Jan. 11, 1966 G. J. HEBERLEIN 3,228,447

APPARATUS FOR CONTROLLED BURNING OF LIQUEFIED PETROLEUM GAS

Filed Oct. 29, 1962 3 Sheets-Sheet 1

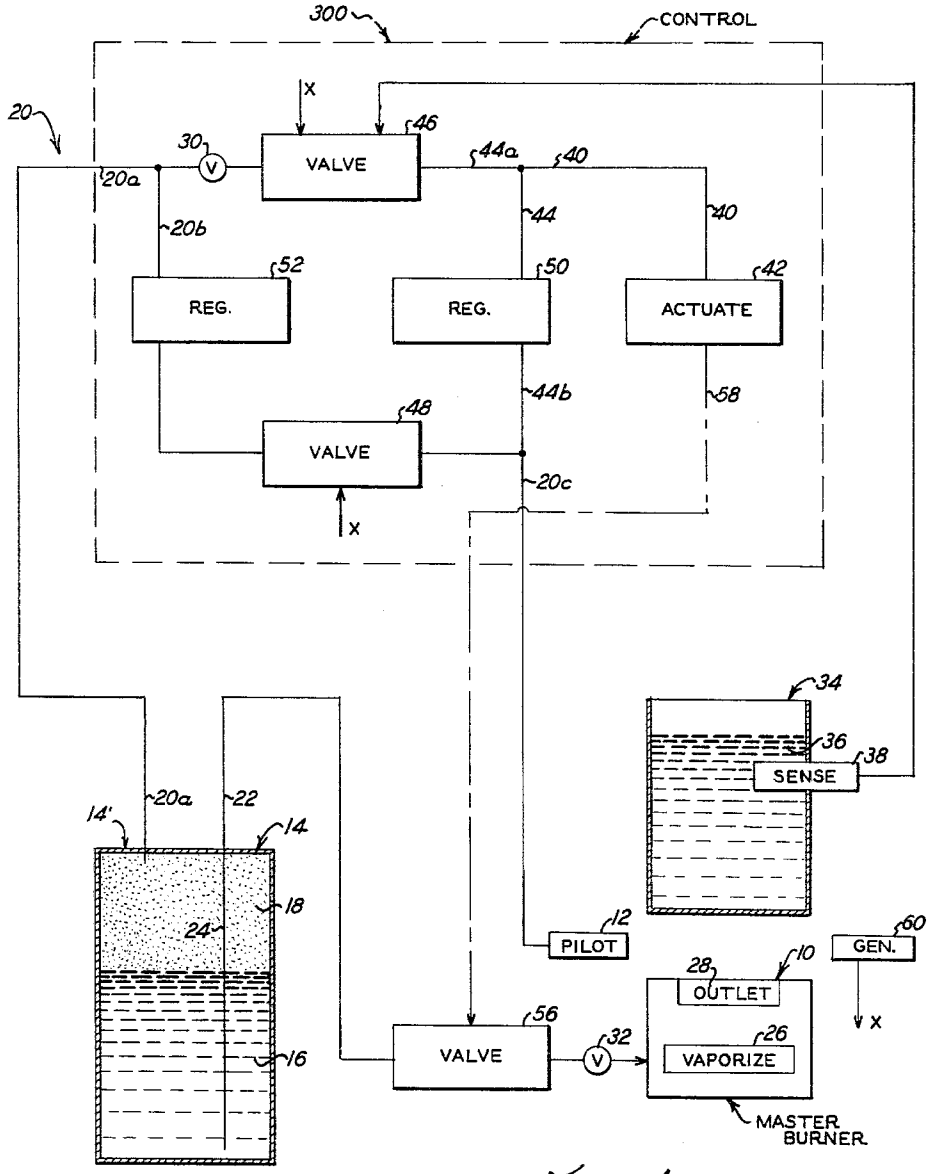



FIG. 1.

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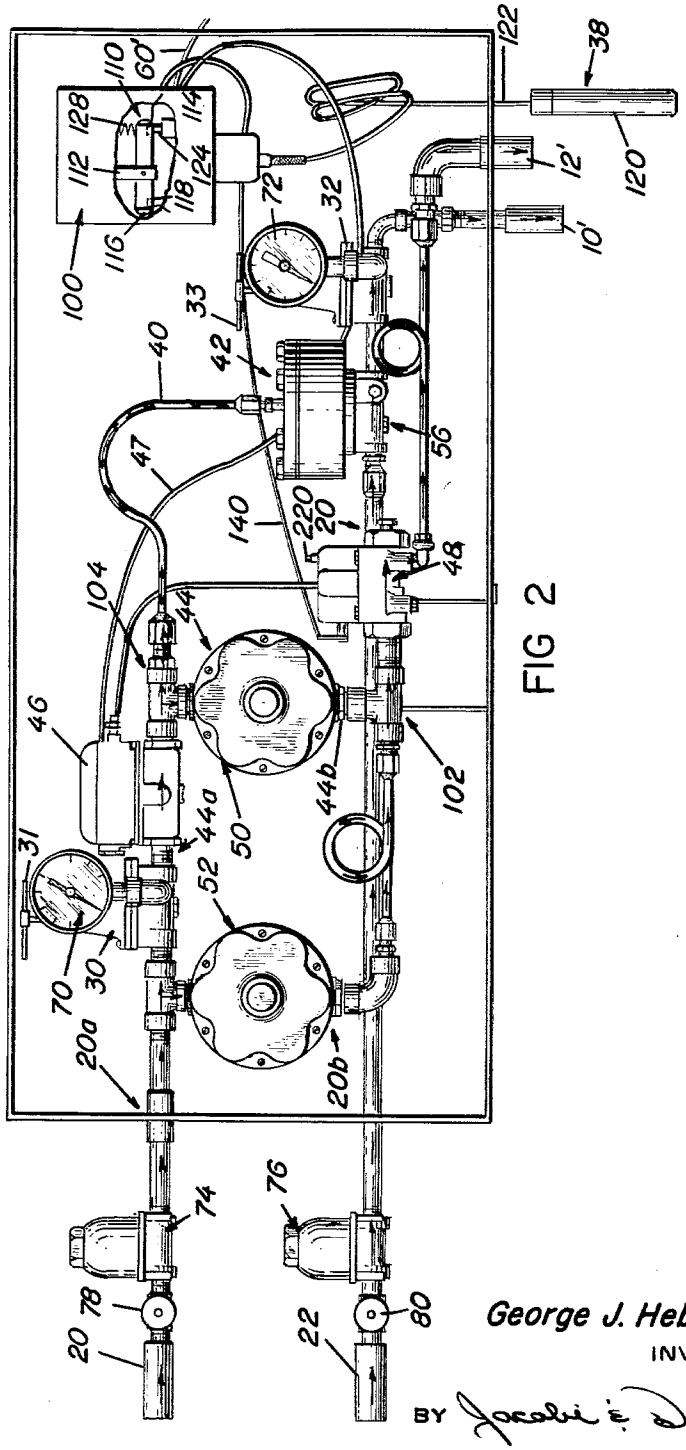



