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Van Mal et al.

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[54] **CONTROL DEVICE FOR MAINTAINING THE LEVEL OF A LIQUIFIED GAS IN A CONTAINER BETWEEN TWO DIFFERENT LIMITS**

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[22] Filed: **Aug. 17, 1972**

[21] Appl. No.: **281,342**

Related U.S. Application Data

[63] Continuation of Ser. No. 153,244, June 15, 1971.

[30] **Foreign Application Priority Data**

June 26, 1970 Netherlands 7009420

[52] **U.S. Cl.** **62/55,** 62/514

[51] **Int. Cl.** **F17c 7/02**

[58] **Field of Search** 62/45, 55, 218, 514

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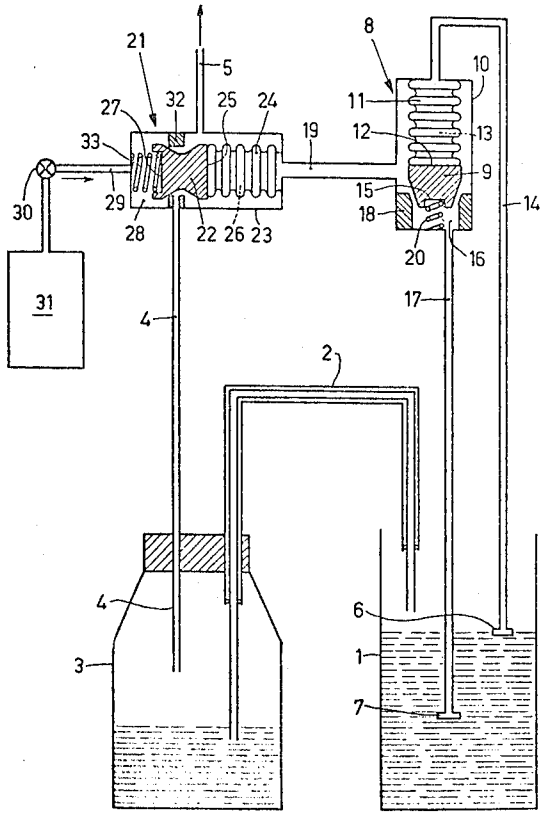
Primary Examiner—Meyer Perin

Attorney, Agent, or Firm—Frank R. Trifari

[57] **ABSTRACT**

A control device for maintaining the level of a liquefied gas in a main container between two differenct limits, comprises a first vapor pressure bulb which is at the higher limit and a second vapor pressure bulb which is at the lower level, the bulbs containing a medium under pressure which condenses at the temperature of the liquefied gas. The medium pressures can actuate first and second control valves, which control flow of liquified gas from a storage container into said main container.

