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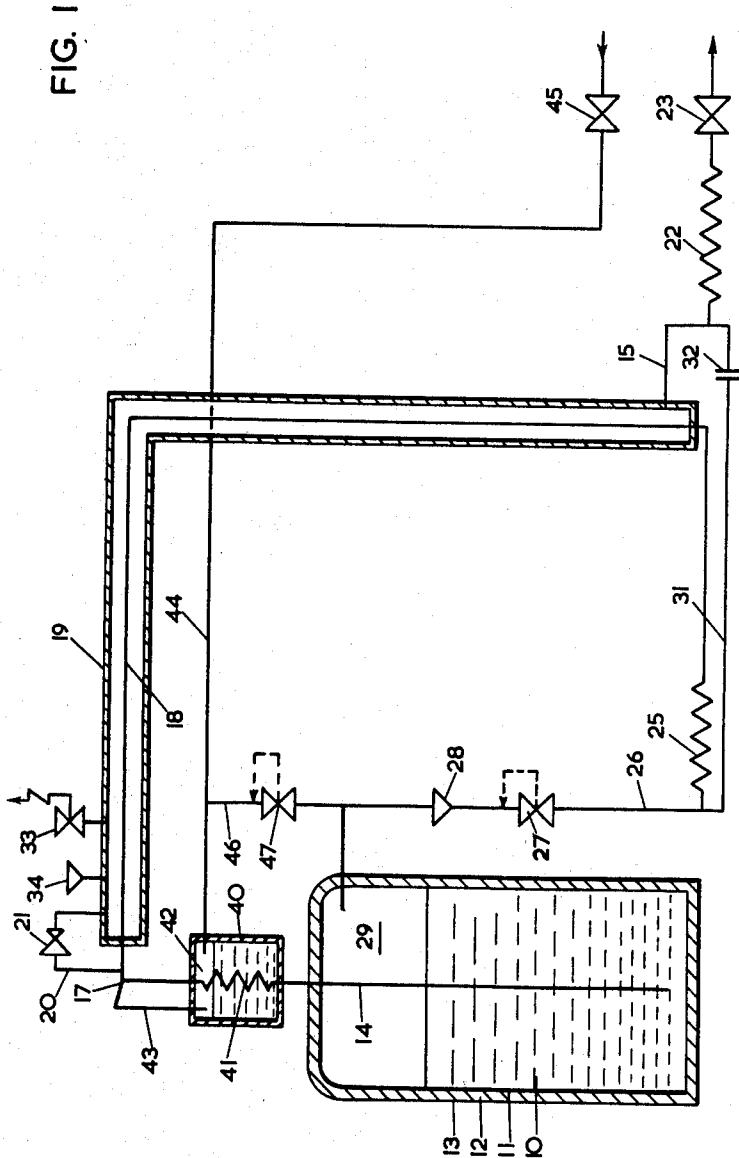
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APPARATUS FOR STORING AND DISPENSING LIQUEFIED GASES