FIG 2

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Filed Oct. 29, 1962 3 Sheets-Sheet 3

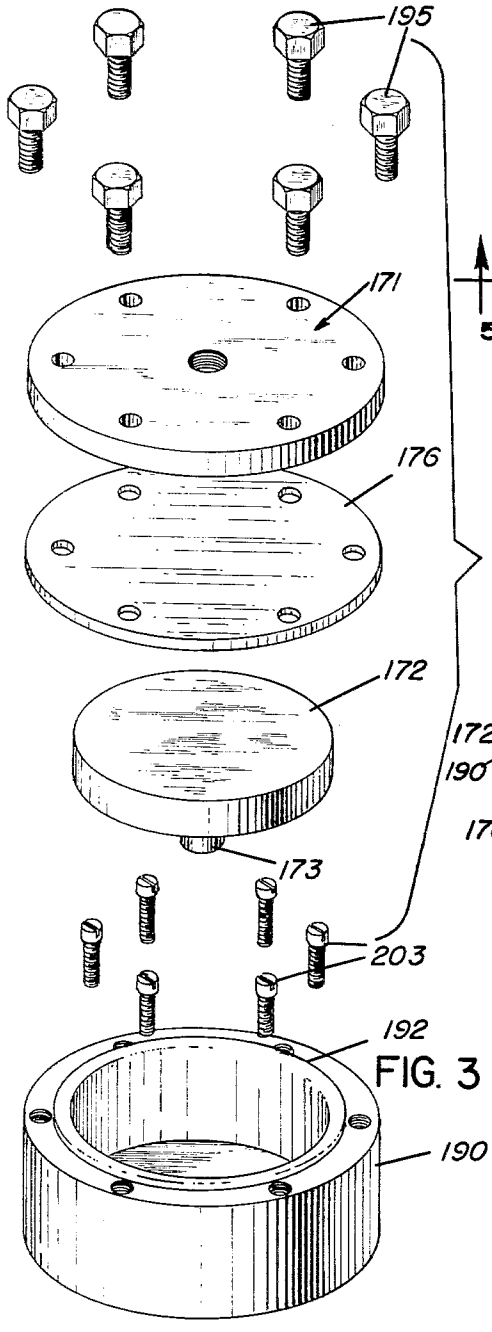
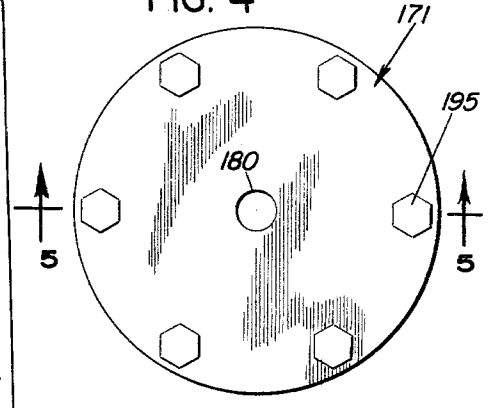



FIG. 3

FIG. 4



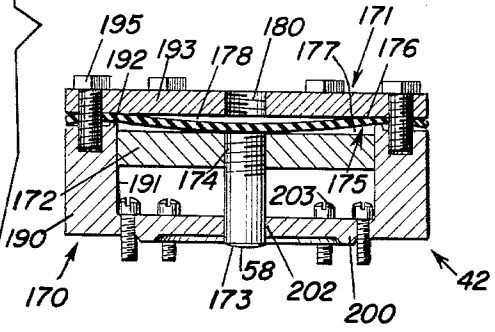




FIG. 5

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United States Patent Office 3,228,447
Patented Jan. 11, 1966



3,228,447

# APPARATUS FOR CONTROLLED BURNING OF LIQUEFIED PETROLEUM GAS

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Filed Oct. 29, 1962, Ser. No. 233,617
13 Claims. (Cl. 158—28)

This invention relates generally to methods of, and apparatus for, burning L.P.G. The designation "L.G.P." is used conventionally in the trade and art, as well as in the instant specification and claims to designate liquefied petroleum gas.

As well known, L.P.G. normally exists in both a liquid state and a vapor state. In fact, when L.P.G. is enclosed within a tank, or other suitable container, the same possesses the inherent ability to generate its own vapor under pressure within the tank or container, provided the tank or container and contents thereof are maintained at ambient temperatures such as normally existent in the atmosphere. Thus, L.P.G. is customarily commercially available in a strong-wall tank having a top valve outlet. As stored in such tank, the L.P.G. comprises a liquid body filling the lower portion of the tank at least, and a vapor body disposed above the liquid body within the tank, and conventionally communicating with the valve outlet of the tank.

Possibly the most common use of L.P.G. is in communities where utility gas lines are not available, and stoves are operated from L.P.G. (e.g. propane or butane) tanks. In such instances, the tanks are disposed exteriorly of the building and a suitable line is run within the building to the stove. The stove burner is coupled with the vapor body of L.P.G. within the tank, which by virtue of the inherent properties of the L.P.G. is under pressure. The L.P.G. vapor delivered to the stove is burned at a sufficiently slow rate that the L.P.G. itself generates sufficient vapor continuously to replace that which is used by the stove, thus maintaining adequate pressure within the tank for automatic supply therefrom to the stove burner.

While the foregoing conventional use, and similar conventional uses, permit the burning of the L.P.G. vapor itself, and the replacement of the vapor body and pressure within the tank through the inherent properties of the liquid L.P.G. within the tank, where a substantial quantity of heat is to be generated, the foregoing arrangement does not function properly. Specifically, where substantial heat is to be produced, the requirement for fuel can result in an attempt to draw L.P.G. vapor from the tank at a faster rate than the rate at which the vapor can be replaced by the inherent vaporization of the L.P.G. within the tank. Thus, where a substantial quantity of vapor is to be burned, either a sufficient and substantial number of L.P.G. tanks are required, or the pressure within the tank or tanks being used becomes substantially reduced so that the supply of L.P.G. vapor cannot be maintained at a proper rate. Moreover, where an attempt is made to draw a substantial quantity of vapor from a tank at a rapid rate, the tank tends to freeze. In this latter regard, it will be remembered that there is a reduction of pressure within the tank first if the draw thereon exceeds the rate at which vaporization occurs therein, and secondly, there is substantial heat taken away from the tank in vaporizing the liquid within the tank to produce the vapor within the tank. This combination of factors results in the freezing, and also contributes to the reduction in B.t.u. output of the burner system.