7 Claims, 7 Drawing Figures



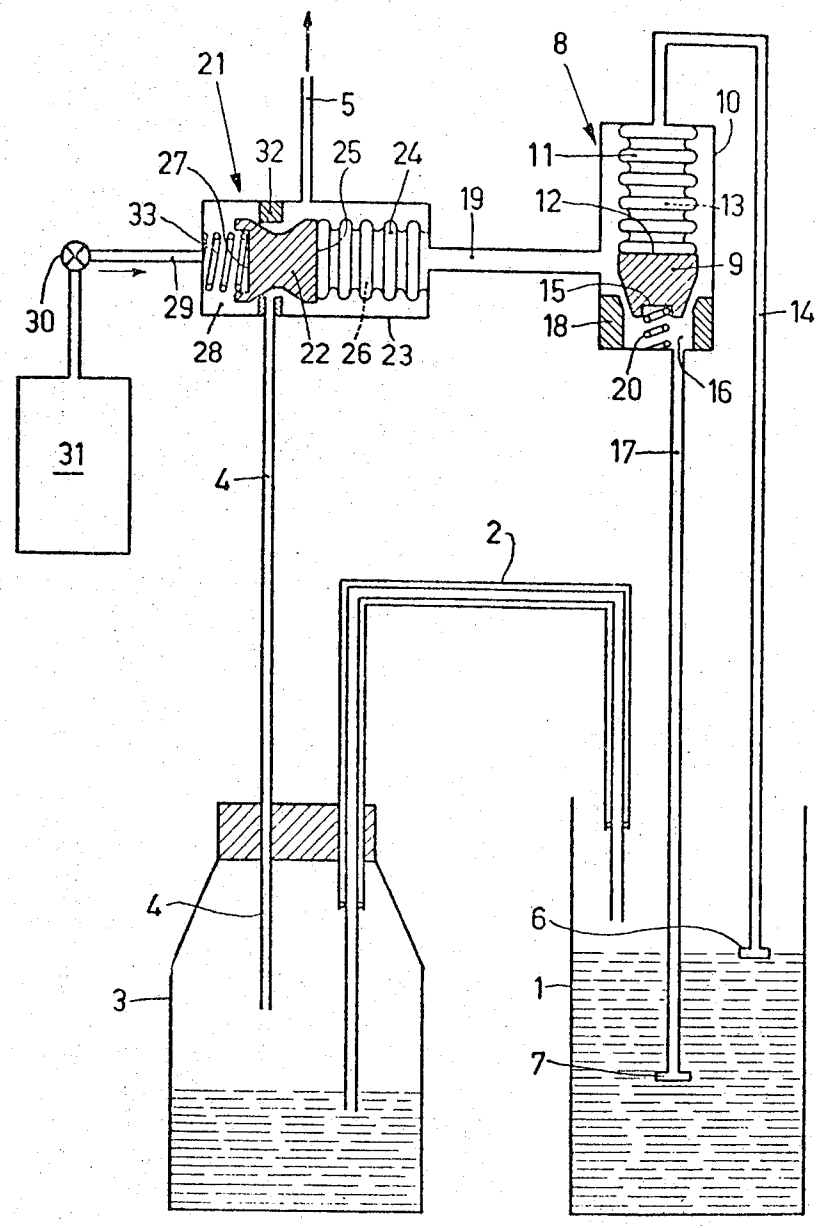

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Fig.1

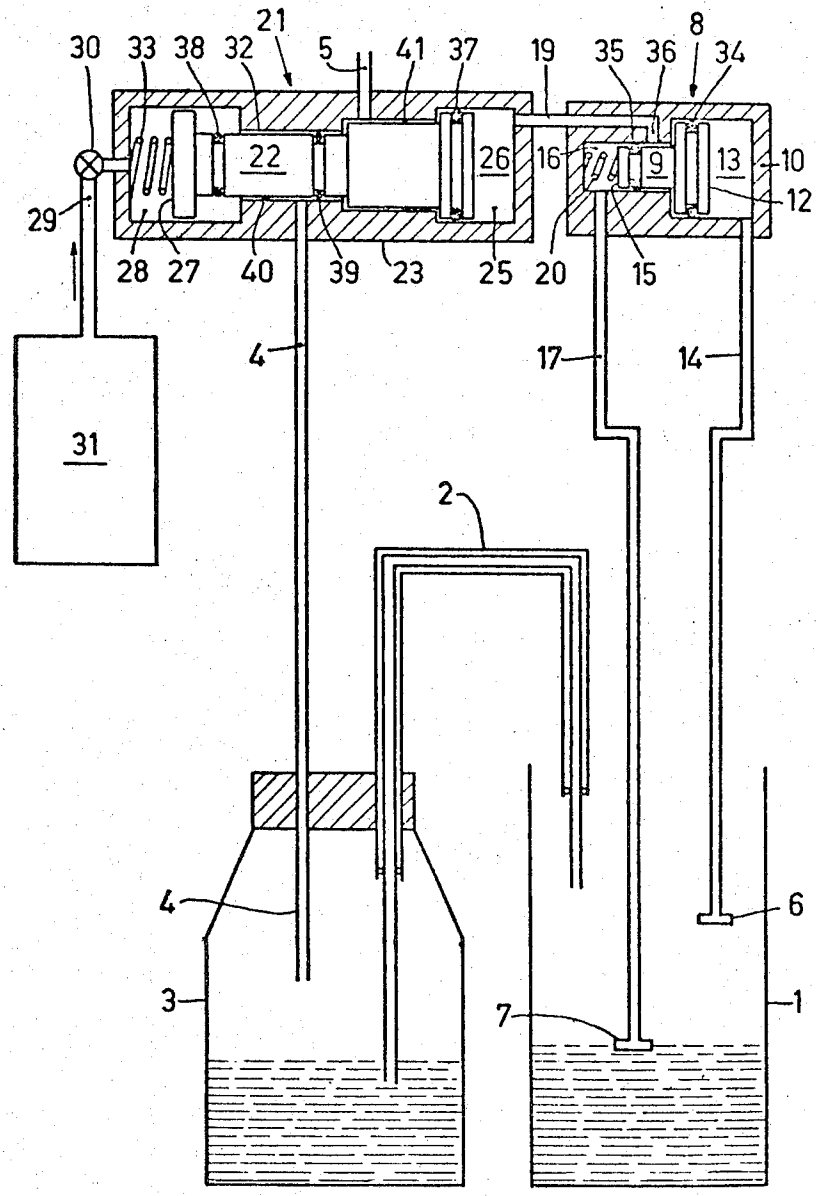
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Fig. 2