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3 Sheets-Sheet 1



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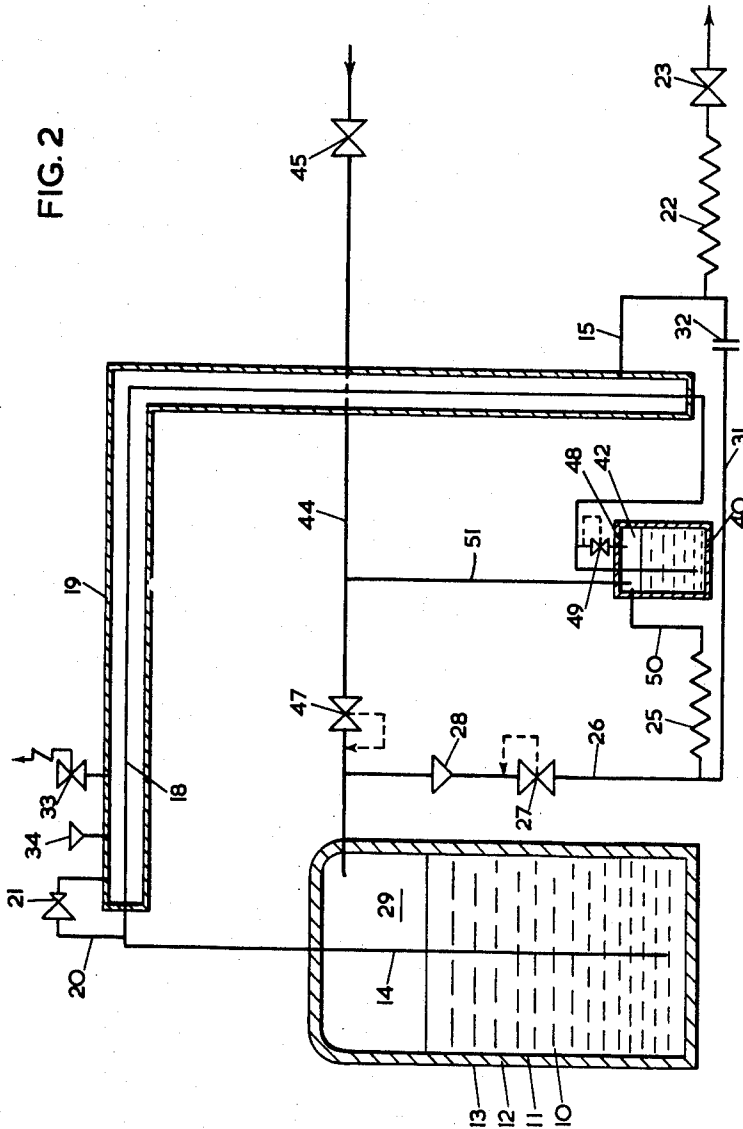
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FIG. 2



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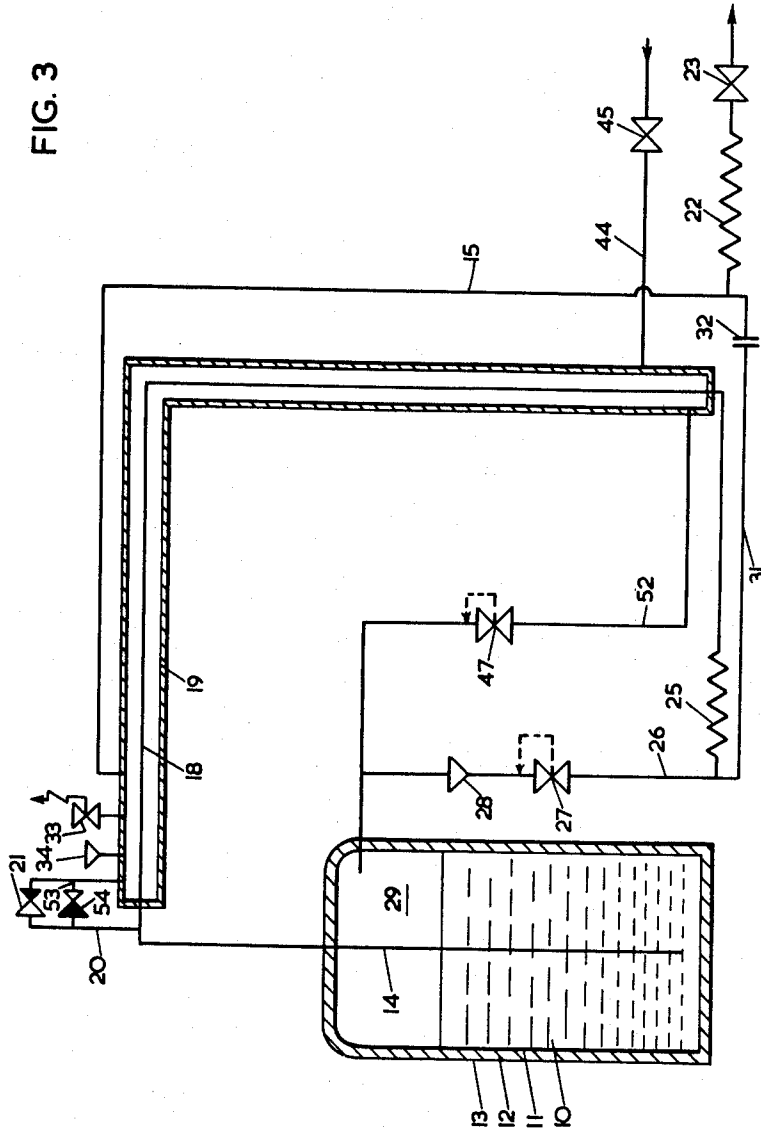
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APPARATUS FOR STORING AND DISPENSING LIQUEFIED GASES