In view of the above conditions, it is recognized that the vapor existent in an L.P.G. tank cannot be tapped as a suitable source for producing a substantial heat output. Accordingly, it has previously been suggested that the L.P.G. in liquid form existent within the tank be used as a fuel for any burner wherein a substantial heat is to be



produced, and that the vapor existent within the tank be used merely for purposes of maintaining the liquid within the tank under suitable pressure. To achieve this purpose, a tube, commonly known as a "dip tube," is inserted within the L.P.G. tank in communication with the lower portion thereof containing L.P.G. in a liquid state. The pressure which is built up by the L.P.G. vapor within the tank and above the liquid body forces the liquid body through the dip tube and into a suitable supply line. The liquid which is entering the line is then vaporized, in some suitable fashion, and as vaporized, burned to produce the desired heat within the burner or by the burner. The drain of liquid from the L.P.G. tank in this instance, even for substantial burning, is sufficiently small that the pressure of L.P.G. vapor within the tank is maintained within proper limits. (A comparatively small quantity of liquid is needed to produce a substantial quantity of burnable vapor.) Thus, the liquid body within the tank is constantly maintained under suitable pressure, and the feed of liquid to the burner is maintained by the pressure inherently available in the tank due to the continuous vaporization of the liquid L.P.G. within the tank as liquid L.P.G. is drained or drawn therefrom.

While the above basic operating techniques or methods have previously been suggested, there are many instances where it is necessary or desirable to produce a substantial quantity of heat with an L.P.G. burner system, and yet where it is necessary to control the quantity of heat produced whereby a particular characteristic of a given substance heated by the system, such as the temperature, pressure or level thereof, can be maintained within a prescribed range. For example, in certain road construction operations, it is desirable to maintain an oil used in the formation of an asphalt surface within a predetermined temperature range. Substantial heat is required for this purpose, and at the same time, in many instances, "off-on" type control is necessary. Another instance when such a system may be used is encountered in an oil field where one desires to obtain, through conventional methods, a separation of oil and water, for example. These two particular types of operations wherein a system such as described in this paragraph may be used are but exemplary of various types of operations, and are set forth merely for purposes of explaining exemplary utility of the instant invention.

As suggested above, in order to burn the liquid body of L.P.G. existent within a conventional L.P.G. tank, it is necessary to vaporize the same in some manner. This either requires the use of a rather complex vaporizing system, the use of a spray-type nozzle or orifice which can easily become clogged, or the use of a special burner which I have previously developed and which is described in my prior United States Patent No. 2,851,096. The use of complex vaporizing systems is, of course, undesirable, as is the use of cloggable nozzles, and accordingly a burner such as described in my aforesaid prior patent is incorporated in any burner system where L.P.G. liquid is to be burned. Such a burner is simple in construction, and operates to vaporize liquid L.P.G. therein without the use of a cloggable nozzle or small orifice, but still such a burner is more expensive than a simple outlet such as is needed for a pilot for the burner system. Moreover, for purposes of providing a pilot for the burner system, it is not necessary to generate any substantial quantity of heat since the pilot merely serves to maintain combustion so that there is automatic ignition of the primary burner or main or master burner system.

A primary object of the present invention is to provide a method of, and apparatus for, burning L.P.G. which overcomes the above disadvantages, and utilizes the inherent properties of the L.P.G. to the best advantage. Specifically, a primary aspect of the present invention lies

in the discovery that it is preferable to operate a burner system with L.P.G. by utilizing the likuid body of L.P.G. within an L.P.G. tank for the main burner thereof, and by utilizing the vapor body within an L.P.G. tank for the pilot burner system fuel supply. Consistent with this aspect of the invention, a burner system having a pilot and a main burner capable of producing substantial heat is operated by supplying to the main burner liquid fuel from the L.P.G. tank and by supplying to the pilot burner, which is of very small capacity, vapor fuel from the L.P.G. tank. This eliminates the above discussed problems which result from supplying vapor fuel from the L.P.G. tank to the main burner, and also eliminates the need for providing a vaporizing system and/or a special burner as the pilot.

Aside from the foregoing basic aspects of the invention, the same is also concerned with the provision of a control system which can be used in accordance with the method hereof to control the operation of the burner system. Specifically, the invention is concerned with providing a control system which is not in any way dependent on an outside suorce of power, which operates automatically to "shut-off" the entire system in the event of pilot failure, and which in addition automatically controls the heat supply to a body of material to maintain a predetermined characteristic thereof (e.g., temperature, pressure or level), within a predetermined temperature range by the burner system. Consistent with this latter phase of the invention, the invention has as primary objects: (a) the provision of a method for controlling the feed of L.P.G. from a conventional L.P.G. tank to an L.P.G. burner system, which method takes advantage of the inherent properties of the L.P.G. to achieve most efficient burning, which method utilizes L.P.G. vapor for effective system control, and which method utilizes power generated by and through operation of the system to power controllable components; (b) to provide an apparatus for carrying out such method, which apparatus is simple in construction, trouble free in operation, and formed substantially entirely from available components, and/or suitably constructed auxiliary components; and (c) to provide such an apparatus which can be independently provided on a moving vehicle, or transported from place to place, for use independently of outside power and with commercially available L.P.G. tanks.

A still further aspect of the present invention lies in the provision of a pressure responsive activating device which is adapted to control a supply valve assembly, and yet maintain an effectively sealed line in use. More specifically, in this regard, it is a primary object of the present invention to provide a pressure responsive activating device which can be easily constructed and used in a control system provided hereby which is operated in accordance with the methods hereof.

The invention lies in the methods of operation, apparatus combinations, and construction and arrangement of components, as will be more fully appreciated when consideration is given to the following detailed description of the invention. Moreover, objects other than those set forth above, and advantages other than those specifically recited in the preceding discussion, will become apparent after reading such description.

The description refers to the annexed drawings, presenting preferred and illustrative embodiments of the invention, and wherein:

FIGURE 1 is a schematic diagram, in box form, showing a system which operates in accordance with the methods hereof;

FIGURE 2 is a schematic view of a slightly modified arrangement and coupling between exemplary components provided in a control system constructed in accordance herewith;

FIGURE 3 is an exploded view of a pressure responsive activating device constructed in accordance herewith;



FIGURE 4 is a plan view of the pressure responsive activating device shown in FIGURE 3; and

FIGURE 5 is a cross-sectional view of a pressure responsive activating device as shown in FIGURE 3, when the same is in assembled condition.

*Method of operation*

The methods provided by the instant invention are for operating a burner apparatus having, as shown in FIGURE 1, a master burner system **10** including a master burner fuel outlet and vaporizing means for converting liquid fuel fed to the burner system from a liquid state to a vapor state, and a pilot burner system **12** including a pilot fuel outlet ignitably associated with the master burner fuel outlet. As explained more fully below, the particular construction of the master burner system and the particular construction of the pilot burner system form no part of the instant invention, and any conventional systems can be used respectively in the boxes designated by the numerals **10** and **12** in FIGURE 1.

The burner apparatus, as suggested above, is to be operated with L.P.G., and as conventional such L.P.G. is carried within a suitable tank such as that schematically shown in FIGURE 1 and designated by the numeral **14**. The tank **14** is enclosed and contains L.P.G. in a liquid state in the lower portion **16** thereof and L.P.G. in a vapor state in the upper portion **18** thereof. The liquid L.P.G. in the lower portion **16** inherently vaporizes thus forming the vapor L.P.G. in the upper portion **18** of the tank **14**, and the vapor continues to be formed from the liquid until equilibrium is reached. Naturally, as the tank **14** is obtained from a commercial establishment, the same is in equilibrium condition, and moreover includes a suitable valve connection at the upper end **14'** thereof.