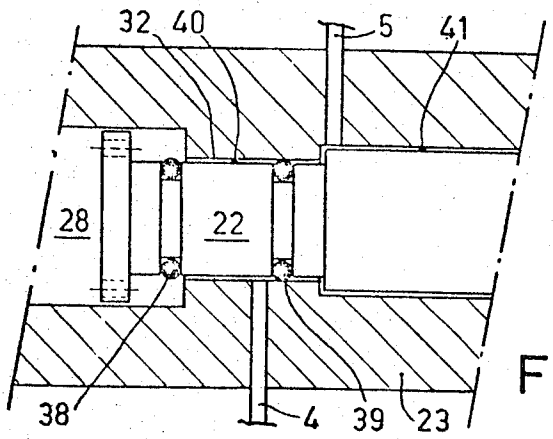

Fig.3a

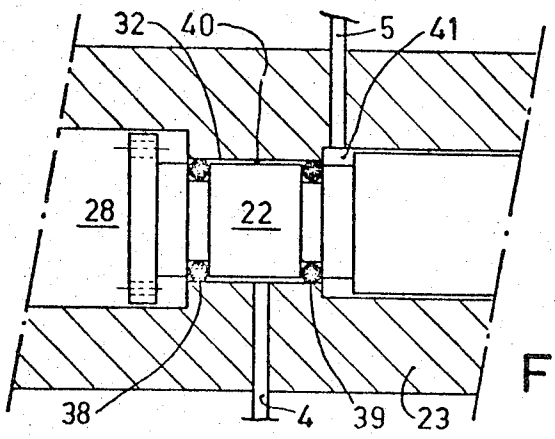

Fig.3b

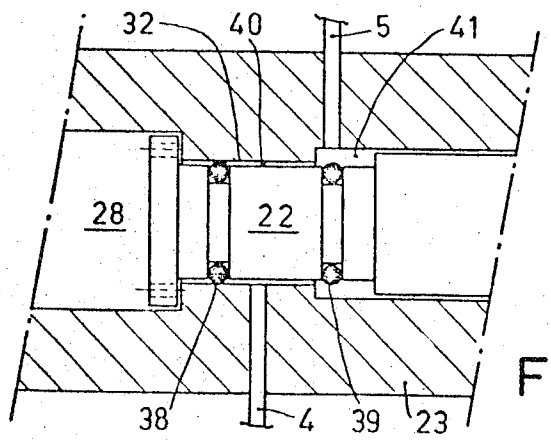

Fig.3c

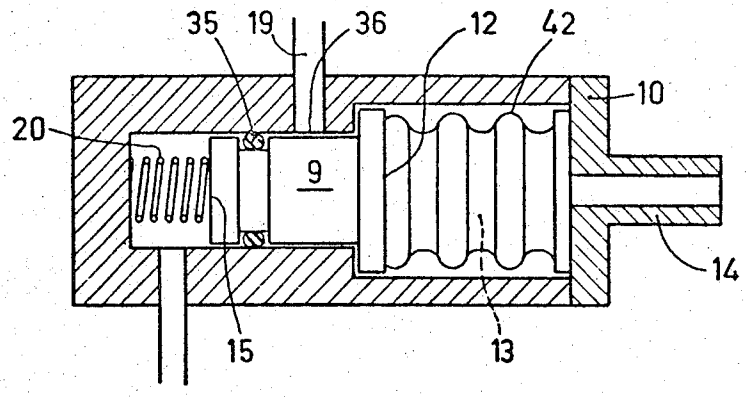

Fig. 4

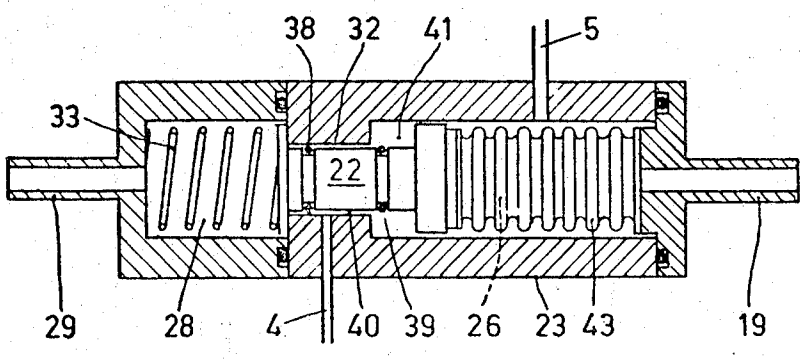

Fig. 5

CONTROL DEVICE FOR MAINTAINING THE LEVEL OF A LIQUIFIED GAS IN A CONTAINER BETWEEN TWO DIFFERENT LIMITS

This is a continuation of application Ser. No. 153,244, filed June 15, 1971.

The invention relates to a control device for maintaining the level of a liquefied gas in a container between two different limits. The container communicates, via a siphon with the liquid space of a storage container, the vapour space of the container being made to communicate with a vapour outlet. The control device comprises a first vapour pressure bulb arranged at the higher limit and a second vapour pressure bulb arranged at the lower limit, the bulbs containing a medium under pressure which condenses at the temperature of the liquefied gas. The medium pressures are capable of actuating first and second control valves in such manner that the communication of the vapour space of the storage container with the vapour outlet is interrupted by the valves when the level of the liquefied gas in the container falls below the lower limit, and is released when the level exceeds the higher limit. A device of this type is known from "Cryogenics" 1962, pg. 145: "An automatic arrangement for supplying a space with liquid nitrogen." The medium in the vapour pressure bulbs may be the same as in the container and storage container, respectively, but this is not strictly necessary.

The known device exhibits a few drawbacks. The construction of the control mechanism which comprises two control valves is rather complicated and expensive. One control valve moves transverse to the direction of movement of the other so as to control the stroke of the last-mentioned control valve via a mechanical contact with the other. For that purpose, the first mentioned control valve comprises a frame construction having a pin which is to cooperate accurately with a special jacket arranged around the other control valve and serving as a guide. A reliable operation of such a construction requires accurate dimensions and accurate assembly of the components, respectively. Due to the mechanical contact between the two control valves which are each subject to variable pressures, the control mechanism is subject to rather strong detrition and sensitive to disturbances. Both control valves are difficult to assemble and dismantle.

A further drawback of the known device is that, when the level of the liquefied gas in the container has fallen below the lower limit and therefore the communication of the vapour space of the storage container with the vapour outlet which usually communicates with the atmosphere is interrupted. The transport of liquid from the storage container to the container starts only when so much liquid has evaporated in the storage container due to heat inleak from without that a sufficiently high pressure in the vapour space has built up to effect the siphoning action. So the liquid flow into to the container lags behind in time with respect to the instant of closure-off of the vapour space from the vapour outlet. This is often undesirable, in particular in the case of measurements.

