FIG. 1.

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APPARATUS FOR CONTROLLED BURNING OF LIQUEFIED PETROLEUM GAS

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This invention relates generally to methods of, and apparatus for, burning L.P.G. The designation "L.P.G." 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 exist 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 portion 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, 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 source of fuel in the burning of 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 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 at a substantially constant pressure. A constant production 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 thereby 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 where 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 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 cloggeble 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 liquid 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 source 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 whereby it 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.

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 vaporizing 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 ignited 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 in a suitable vessel 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 system 20 shown in FIGURE 3, 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 thereof.

Having now explained the burner system 10 itself, such master burner system includes a vaporizer 26 which is preferably part of the master burner 10 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, it being 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 system 20 by the 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 therewith. Similarly, the liquid L.P.G. which is fed from the lower portion 16 of the 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 for a given unit of time than the quantity of L.P.G. as 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 controlling 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 38 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, any one of 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 the 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 normal upper and lower limits. For example, let it be assumed that the body 36 can 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 the temperature range of 300°.
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 substantial and actuating device to the pilot fuel system, specifically pilot fuel outlet thereof and continuous burning of the fuel passing thereto. Thus, regulators such as those designated by the numerals 52 and 59 are incorporated respectively in the branch 20b directly, and bypass branch 44b thereof. The regulator 59 and the regulator 52 close when the back pressure, i.e. pressure on the pilot burner 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 to 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 as part 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 20a, 20b, and 20c 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 20b 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 in the closed position 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 20c 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 20a of line 20, the section 20b and the regulator 52 therein, and then the section 20c 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 L.P.G. 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 69 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 control of the regulator 30 as shown in FIGURE 2, and 52. The valves 46 and 48 are supplied with power by the generator 69, 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 are closed. If the valve 48 is 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. 2102A2. As shown in FIGURE 2, 30 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 44a of the line 20.

From the output of the regulator 52, the line 20 feeds through a T connection 192 to the line 192 of the storage area 18, or the means, either by the line 46 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
9 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 pressures. As described in the general section of this specification, the regulator 50 is initially 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 clamping upward or 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 52 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 reasons for this variation, and the reasons for 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 the line 136. 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 the pilot is operating under normal conditions, the output from the generating device and electrical current which exists in the line 60 serves 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 173 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 188 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 188 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
The same presses downwardly on the diaphragm 176 thereby causing downward movement of the piston rod 173 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 46 is depressed, thus releasing fluid to the pilot burner system, and pilot burner 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 transmits 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 at all times.

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 filling 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 activating 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 time 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 storing 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 safety valve 48, and both of these valves remain closed under all conditions.

Should this shutdown 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 master 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 herein, 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 coupled 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 providing for opening 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 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 establishing 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 communicating coupling said actuating means with the second conduit means to transmit L.P.G. in said second conduit means to said actuating means in accordance with 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 ignitantly 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;
(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 substantially uniform feed of L.P.G. to said pilot fuel outlet and continuous burning thereof.

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