Having now explained the burner system, and the source of fuel with which such system is operated in accordance herewith, attention can be directed to the method steps used in the operation.

First, and very basically, the method hereof contemplates directing L.P.G. in a vapor state solely from the upper portion **18** of the tank **14** to the pilot fuel outlet of the pilot burner system **12**. The line **20** shown in FIGURE 1 and including the respective sections **20***a*, **20***b*, and **20***c* serves this purpose. Secondly, L.P.G. in a liquid state is directed solely from the lower portion **16** of the tank **14** to the master burner system **10**. The line **22** shown in FIGURE 1 serves this purpose, as it is connected at one end with a suitable dip tube schematically shown in FIGURE 1 and designated by the numeral **24**, and at its other end with the master burner system **10** itself. Such master burner system includes a vaporizer **26** which is preferably part of the master burner itself. In this regard, attention is again directed to my prior U.S. Patent No. 2,851,096 which discloses a burner arrangement wherein liquid L.P.G. fed thereto is vaporized in coils extending circumferentially of the axial path of the fuel outlet. Actually, in the burner system of my aforesaid prior patent, the vaporizing means and combustion chamber are combined into a unitary structure wherein the L.P.G. is vaporized in coils disposed about the vapor L.P.G. outlet thereof, and the coils in essence define the combustion chamber. The burner as disclosed in this patent can well be used as the master burner in a method operated in accordance herewith, however, it is to be understood that other forms of master burners can be used including those having a separate vaporizing system and those having a vaporizing orifice. In any event, consistent with the method hereof, and consistent with a generic description of different types of burner systems which can be used in accordance herewith, the L.P.G. fed to the vaporizing means **26** of the master burner system **10** is converted into a vapor state within the vaporizing means, and then directed, as converted, from the vaporizing means **26** to the master burner fuel

outlet which is schematically shown in FIGURE 1 and designated by the numeral 28.

From the above, it will be apparent that vapor L.P.G. is fed from the upper portion 18 of the tank 14 to the pilot burner system, and then burned thereadjacent. Similarly, the liquid L.P.G. which is fed from the lower portion 16 of the tank 14 is converted into a vapor in the vaporizing means 26, and then fed to the master burner fuel outlet 28 where it is burned thereadjacent.

Utilizing the vapor L.P.G. from the upper portion 18 of the tank 14 permits the use of a very simple pilot burner system, and since the draw on the vapor by such pilot system is substantially small, the pressure within the tank 14 can easily be maintained. At the same time, the use of the liquid L.P.G. from the lower portion of the tank 14 provides an adequate fuel supply for the master burner means or system 10 so that substantial heat can be generated thereby. The basic aspects of the invention thus in and of themselves afford substantial advantage. Although the method is operative where only small quantities of heat are to be produced, the same finds substantial advantage where the quantity of L.P.G. as converted and fed to the master burner fuel outlet is substantially greater per given unit of time than the quantity of L.P.G. fed to the pilot fuel outlet during a heating operation.

Aside from the basic aspects, but consistent therewith, the steps above described are carried out by controllling the quantities of L.P.G. directed from the tank to the pilot fuel outlet and from the tank to the master burner system and specifically the vaporizing means thereof so as to maintain the pressure of L.P.G. in a vapor state within the tank and on the L.P.G. in a liquid state within the tank at least substantially constant while the other steps are performed. To this end, regulators such as those schematically shown in FIGURE 1 and designated respectively by the numerals 30 and 32 can be provided in a bypass branch 44 of the supply line 20 and in the supply line 22, respectively.

The method hereof, as indicated in the introductory portion of this specification finds particular utility when the burner system is utilized for purposes of heating a given body requiring substantial heat, or for purposes of controlling a particular characteristic of a given body (e.g. temperature, pressure or level) where substantial heat is required for the control. Since temperature sensing elements, level sensing elements and pressure sensing elements are well known, and since a desired type output can be obtained from a particular element, regardless of the characteristic sensed, the invention is described below in connection with a temperature sensing operation. It is to be understood, however, that the methods and apparatus are applicable to sensing of various characteristics, and that while temperature sensing is important the sensing phase of the invention is not limited thereto. There is shown in FIGURE 1 a tank 34 having a fluid body 36 therein in liquid form. The master burner system is shown as being disposed to heat the fluid body 36. Now, in this example, the characteristic to be sensed is temperature and the method hereof contemplates sensing when the temperature of the body 36 has reached at least one predetermined level, and then controlling the feed of L.P.G. to the master burner outlet in response to sensing of the predetermined temperature level. Thus, a suitable sensing means 38 is provided consistent with the method to sense the temperature of the liquid body at least within a predetermined range having at least general upper and lower limits. For example, let it be assumed that the body 36 is to be maintained at a temperature of approximately 300° F. The sensing means, in such instance, and consistent with the method hereof, might well be capable of providing some changeable characteristic, such as an output current, an output pressure, or the like when the temperature sensed is approximately 310°, and might well revert to the original characteristic when the temperature of the body 36 is, for example, 290°. Thus, there is a range of temperatures being sensed, and there are at least general upper and lower levels. The upper and lower levels may be closer together than those in this example, or they may be spread further apart, but normally any sensing means which is utilized need only be sensitive approximately to temperature variations.

Bearing the foregoing in mind, and still further in conformity with the methods hereof, the feed of L.P.G. to the master burner system 10, or specifically the vaporizing means 26 thereof would be stopped in response to sensing of the upper level within the predetermined range sensed by the sensing means, and the feed of L.P.G. to the master burner system 10 would be started in response to sensing of the lower level within the predetermined range of temperatures in question. In other words, the basic method contemplates sensing a characteristic of the body being heated by the master burner system which characteristic is related to the heat transferred to the body by the burner system, and then starting and stopping the feed of fuel to the master burner system from the lower portion 16 of the tank 14 in accordance with the characteristic sensed.

To achieve the above described control, further method steps are provided hereby. Specifically, in this latter regard, the invention contemplates enclosing a portion of the L.P.G. in a vapor state which is directed from the upper portion 18 of the tank 14 in a storage area separate from but communicating with the upper portion of the tank. The storage area, in this instance, and as shown in FIGURE 1 includes an auxiliary line 40 having an activating device 42 coupled therein. The auxiliary line 40 is connected to a parallel branch 44 in the supply line 20, the parallel branch 44 including respective sections 44*a*, and 44*b* which are joined at opposite ends with the section 20*b* of the supply line 20. The storage area may take other forms than that described immediately above, but the exemplary form described and shown in the drawing illustrates the operation of the method hereof.