It is the object of the present invention to provide a control device in which the said drawbacks are avoided. In order to realize this object, the device according to the invention is characterized in that the first control valve is constituted by a first piston-like member which is incorporated in a first housing and can reciprocate therein in the axial direction. The piston has one end face which constitutes a wall of first space which is in open communication with the first vapour pressure bulb and is otherwise closed. The other end face of the piston constitutes the boundary of a second space which is in open communication with the second vapour pressure bulb. The second space furthermore comprises a communication which, when the first piston-like member reciprocates, is alternately closed and released by said member. The second control valve is constituted by a second piston-like member which is accommodated in a second housing with some amount of play and can reciprocate therein in the axial direction. This second piston has one end face which constitutes a wall of a third space which communicates with the communication with the second space and is otherwise closed and constitutes this pistons other end face constitutes the boundary of a fourth space which communicates with an auxiliary vessel containing a pressure medium. The second piston-like member upon reciprocating is capable of communicating the vapour space of the storage container alternately with the fourth space and the vapour outlet. The medium pressures in the vapour pressure bulbs, the pressure medium pressure in the auxiliary vessel, and the surface areas of the end faces of the piston-like members are furthermore chosen such that when the level of the liquefied gas in the container lies below the second vapour pressure bulb, the resulting force on the first piston-like member causes said member to assume a position in which the second space is in open communication with the third space. The resulting force on the second piston-like member causes said member to assume a position in which the vapour space of the storage container is in open communication with the fourth space. When said level increases due to siphoning action, when the second vapour pressure bulb is reached, the resulting force on the first piston-like member causes the said member to interrupt the communication between the second and the third space. A remaining medium pressure in the third space, in which the second piston-like member maintains the open communication between said vapour space and the fourth space, in which, when the said level reaches the first vapour pressure bulb, the resulting force on the first piston-like member causes said member to assume a position in which the open communication between the second and the third space is restored. As a result of the falling medium pressure in the third space, the second piston-like member interrupts the communication between the vapour space and the fourth space and produces an open communication between the vapour space and the vapour outlet. In this manner a reliably operating control device is obtained with control valves of a simple and cheap construction, these valves ensure in addition that immediate transport of liquid from the storage container to the container takes place when the liquid level in the container falls below the lower limit and discontinues immediately when sai level reaches the higher limit. The control valves mutually may be arranged in any position and since they are not in direct mechanical contact with each other, they are less subject to detrition. The valves can be mounted and dismantled separately.

In a favourable embodiment of the control device according to the invention, the second piston-like mem-

ber can cooperate in a sealing manner over at least a part of its length with a cyclindrical seat present between the third and the fourth space via at least one first and at least one second seal. These seals, viewed in the axial direction, are located one behind the other at a mutual distance which is smaller than the axial dimension of the seat and are each incorporated in a groove in the wall of the second piston-like member and which seals separate the fourth space from a fifth space which is in open communication with the vapour outlet. The slit-like annular duct present between the said seals and constituted by the relevant wall parts of second piston-like member and seat is in open communication with the vapour space of the storage container; the seals are capable of alternately communicating the annular duct with either the fourth or the fifth space when the second piston-like member reciprocates.

This presents the advantage that the second control valve operates without losses, thus when the second piston-like member interrupts the communication between the fourth space and the annular duct and communicates said annular duct with the fifth space, no communication will be produced between the fourth and the fifth space during the switching. Pressure medium from the auxiliary vessel cannot reach the vapour outlet via the fourth space, the annular duct, and the fifth space, and hence be lost, and cannot produce a fall in pressure in the auxiliary vessel.

In a further favourable embodiment of the control device according to the invention, first resilient means are present which exert a force on the first piston, said force being directed opposite to the force exerted on said member by the medium in the first space.