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Claims priority, application Great Britain Aug. 23, 1960 5 Claims. (Cl. 62—51)

This invention relates to the dispensing of liquefied gases having a boiling point substantially below atmospheric temperature at normal atmospheric pressure, such as, for example, liquid oxygen or liquid nitrogen.

Such liquefied gases are normally stored in and dispensed from a thermally insulated vessel, provided with a bottom connection through which liquid is withdrawn both to the service connection and for use with a pressure raising and maintaining circuit. In order to simplify vessel construction and thereby to lower its costs and also to avoid heat leak, it would be desirable if the bottom connection were to be eliminated. One form of apparatus in which this is accomplished without loss of the ability to maintain the container pressure constant throughout the liquid withdrawal period forms the subject of Patent 2,997,855 application Ser. No. 50,772 which has been assigned to the assignees of the present application.

According to this application, apparatus for storing and dispensing a liquefied gas as hereinbefore defined comprises a thermally insulated container for the liquefied gas, a liquid withdrawal pipe opening at a point near to the bottom of the container and extending through the top thereof, a liquid feed line connecting the liquid withdrawal pipe with one end of a pressure raising coil located below the level of the bottom of the container, a vapour feed line connecting the other end of the pressure raising coil with the vapour space of the container through an automatic valve arranged to open when the pressure in the container falls below a predetermined value and a jacket surrounding the part of the liquid feed line above the level of the container, said jacket having a connection to the liquid withdrawal pipe through valve means arranged to maintain a pressure drop between the liquid feed line and the jacket and a liquid service connection.

Since the pressure raising coil is located at a lower level than the liquid in the container, the liquid withdrawal pipe and the liquid feed pipe to the coil will act as a syphon when filled with liquid and liquid will therefore syphon from the container through the liquid withdrawal pipe and the liquid feed pipe to the pressure raising coil as soon as the automatic valve in the vapour feed line from the pressure raising coil is opened, this liquid being vaporised in the pressure raising coil and the vapour fed back to the container until the pressure therein rises to the predetermined value and the automatic valve closes. Vaporisation of liquid in the liquid feed line to the pressure raising coil, which might cause vapour locking in the line and hence prevent the syphoning action, is prevented by the cooling effect of the liquid in the jacket, which liquid being at a lower pressure than that in the liquid feed line is cooled below the tem-

2

perature of the liquid in the liquid feed line by partial vaporisation.

Vaporisation in the lower part of the jacketed portion of the liquid feed line by heat leak along the line while the automatic valve is closed may be prevented by inserting a bleed line between the liquid feed line downstream of the end of the jacket and the service connection from the jacket, this bleed line being arranged to allow a continuous but slow flow of liquid through it. In addition, when the service connection is closed, any small accumulation of liquid in the jacket may pass back through the bleed line to the pressure raising coil and thence to the container. Alternatively this bleed line may be located between the vapour feed line upstream of the automatic valve and the service connection.