With the supply area connected as described above, the enclosed portion of the L.P.G. within the storage area normally has a pressure at least proportional to the pressure of L.P.G. vapor within the tank 14. Now, the invention contemplates using the pressure of the L.P.G. in the storage area to effect the stopping and starting of the feed of L.P.G. to the master burner system 10. Consistent with this approach, the pressure of the L.P.G. in the storage area is at least substantially reduced in response to sensing of the upper level within the predetermined range of temperatures being sensed by closing communication between the tank 14 and the storage area, and permitting L.P.G. in the storage area to pass therefrom. Still further, the pressure is substantially increased in the storage area in response to sensing of the lower level within the predetermined range of temperatures, by opening communication between the tank 14 and the storage area. These steps are performed in the exemplary arrangement of FIGURE 1 by operating a valve such as that designated by the numeral 46 with the sensing means 38 so that the valve shuts off communication to the auxiliary line 40 when the upper level of temperature is sensed and so that the valve passes vapor to the auxiliary line 40 when the sensing means indicates that further heat is to be supplied by the master burner system. Naturally, the pressure is increased in the storage area when the valve 46 is open, and as explained in the following paragraph, the pressure automatically decreases in the storage area when the valve 46 closes.

Specifically, in this latter regard, and consistent with the method hereof, L.P.G. in the storage area is permitted to pass therefrom through the branch 44*b* of the line 44 when the valve 46 is closed. To insure the passage of L.P.G. from the storage area, and to direct the same to the pilot burner system for use therein, so as to eliminate waste of gas, the method contemplates controlling

the feed of L.P.G. from the upper portion of the tank to the pilot burner system **12** and controlling the feed of L.P.G. permitted to pass from the storage area to the pilot fuel outlet thereof to provide a continuous substantially uniform feed of L.P.G. to the pilot fuel system, or specifically pilot fuel outlet thereof and continuous burning of the fuel passing thereto. Thus, regulators such as those designated by the numerals **52** and **50** are incorporated respectively in the branch **20***b* directly, and bypass branch **44***b* thereof. The regulator **50** and the regulator **52** close when the back pressure, i.e. pressure on the pilot burner system side thereof, exceeds certain values. Specifically, the regulator **52** will close to prevent the flow of vapor therethrough when the back pressure thereon reaches a given value, and the regulator **50** will close to prevent the flow of vapor therethrough when the back pressure thereon exceeds another certain value. The closing value for the regulator **50** is higher than the closing value for the regulator **52**, and thus when vapor is permitted to escape from the storage area the regulator **52** is so adjusted that the back pressure caused thereby results in closing thereof, whereas the regulator **50** remains open to permit the drain of vapor therefrom from the storage area.

Now, having described the detailed method steps contemplated hereby, it is important to again review the overall system operation. It will be remembered that at the outset of this description it was stated that liquid L.P.G. is sent directly from the base portion or lower portion **16** of the tank **14** through the line **22** to the master burner system **10**. Similarly, vapor L.P.G. is sent from the upper portion **18** of the tank **14** through the line **20**, and sections **20***a*, **20***b*, and **20***c* thereof to the pilot burner system **12**. In normal operation, however, due to the setting of the respective regulators **50** and **52**, the vapor passes through the valve **46** and line **44** forming the bypass portion of the section **20***b* of the line **20**. Still, it will be noted that the vapor L.P.G. passes from the upper portion **18** of the tank to the pilot burner system.

It will be further noted that during the above described operation, the auxiliary line **40** serves to provide a connection between the actuating device **42** therein and the line **44** so that the pressure of the vapor L.P.G. within the line **44** is applied to the actuating device **42**. This actuating device, as shown, is coupled to a valve **56** in the line **22**, as by a mechanical connection schematically designated by the numeral **58**. When the pressure transmitted to the actuating device **42** is sufficient, as during normal operation, the actuating device serves to maintain the valve **56** open, thereby permitting the passage of liquid L.P.G. from the base portions **16** of the tank **14** through the line **22** to the master burner system **10**. However, when the pressure of the vapor L.P.G. transmitted or directed to the actuating device **42** is not sufficient, the same causes closing of the valve **56**, and thereby stopping of the supply of liquid L.P.G. from the tank **14** to the master burner system **10**.

Now, in review, it will be seen that when the sensing device **38** operates the valve **46**, and the valve **46** closes, there is no longer pressure transmitted through the auxiliary line **40** to the actuating device **42**, and as a result the same cannot maintain the valve **56** open. Thus, the supply of liquid L.P.G. through the line **22** to the master burner system is stopped. Simultaneously, however, due to the incorporation of the regulators **50** and **52**, the vapor L.P.G. in the storage area formed by the auxiliary line **40** and actuating device **42** is permitted to pass from the storage area through the regulator **50** and to the pilot burner system **12** for burning therein. After a substantial quantity, and in fact almost all of the vapor within the storage area has passed through the regulator **50**, then the back pressure in the branch **20***c* of the line **20** is minimal, and the regulator **52** opens thereby permitting the vapor in the upper portion **18** of the tank **14** to pass through the section **20***a* of line **20**, the section **20***b* and the regulator **52** therein, and then the section **20***c* of such line to the pilot system **12**. Thus, the pilot system remains in operation at all times. Of course, the sensing arrangement **38** is sensitive to a particular characteristic of the liquid body **36** (e.g., temperature, pressure or level) which is maintained by the master burner system **10**, and accordingly it will be seen that the characteristic of the body **36** to be maintained serves, in accordance with the methods hereof, to control the supply of liquid L.P.G. to the master burner system, through the use of the vapor L.P.G. originally supplied from the tank **14**, and specifically the upper portion **18** thereof.

For safety purposes, and for purposes of providing a system which is wholly independent of an external power source, the invention further contemplates utilizing a generator such as that designated by the numeral **60** for producing an electrical current in response to heat generated by the pilot burner system. This generator might well comprise a millivolt thermo-couple arrangement. The same is coupled with the valve **46**, and with a shut-off valve **48** connected in the line **20**, preferably between the output couplings therein of the regulators **50** and **52**. The valves **46** and **48** are supplied with power by the generator **60**, and when the pilot burner unit is not operating, as is apparent, there is no supply of electricity from the generator, and accordingly both the valves **46** and **48** close thereby preventing any flow of L.P.G., either in vapor form or in liquid form from the tank **14** to either the pilot burner system or the master burner system.

*Apparatus*

Whereas a complete system has been shown in FIGURE 1 which is constructed in accordance herewith, and which is adapted to carry out the method steps hereof, FIGURE 2 presents in some detail an actual assembly of components and the coupling therebetween for a control system provided hereby. In the arrangement of FIGURE 2, it is assumed that the line **20** is coupled at the input or lefthand end thereof with the upper portion of an L.P.G. tank, and that the line **22**, or left end thereof as shown is coupled with the lower portion of an L.P.G. tank in the same manner as such lines are coupled with the respective portions of the tank in FIGURE 1. Moreover, it is assumed that the output couplings **10'** and **12'** of the respective lines **22** and **20** are connected with a master burner system and a pilot burner system respectively, as indicated in FIGURE 1.

