to said chamber responsive to the pressure of the gases therein for regu-

lating the amount of air introduced directly into said liquid hydrocarbons and means responsive to the temperature of said liquid hydrocarbons for modifying the operation of said pressure responsive means.

12. An apparatus for carbureting air with volatile liquid hydrocarbons to produce a gaseous fuel of substantially constant heating value, which comprises a liquid hydrocarbon supply tank, a carburetor, automatic means for maintaining a constant amount of liquid hydrocarbons in said carburetor, means providing a gas space above the liquid level in said carburetor, means for maintaining a superatmospheric pressure within said gas space, means for introducing air directly into said liquid hydrocarbons, means connected to said means for introducing air and responsive to the pressure of the gases within said gas space for regulating the amount of air introduced directly into said liquid hydrocarbons and means responsive to the temperature of said liquid hydrocarbons for modifying the operation of said last-named means.

13. An apparatus for gasifying volatile liquid hydrocarbons to produce a gaseous fuel of substantially constant heating value, which comprises a container partly filled with volatile liquid hydrocarbons, means for maintaining a superatmospheric pressure in the vapor space of said chamber, means for introducing air directly into said liquid hydrocarbons, means connected to said means for introducing air and responsive to the pressure within said chamber for regulating the amount of air introduced into said liquid hydrocarbons and means responsive to temperature changes of said liquid hydrocarbons and co-acting with said pressure responsive means to modify the operation of said pressure responsive regulating means, said temperature responsive means being operable to raise and lower the pressure limit of said pressure responsive regulating means as the temperature in said container is increased or decreased, respectively.

14. The method of carbureting air with vapors of volatile liquid hydrocarbons to provide an air-gas mixture of substantially constant heating value having a substantially uniform ratio of air to hydrocarbon, comprising maintaining a body of said liquid hydrocarbon, introducing air into intimate contact with said liquid hydrocarbon body at a superatmospheric pressure whereby all the air is completely saturated with vapors of said hydrocarbon, collecting the resulting air-gas mixture and controlling said super-atmospheric pressure by automatically regulating the introduction of air in a manner to maintain a substantially constant ratio of air to hydrocarbon in said air-gas mixture under varying conditions of temperature of said liquid hydrocarbon.

15. The method of claim 14 wherein the introduction of air is automatically regulated to maintain a substantially constant ratio of air to hydrocarbon in said air-gas mixture under varying conditions of temperature and specfic gravity of said liquid hydrocarbons.

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