While this apparatus is satisfactory in maintaining pressure within the container throughout the liquid withdrawal period without the use of a bottom connection, it has the disadvantage that it is impossible to fill the container during use whilst maintaining the pressure during filling. The apparatus has the further disadvantage that the pressurising of the container depends on the flow of liquid and consequently if there is no flow (for example, when the vessel is standing idle overnight), the pressure falls.

It is an object of the present invention, to provide a modification of the apparatus in which these two disadvantages are overcome.

According to the present invention, apparatus for storing and dispensing a liquefied gas as hereinbefore defined comprises a thermally insulated container for the liquefied gas, a liquid withdrawal pipe opening at a point near to the bottom of the container and extending through the top thereof, a liquid feed line connecting the liquid withdrawal pipe with one end of a pressure raising coil located below the level of the bottom of the container, a vapour feed line connecting the other end of the pressure raising coil with the vapour space of the container through an automatic valve arranged to open when the pressure in the container falls below a predetermined value, a jacket surrounding the part of the liquid feed line above the level of the bottom of the container and having a connection to the liquid withdrawal pipe through valve means arranged to maintain a pressure drop between the liquid feed line and the jacket, a liquid service connection to said jacket, and a filling line connected to the vapour space of the container through an automatic valve arranged to open when the pressure in the container exceeds the predetermined value and to the liquid space of the container through a lightly thermally insulated liquid storage vessel.

The liquid storage vessel is only lightly thermally insulated so that during shut-down periods, liquid trapped in the vessel during filling will evaporate, the vapour passing into the liquid space of the container and there condensing to raise the pressure within the container.

The liquid storage vessel may be connected to the liquid space of the container in various ways. It may, for example, be connected directly to the liquid withdrawal pipe. Alternatively, it may be connected in the liquid feed line downstream the end of the jacket and thus connected to the liquid space via the liquid withdrawal pipe. If desired, the jacket itself may be arranged to function as the liquid storage vessel, being connected to the liquid

3

withdrawal pipe and thence to the liquid space of the container through a loaded non-return valve arranged to permit liquid to flow from the jacket to the liquid withdrawal pipe.

The invention will now be more particularly described with reference to the accompanying drawings in which:

FIGURES 1, 2 and 3 are diagrammatic side sectional views of three forms of apparatus according to the invention. In the figures, like parts are designated by the same reference numeral.

Referring to FIGURE 1, the liquefied gas 10, for example, liquid oxygen, is stored within an inner container 11 surrounded by thermal insulation 12 in an outer container 13. A liquid withdrawal pipe 14 opening at a point within the liquid 10 adjacent the bottom of the container 11 extends through the top of the container and is connected at a T-junction 17 to a liquid feed line 18 having a horizontal portion and a vertical portion extending downwardly to a point below the level of the bottom of the liquid 10 in the container 11. The line 18 is surrounded by an annular jacket 19, the outer surface of which may be thermally insulated. The end of the jacket 19 adjacent the T-junction 17 is connected to the line 18 upstream of the jacket by a line 20, flow of liquid through which is controlled by a valve 21 arranged to maintain a drop in pressure between the line 18 and the interior of the jacket 19 and preferably of the type described in Patent 2,997,855. This drop in pressure ensures that the temperature of the fluid in the jacket 19 will be below that in the line 18 and will therefore ensure that a continuous column of liquid is formed in the line 18. The jacket is connected downstream of the connection to the line 20 by a line 15 to a vaporiser 22 and thence to a valve 23 which controls the flow of gas from the system. It is from this valve that the gas is drawn to supply the demand.

The liquid feed line 18 is connected to one end of a pressure raising coil 25 in which liquid fed through the line 18 is vaporised, the vapour being fed through a vapour feed line 26 via an automatic control valve 27 and a non-return valve 28 to the vapour space 29 of the container 11. The control valve 27 is arranged to open automatically should the pressure in the container 11 fall below a predetermined value. The non-return valve 28 prevents reverse flow through the line 26 under start-up conditions. The line 26 is connected upstream of the valve 27 through a bleed line 31 and an orifice 32 to the inlet of the vaporiser 22, the orifice 32 being arranged to permit a slow stream of vapour to pass through the bleed line 31 to the vaporiser 22 and thus to permit a slow flow of liquid through the line 18 to avoid vaporisation in the line 18 due to heat leak.