Bearing the above factors in mind, attention can be directed to suitable commercially available components which can be provided in the respective lines. Initially, each of the lines **20** and **22** preferably has connected therein a needle valve **78** and **80** respectively. Following the needle valve, an L.P.G. filter, preferably of type No. 302 produced by J and S Carburetor Co. of Dallas, Texas, is connected in each of the lines. The line **20** leads from the filter **74** connected therein to the input coupling of the regulator **52** and also to the input of the regulator **30**. The regulator **30** may well comprise a Rego regulator No. 567, and the regulator **52** may well comprise a Rego regulator No. 2302A2. As shown in FIGURE 2, there is connected with the regulator **30** an adjustment handle **31** and a gauge **70** which handle and gauge cooperate in use to permit establishment of a proper feed pressure within the bypass branch **44***a* of the line **20**.

From the output of the regulator **52**, the line **20** feeds through a T connection **102** to a safety valve **48** which may well comprise a General Controls thermo-pilot valve No. MR2YA07. The output of the safety control valve is connected with the coupling **12'** leading to the pilot burner systems.

In the bypass branch of the line **20**, and following the regulator **30**, is a valve arrangement **46** which is electrically responsive. Moreover, the valve **48** referred to above is similarly electrically responsive. The output of the valve **46** feeds to a T connection **104**, and from the

T connection through the regulator **50**, as well as to the auxiliary line **40**. The regulator **50**, like the regulator **52** may well comprise a Rego regulator No. 2302A2. The regulators designated by the numerals **50** and **52**, as conventional, are diaphragm-type regulators incorporating adjustable spring biasing means which permit the setting thereof in advance for closure in response to predetermined back pressures. As indicated in the preceding section of this specification, the regulator **50** is initally adjusted so as to be responsive to a higher back pressure than the regulator **52**, and these back pressures are adjusted so as to achieve the method steps referred to. Since the adjustments are conventional, further description thereof appears unnecessary.

The auxiliary line **40** feeds to the pressure responsive activating device which preferably takes the form of the device shown in FIGURES 3 through 5. This device, as explained more fully below, produces a mechanical displacement of a connecting rod therein in response to the existence of pressure within the auxiliary line **40**. Such displacement is used to actuate a valve **56**, which may be of any conventional design, provided the same is operative in response to a displacement of a connecting rod to open and close a line in which it is connected. Various valves which perform a closing and opening operation upon a downward push or downward displacement are available, and virtually any of such forms may be utilized in accordance with this invention as the valve **56**, provided the same is adapted to control the liquid L.P.G. flow.

The valve **56** is, as explained, coupled in the line **22** following the filter **76** therein, and the output of the valve **56** feeds to a regulator **32** and then therethrough to the coupling **10'**. At the regulator **32**, there is preferably provided an adjustment handle **33** together with a pressure gauge **72** whereby the ultimate pressure of L.P.G. fed to the coupling **10'** may be suitably adjusted by an operator.

It will be noted that the valve **48**, which is a safety valve, is positioned on the output side of the regulator **50** in the embodiment of FIGURE 2, but positioned between the regulators **50** and **52** in the embodiment of FIGURE 1. The reason for this variation, and the reason why the embodiment of FIGURE 1 is preferred will be explained below.

Now, in FIGURE 2, it is assumed that a suitable thermocouple millivolt arrangement is coupled with the burner to produce an electrical current in response to heat generated thereby, and that the line from the generator leads to a control box **100**. Such line is designated in FIGURE 2 by the numeral **60'**.

The control box **100**, as shown diagrammatically in FIGURE 2, includes a tiltable mercury switch **110** mounted in a suitable bracket **112** and having contacts **114** and **116** at opposite ends thereof. The contacts **114** and **116** cooperate with mercury **118** to pass current through the mercury switch when the switch is in the position shown in FIGURE 2, however, when the switch is tilted, for example, counterclockwise, the mercury remains in engagement with the contact **116**, but not with the contact **114**, so that no current can flow through the switch.

The sensing device **38** which includes a sensing probe **120** and a pressure line **122** is coupled with the control box **100**, and governs the movement of a reciprocal lug **124** within the control box. The lug **124** is engageable with the bulb of the mercury switch **110** to cause tilting thereof against the action of a compression spring **128**. When the probe **120** senses a given characteristic (e.g., temperature, pressure or level) it causes displacement or expansion of a connecting means (e.g., fluid) within the line **122**, and such displacement in turn causes movement of the lug **124**, whereupon the lug moves upwardly as shown in FIGURE 2, thereby tilting the mercury switch, and breaking connection in a circuit in which the mercury switch is included. The described arrangement is shown schematically, and is illustrative, since various types of characteristic sensing means may be used without departing from the scope and spirit of the invention.

The electrical current which exists in the line **60'** leading to the control box is fed directly by the line **140** to the safety control valve **48**, and is fed through the mercury switch **110** via line **47** to the valve **46**. Since both of these valves are electrically responsive, if the pilot should "shut-off," then there is no electrical current in the line **60'**, and in turn there is no power fed to the valve **46** or to the valve **48**, regardless of other connections. Thus, in the event of pilot failure, both the valve **46** and the valve **48** stop the respective flow therethrough. However, when hte pilot is operating under normal conditions, the output from the generating device and electrical current which exists in the line **60'** serve to maintain the safety valve **48** operative, or open, and through the mercury switch **110**, serve to maintain the valve **46** operative. Both the valves **46** and **48**, as indicated above, are of the solenoid operated type wherein the flow of current therethrough causes opening thereof, and the stoppage of current flow therethrough, results in closing thereof.

Before considering the overall operation of the components shown in FIGURE 2, it is desirable to understand the construction and operation of the pressure responsive activating device **42**. As shown in FIGURE 5, such device comprises a hollow housing generally designated by the numeral **170** which is closed at the upper end **171** thereof. A piston **172** is reciprocally movable in the housing toward and away from the end **171**. A piston rod **173** which forms at least part of the mechanical coupling **58** referred to above extends from the lower face of the piston, and is coupled with the piston by a suitable threaded coupling **174**. The opposite face of the piston, the upper face, and the end **171** of the housing **170** form opposed walls of a closed chamber **175** within the housing. A flexible diaphragm **176** is sealingly fixed at its edges within the housing and extends entirely across the housing within the chamber **175**. The diaphragm divides the chamber **175** into two adjacent sections **177** and **178**. The section **177** is defined between the upper face of the piston **172** and the lower face of the diaphragm **176**. The other section **178** is defined between the upper face of the diaphragm **176** and the closed end **171** of the housing. The diaphragm, as shown, is engageable with the upper face of the piston with flexing of the diaphragm. Moreover, the housing has an input coupling **180** to the section **178** of the chamber **175**.

The housing **170**, as shown, preferably comprises a side wall forming member **190** having a bore **191** extending between opposite ends thereof. One end of the member **190**, namely the upper end as shown, has an upstanding sealing projection **192** extending continuously thereabout. The top wall of the housing is preferably formed by a separate plate **193** having the coupling **180** therein. Means, preferably in the form of bolts **195** are provided for securing the top wall plate **193** on the upstanding sealing projection **192**, and the diaphragm **176** is disposed and sealed between the upstanding sealing projection **192** and the plate member **193**. Of course, with tightening of the bolts **195**, sealing relationship as required is achieved.

The bottom end of the housing **170** is adapted to be coupled to a valve to be actuated thereby, and for this purpose a bottom wall plate **200** having an aperture **202** therein slidably receiving the piston rod **173** is provided. This bottom wall plate may well comprise the upper plate of a valve assembly, or a separate unit adapted to receive screws such as those designated by the numeral **203** for coupling the device of FIGURE 5 with the valve to be activated thereby. Quite naturally, as should be apparent, when vapor under pressure enters the coupling

180, the same presses downwardly on the diaphragm 176 thereby causing downward movement of the piston 172 and the piston rod 173. The downward movement of the piston rod 173 causes opening of the valve 56 (FIGURE 2). Opening 193 permits downward movement, and automatic return of the piston to normal position results from the action of valve 56 which is normally biased closed so as to urge the piston upwardly.

In initial operation of the system of FIGURE 2, the activating button 220 of the safety valve 48 is depressed, thus feeding fuel to the pilot burner system, and pilot fuel outlet thereof, and such fuel is ignited. Thereupon an electrical current is generated which serves to maintain the valve 48 open, and which transmits through the mercury switch suitable power to the valve 46 to maintain the same open. Initially, the flow of vapor L.P.G. through the line 20 transcends the regulator 52 and passes through the valve 48. When the valve 46 operates, however, the L.P.G. flows through the regulator 50 primarily to the outlet coupling 12'. At the same time, the pressure of the vapor L.P.G. flowing into the line 20 is transmitted through the auxiliary line 40 to the pressure responsive activating device 42, and this causes a flexing of the diaphragm 176, and downward movement of the piston rod 173 whereupon the valve 56 opens thereby feeding liquid L.P.G. through the line 22 to the coupling 10', and the main burner system. The overall control arrangement is then in operation. As the burner system heats the body to which heat is to be transmitted, the sensing means 38 or more particularly probe 120 thereof senses a predetermined characteristic (e.g., temperature) and causes displacement within the coupling line 122 which in turn causes displacement of the member 124. This results in tilting of the mercury switch 110 and disconnection of the valve 46 from a source of electricity. Accordingly, the valve 46 closes thereby preventing the flow of L.P.G. vapor through the bypass portion of the line 20. At this time, however, the vapor within the auxiliary conduit 40 and pressure sensitive actuating device 42 is permitted to drain through the regulator 50 and to the output coupling 12'. This drain results in upward flexure of the diaphragm 176 and closure of the valve 56 whereupon the supply of liquid L.P.G. to the output coupling 10' is stopped. When the vapor within the auxiliary line 40 has drained therefrom, or at least the pressure thereof has reduced to a sufficient value, then the regulator 52 opens, or opens further, permitting vapor L.P.G. to pass therethrough and to the output coupling 12'. Thus, a supply of fuel to the pilot is maintained at all times, but at the same times the vapor is permitted to drain from the auxiliary line 40 and pressure responsive device 42.

Now, when the characteristic of the body to be heated again decreases, then the member 124 retracts downwardly, as shown, the mercury switch returns to its original position under the action of the spring 128, current is again fed to the valve 46, pressure is again transmitted through the auxiliary line 40 to the pressure responsive activating device 42, and in turn the valve 56 is again opened whereupon fuel is again supplied to the main burner system and heat is again generated. If, however, during any operation of the system, the pilot should cut off, then there is no power fed to the valve 46 or the safey valve 48, and both of these valves remain closed under all conditions.

Should this shutoff occur prior to drain of vapor from the auxiliary line 40, with the arrangement of FIGURE 2, the vapor in the auxiliary line 40 cannot escape therefrom. Thus, preferably, the valve 48 is placed between the output ends of the regulators 50 and 52, as shown in FIGURE 1 and in any event, vapor is permitted to escape from the auxiliary line 40 and pressure responsive activating device 42.

From the preceding description, it should be apparent that the lines 22 and 20 serve respectively as first and second conduit means, the first conduit means communicating directly solely the lower portion of the supply tank with the master burner arrangement, and the second conduit means communicating directly solely the upper portion of the tank with the pilot burner arrangement. The valve means 56 is connected in the first conduit means, consistent with this description, for opening and closing the first conduit means and thereby disestablishing communication between the lower portion of the tank and the master burner arrangement. The sensing means 38 senses heat transferred by the burner arrangement to a given body, and the components within the control arrangement designated by the numeral 300 in FIGURE 1 serve to operate the valve means 56 to open and close the first conduit means in accordance with the heat sensed by the sensing means 38. The other components shown can similarly be regarded as means for performing the prescribed functions, but since the operation has been explained in full, and the means have been referred to consistent with terminology used in the appended claims, further repetition appears unnecessary.

*Conclusion*

After reading the foregoing detailed description of the illustrative and preferred embodiments of the instant invention, it should be apparent that the objects set forth at the outset of the specification have been successfully achieved. It should also be apparent that various modifications may be made in the methods and systems provided hereby, and accordingly, what is claimed is:

1. For use with a body to be heated, apparatus for controlling the supply of L.P.G. from an enclosed tank, having L.P.G. in a liquid state under pressure in the lower portion thereof and L.P.G. under pressure in a vapor state in the upper portion thereof, to a burner system having a master burner means adapted to receive L.P.G. in a liquid state and a pilot burner means adapted to receive L.P.G. in a vapor state, said apparatus comprising the combination of:

(a) first conduit means communicating directly solely the lower portion of said tank with said master burner arrangement;

(b) second conduit means communicating directly solely the upper portion of said tank with said pilot burner arrangement;

(c) valve means connected in said first conduit means for opening and closing said first conduit means and thereby disestablishing communication between said lower portion of said tank and said master burner arrangement;

(d) means for sensing a characteristic of said body related to the heat transferred thereto by said burner system;

(e) control means for operating said valve means to open and close said first conduit means in accordance with the heat sensed by said means for sensing, said control means being electrically powered, said control means including pressure sensitive actuating means for operating said valve means, auxiliary conduit means communicatingly coupling said actuating means with the second conduit means to transmit L.P.G. in said second conduit means to said actuating means for operation thereof by the pressure of L.P.G. so transmitted thereto, second valve means for opening and closing said auxiliary conduit means, and means for allowing L.P.G. to escape from said actuating means when said auxiliary conduit means is closed;

(f) generating means for producing an electrical current from heat created by said burner system;

(g) means coupling said generating means with said control means to power said control means with said current; and

(h) means for operatively coupling said means for sensing to said second valve means to open and close

said auxiliary conduit means in accordance with the heat sensed by said means for sensing, and to thereby control the pressure applied to said actuating means by said L.P.G.