Before reaching the T-junction 17, the liquid withdrawal line 14 passes through a lightly insulated liquid storage vessel 40, the part of the line 14 which is within the liquid space of the vessel 40 being in the form of a coil 41. The vapour space 42 of the vessel 40 is connected by a line 43 to the T-junction 17. A filling line 44, which may be connected through a stop valve 45 with a source of the liquefied gas under pressure, is also connected to the vapour space 42 of the vessel 40 and to the line 26 downstream of the valves 27 and 28 by a line 46 through an automatic valve 47 which is arranged to open when the pressure within the container 11 exceeds the predetermined pressure.

To release excessive pressure in the system, the jacket 19 is provided with a safety valve 33 and a bursting disc 34.

In operation, if the pressure within the container 11 is above the predetermined value when the valve 23 is opened to withdraw gas from the system, the automatic valve 47 will be open and flow can consequently take place from the vapour space 29 of the container 11 through the valve 47, the vessel 40, line 43, T-junction

4

17, valve 21, jacket 19, line 15, vaporiser 22, valve 23 and thence out of the system.

If the pressure within the container is at the predetermined value, the automatic valve 47 will be closed, and flow will be established via the liquid withdrawal pipe 14, T-junction 17, valve 21, jacket 19, line 15, vaporiser 22 and valve 23 and hence out of the system. Under these conditions, there will be a tendency for the pressure in the container 11 to fall and consequently the automatic valve 27 will open. By the time this occurs, a full liquid head will have been built up in the line 18 and consequently when the valve 27 opens, a flow through line 18, pressure raising coil 25, line 26, valve 27, and non-return valve 28 to the vapour space 29 of the container 11 will take place and will serve to restore the pressure in the container 11 to and maintain it at the predetermined value.

When it is desired to fill the container 11, the filling line 44 is connected to a suitable source of liquefied gas under pressure and the valve 45 is opened. If the pressure in the container 11 is at or below the predetermined value, the automatic valve 47 will be closed and filling will take place through line 44, vessel 40, line 43, T-junction 17 and pipe 14 to the liquid space of the container 11. It is probable that in the later stages of the filling operation, the pressure in the container 11 will rise above the predetermined value, in which case the automatic valve 47 will open and some alternative flow will take place through valve 47, line 46 and line 26 to the vapour space 29 of the container 11. The cold liquid thus entering the container will cause a decrease in the pressure therein, until the predetermined value is reached when the valve 47 will close and this alternative flow will cease.

During the filling operation, the liquid storage vessel 40 will be filled with liquid and will be maintained so during subsequent withdrawal of liquid by the passage of liquid through the coil 41 in its passage up pipe 14 to the T-junction 17. The liquid within the storage vessel 40 will be colder than would normally be associated with the operating pressure of the apparatus. When the valve 23 controlling liquid withdrawal is closed and withdrawal from the system ceases, heat leak to the vessel 40 will continue but will not be absorbed by the passage of liquid through the coil 41. Thus the liquid in the storage vessel 40 will tend to evaporate and will force vapour through the line 43 to the T-junction 17 and thence through pipe 14 into the liquid 10 where it will be condensed. This process will continue until the vessel 40 is empty and by that time the liquid in the container 11 will have reached a satisfactory equilibrium pressure.

In the embodiment illustrated in FIGURE 2, the liquid storage vessel is located in the liquid feed line 18 between the end of the jacket 19 and the pressure raising coil 25. The end of the line 18 is arranged to extend almost to the bottom of the vessel 40 and opens below the surface of any liquid therein. The line 18 is connected by line 48 with the vapour space 42 of the vessel 40 through an automatic valve 49 arranged to open when the pressure in the container 11 falls below the predetermined value. The vapour space 42 is also connected to the inlet of the pressure raising coil by a line 50 and to the filling line 44 by a line 51. As in the embodiment of FIGURE 1, the filling line 44 is connected to line 26 and thence to the vapour space 29 of the container 11 through the automatic valve 47.

In describing the operation of this system a number of different operational cases have to be considered.

When the system is started up after a period of no demand, valve 47 will be open since the pressure will have risen to a figure above the predetermined value. Gas will therefore leave the vapour space 29 of the container 11 through line 26, valve 47, line 44 and line 51 to the vessel 40. Since the pressure is above the predetermined value, the automatic valve 49 will be closed

5

and since the vessel 40 will be empty, the gas will pass up through line 20, valve 21, jacket 19, line 15, vaporiser 22 and valve 23. At the same time, some liquid may be withdrawn via the liquid withdrawal pipe 14, unless it is arranged that the pressure drop in the circuit just described is low enough to avoid the liquid in pipe 14 rising to the junction with line 18.

During normal operation, the pressure will drop to the predetermined value and the valve 47 will accordingly close. Under these circumstances, the liquid will rise in the liquid withdrawal pipe and will pass via line 18, line 20, valve 21, jacket 19, line 15, vaporiser 22 and valve 23 to the point of use. At the same time, line 18 will fill with liquid and a flow will be established into vessel 40 and thence through line 50, pressure raising coil 25, line 31, orifice 32, to the vaporiser 22 and thence out of the system. If the pressure in the container 11 falls below the predetermined value, the valve 27 will open and a flow will be established from the vessel 40 through line 50, pressure raising coil 25, line 26, valves 27 and 28 to the vapour space 29 of the container 11, which serves to maintain the pressure therein.

When the contents of the container 11 are low, it will be necessary to pump or pressure fill liquefied gas to the container through the valve 45 and the filling line 44. If the pressure in the container is above the predetermined value, the automatic valve 47 will be open and consequently the fresh liquid may pass to the container 11 either via filling line 44, valve 47 and line 26 to the vapour space 29 of the container 11, or, alternatively, via line 44, line 51, vessel 40, line 18, and pipe 14 to the liquid space of the container. The pressure in the container 11 will fall as a result of the passage of liquid into the gas space 29 and as soon as the predetermined value is reached, valve 47 will close. If the container pressure falls below the predetermined value, the automatic valve 27 will open and permit a part of the liquid entering the system to flow from the vessel 40 through the pressure building circuit (line 50, coil 25, line 26) to the gas space 29 in order to maintain the predetermined operating pressure. When filling is complete this same circuit will operate to maintain the pressure in the container 11 while gas is consumed via valve 23.

When the container has recently been pump filled and then shut down, it is probable that the liquid contents will be at a lower temperature than will be represented by vessel pressure. In this case, if the liquid storage vessel 40 were not provided, when the apparatus was shut down the pressure would gradually fall off. The vessel 40 will, however, be full of liquid after filling and during the shut-down period, this liquid will gradually vaporize and pass via the valve 49, which will be open, through lines 18 to the liquid withdrawal pipe 14 and into the liquid space of the container 11, where it will condense and warm up the liquid in doing so. The size of valve 49 must be sufficient to avoid the passage of liquid from vessel 40 through line 18. The evaporation of liquid from the vessel 40 will continue until the pressure in the container 11 rises to the predetermined value when the valve 49 will close. The rest of the liquid in vessel 40 will then be transferred through line 18 to the container.

In the embodiment of the invention illustrated in FIGURE 3, the jacket 19 is arranged to function as the liquid storage vessel. The lower end of the jacket 19 is connected to the filling line 44 and by a line 52 to the vapour feed line 26 through the automatic valve 47. The only other modification of the basic assembly required is the provision of a by-pass line 53 across the valve 21. Flow through this by-pass line is controlled by a loaded non-return valve 54 which will permit liquid or gas to flow through line 20 from the jacket 19 to the liquid withdrawal pipe 14.