2. The combination defined in claim 1 wherein said second valve means is electrically powered, and wherein said control means further includes means coupling said generating means to said second valve means to power said second valve means with said current.

3. The combination defined in claim 2 wherein said auxiliary conduit means is connected in parallel across a portion of said second conduit means, and wherein said combination further includes electrically operated safety valve means connected in said second conduit means for at least opening and closing communication between said portion of said second conduit means and said pilot burner means, and means coupling said generating means with said safety valve means to power said safety valve means with said current.

4. The combination defined in claim 3 and further including first pressure sensitive flow regulating means connected in said auxiliary conduit means between said actuating means and said pilot means, and second pressure sensitive flow regulating means connected in said portion of said second conduit means in parallel with said auxiliary conduit means, each of said pressure sensitive flow regulating means being operative to at least decrease the flow of the respective conduit means in which they are connected when the pressure of L.P.G. at the junction of the auxiliary conduit means and second conduit means nearest the pilot burner means exceeds a predetermined value, said first pressure sensitive regulating means being operatively responsive to a higher predetermined value than said second pressure sensitive regulating means.

5. For use with a body to be heated, apparatus for controlling the supply of L.P.G. from an enclosed tank, having L.P.G. in a liquid state under pressure in the lower portion thereof and L.P.G. under pressure in a vapor state in the upper portion thereof, to a burner system having a master burner means adapted to receive L.P.G. in a liquid state and a pilot burner means adapted to receive L.P.G. in a vapor state, said apparatus comprising the combination of:

(a) first conduit means communicating directly solely the lower portion of said tank with said master burner arrangement;

(b) second conduit means communicating directly solely the upper portion of said tank with said pilot burner arrangement;

(c) valve means connected in said first conduit means for opening and closing said first conduit means and thereby disestablishing communication between said lower portion of said tank and said master burner arrangement;

(d) means for sensing a characteristic of said body related to the heat transferred thereto by said burner system;

(e) control means for operating said valve means to open and close said first conduit means in accordance with the heat sensed by said means for sensing, said control means being electrically powered, said control means including pressure sensitive actuating means for operating said valve means, auxiliary conduit means communicatingly coupling said actuating means with the second conduit means to transmit L.P.G. in said second conduit means to said actuating means for operation thereof by the pressure of L.P.G. so transmitted thereto, second valve means for opening and closing said auxiliary conduit means, and means for allowing L.P.G. to escape from said actuating means when said auxiliary conduit means is closed, said actuating means operating said valve means in accordance with the pressure of L.P.G. in said second conduit means; and

(f) means for controlling said actuating means in accordance with the characteristic sensed by said means for sensing.

6. The combination defined in claim 5 wherein said means for controlling said actuating means is electrically responsive, and further including generating means for producing electricity in response to heat generated by said burner system, and means for feeding said electricity to said control means to power said control means.

7. In a burner apparatus having (a) a master burner system including a master burner fuel outlet and vaporizing means for converting liquid fuel fed to said burner system from a liquid state to a vapor state, (b) a pilot burner system including a pilot fuel outlet ignitably associated with said master burner fuel outlet, and (c) an L.P.G. supply comprising an enclosed tank containing L.P.G. under pressure in a liquid state in the lower portion thereof and L.P.G. under pressure in a vapor state in the upper portion thereof, the improvement comprising the combination of:

(1) means adapted to direct L.P.G. in a vapor state solely from the upper portion of said tank to said pilot fuel outlet;

(2) means adapted to direct L.P.G. in a liquid state solely from the lower portion of said tank to said vaporizing means;

(3) means adapted to convert L.P.G. fed to said vaporizing means into a vapor state within said vaporizing means;

(4) means adapted to direct said L.P.G., as converted, from said vaporizing means to said master burner fuel outlet;

(5) means adapted to burn said L.P.G., as converted and fed to said master burner outlet, adjacent said master burner outlet; and

(6) means adapted to continuously burn said L.P.G. as feed to said pilot fuel outlet while said L.P.G. is directed in a vapor state solely from the upper portion of said tank to said pilot fuel outlet, while said L.P.G. in a liquid state is directed solely from the lower portion of said tank to said vaporizing means, while said L.P.G. fed to said vaporizing means is converted into a vapor state within said vaporizing means, while said L.P.G., as converted, is directed from said vaporizing means to said master burner fuel outlet, and while said L.P.G. as converted and fed to said master burner outlet, is burnt adjacent said master burner outlet.

8. The improvement defined in claim 7 and further including means adapted to control the quantities of L.P.G. directed from said tank to said pilot fuel outlet and vaporizing means respectively to maintain the pressure of said L.P.G. in a vapor state within said tank and on said L.P.G. in a liquid state within said tank at least substantially constant during operation of the other said means.

9. The improvement defined in claim 7 and further including:

(7) a body to be heated by said apparatus;

(8) means adapted to sense when a characteristic of said body related to the heat transferred thereto by said apparatus has reached at least one predetermined level; and

(9) means adapted to control the feed of liquid L.P.G. to said master burner outlet in response to sensing of said predetermined level.

10. The improvement defined in claim 7 and further including:

(7) a given body to be heated by said apparatus;

(8) means adapted to sense a given characteristic of said body at least within a predetermined range having at least general upper and lower levels;

(9) means adapted to stop the feed of liquid L.P.G. to said master burner system in response to sensing of the upper level within said predetermined range; and

(10) means adapted to start the feed of liquid L.P.G.

to said master burner system in response to sensing of the lower level within said predetermined range.

**11.** The improvement defined in claim **9** and further including:

(11) storage means adapted to enclose a portion of said L.P.G. in a vapor state separate from but communicating with said upper portion of said tank whereby the enclosed portion of said L.P.G. normally has a pressure at least proportional to the pressure of said L.P.G. in a vapor state within said tank;

(12) means communicating said storage means with said means adapted to start and said means adapted to stop whereby said means adapted to start and said means adapted to stop are responsive to the pressure of said L.P.G. in said storage means;

(13) means adapted to substantially reduce the pressure of said L.P.G. in said storage means in response to sensing of said upper level within said predetermined range by closing communication between said tank and said storage means and permitting L.P.G. in said storage means to pass therefrom; and

(14) means adapted to substantially increase the pressure of said L.P.G. in said storage means in response to sensing of said lower level within said predetermined range by opening communication between said tank and said storage means.

**12.** The improvement defined in claim **11** and further including:



(15) means adapted to direct L.P.G. passing from said storage means to said pilot fuel outlet.

**13.** The improvement defined in claim **12** and further including:

(16) means adapted to control the feed of L.P.G. from said upper portion of said tank to said pilot fuel outlet and control the feed of L.P.G. permitted to pass from said storage means to said pilot fuel outlet to provide a continuous substantially uniform feed of L.P.G. to said pilot fuel outlet and continuous burning thereof.


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