When it is required to fill the container 11 a pump or other suitable source of liquid under pressure is connected to the filling line 44 and the valve 45 is opened. If the

6

pressure in the container is below the predetermined pressure, the valve 47 will be closed and the liquid will pass through the jacket 19, valve 21 and the pipe 14 into the liquid space of the container 11. If, however, the container pressure is above the predetermined pressure, valve 47 will be open and valve 21 will remain closed by virtue of being a loaded non-return valve. Consequently, the liquid will pass from jacket 19 through line 52, valve 47 and line 26 to the vapour space 29 of the container 11.

Under normal conditions of filling, it is unlikely that the equilibrium pressure within the container 11 will be sufficiently high for normal operation to commence when filling has been completed. Consequently, the liquid which will have accumulated in the jacket 19 after closure of the valve 47 when the pressure fell below the predetermined value, will gradually evaporate and pass via the valve 21 and the pipe 14 into the liquid 10 where it will condense, thus raising the equilibrium pressure of the liquid. If the pressure exceeds the predetermined pressure, valve 47 will open and make possible the transfer of liquid remaining in the jacket 19 to the gas space 29 of the container 11.

During normal withdrawal of gas from the system, if the pressure is above the predetermined value, valve 47 will open and valve 21 being a loaded non-return valve will be closed. When valve 23 is opened, the flow will therefore be established from the gas space 29 of container 11 through line 26, valve 47, line 52, jacket 19, line 15, vaporiser 22, and valve 23 to the point of consumption. Where the pressure in the container 11 is at or below the predetermined value, valve 47 will be closed and flow will take place through pipe 14, valve 21, jacket 19, line 15, vaporiser 22 and valve 23. Under these conditions, it is usual to find that the pressure in container 11 will decrease and consequently the valve 27 in the pressure raising circuit will open, permitting flow through pipe 14, line 18, pressure raising coil 25, and line 26 to the gas space 29 of the container 11 to restore the pressure to the predetermined value.

It will be appreciated that in all three of the embodiments described, the pressure in the converter is automatically maintained during filling of the container, and provision is made to rectify any loss of pressure during shut-down by vaporisation of liquid from the liquid storage vessel or the jacket where this acts as the storage vessel.

We claim:

1. Apparatus for storing and dispensing a liquefied gas having a boiling point substantially below atmospheric temperature at normal atmospheric pressure comprising a thermally insulated container for the liquefied gas, a liquid withdrawal pipe opening at a point near to the bottom of said container and extending through the top thereof, a pressure raising coil located below the level of the bottom of said container, a liquid feed line connecting said liquid withdrawal pipe with one end of said pressure raising coil, a vapour feed line connecting the other end of said pressure raising coil with the vapour space of said container through an automatic valve arranged to open when the pressure in said container falls below a predetermined value, a jacket surrounding the part of the liquid feed line above the level of the bottom of said container and having a connection to said liquid withdrawal pipe through valve means arranged to maintain a pressure drop between said liquid feed line and said jacket, a liquid service connection to said jacket, and a filling line connected to the vapour space of said container through an automatic valve arranged to open when the pressure in said container exceeds said predetermined value and to the liquid space of said container through a lightly thermally insulated liquid storage vessel.

2. Apparatus according to claim 1 wherein the vapour space of said liquid storage vessel is connected directly to said liquid withdrawal pipe.

3. Apparatus according to claim 1 wherein said liquid

7

storage vessel is connected in said liquid feed line downstream of the end of said jacket.

4. Apparatus according to claim 1 wherein said liquid storage vessel is constituted by said jacket, said jacket being connected to said liquid withdrawal pipe through a loaded non-return valve arranged to permit liquid to flow from said jacket to said liquid withdrawal pipe.

5. Apparatus according to claim 1 including a bleed line connected between said vapour feed line upstream of said automatic valve in said vapour feed line and said

8

liquid supply connection, said bleed line being arranged to allow a continuous but slow flow of vapour there-through.

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