On the one hand this has the advantage that the first piston as a result of this has a larger response rate in the case of pressure variations; on the other hand, the use of said resilient means permits the use of a first piston with equal surface areas of the end faces. This makes the manufacture of the first piston simpler and cheaper since it is now possible to use pistons having a substantially constant cross-section. Notably in the case of metal piston this requires no chipping operation, which is time-consuming and expensive. In addition it is furthermore possible now to choose a lower pressure limit in the second vapour pressure vessel.

A further favourable embodiment of the control device according to the invention is characterized in that second resilient means are present which exert a force on the second piston, said force being directed opposite to the force exerted on said member by the medium in the third space.

As a result of this the same advantages are obtained as in the case of the first piston. The pressure medium in the auxiliary container may now have a pressure which is only slightly higher than atmospheric pressure.

In order that the invention may be readily carried into effect, it will now be described in greater detail, by way of example, with reference to the accompanying diagrammatic drawings which are not drawn to scale.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1** and **2** show embodiments of the control device,

FIG. **3** shows various positions of the first control valve of the control device shown in FIG. **2,**

FIG. **4** shows a further embodiment of the first control valve,

FIG. **5** shows a further embodiment of the second control valve.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. **1,** reference numeral **1** denotes a container which contains liquid nitrogen. Via a siphon **2** the container communicates with the liquid space of a storage first container **3** which also contains liquid nitrogen. A vapour duct **4** communicates with the vapour space of the storage container **3** and can be made to communicate with a vapour outlet **5.**

Two vapour pressure bulbs **6** and **7** or sensing means which are arranged at different limits are present in the container **1,** namely the first bulb **6** at the higher limit and the second bulb **7** at the lower limit. The two vapour pressure bulbs also contain nitrogen.

The control device comprises a control valve **8** having a piston **9** which can reciprocate in the axial direction in a housing **10** and is secured to the housing **10** via a bellows **11.** One end face **12** of the piston **9** constitutes a wall of a first space **13** present inside the bellows **11,** which space is in open communication with the vapour pressure bulb **6** via a duct **14.** The other end face **15** faces a second space **16** which is in open communication with the vapour pressure bulb **7** via a duct **17.**

The piston **9** can cooperate in a sealing manner with a seat **18** and in this manner communicates or not communicates the space **16** with a duct **19** by being in on or off conditions, correspondingly. Between the end face **15** and the wall of the housing **10** there is a compression spring **20** which exerts a force upwards on the piston.

The control device furthermore comprises a second control valve **21,** having a piston **22** which can reciprocate in the axial direction in a housing **23** and is secured to said housing via a bellows **24.** One end face **25** of the piston **22** constitutes a wall of a third space **26** present within the bellows **24,** with which space the duct **19** communicates with its other side. The other end face **27** of the piston **22** also bounds a fourth space **28** which communicates, via a duct **29** in which a cock **30** is incorporated, with an auxiliary vessel **31** containing nitrogen gas as a pressure medium.

In its central longitudinal part the piston **22** is shaped so that in cooperation with seat **32,** it can operate as a double-operating valve: in the extreme right position or closed condition, as shown in the drawing, the vapour duct **4** communicating with the second control valve **21,** communicates with the vapour outlet **5** which likewise communicates with said second control valve and is cut off from the fourth space **28;** in the extreme left position or open condition, the fourth space communicates with the vapour duct **4,** which duct is then cut off from the vapour outlet **5.** Furthermore a compression spring **33** is present between the end face **27** of the piston **22** and the wall of the housing **23,** which spring exerts a force to the right of said member.

The operation of the control device is as follows: When the liquid nitrogen level in the container **1** lies below the vapour pressure bulb **7,** the nitrogen in the two vapour pressure bulbs is in the gaseous phase. Vapour pressure bulb **7** has a higher filling pressure than vapour pressure bulb **6,** namely 7 and 4 atmospheres,

respectively. As a result of this, the pressure in the space 16 is also higher than in the space 13 and hence the pressure on the end face 15 is larger than on the end face 12. Together with the force exerted by the compression spring 20 on the piston 9, this results in an open position of the control valve 8, as a result of which a nitrogen pressure in the order of magnitude of 7 atmospheres prevails also in the duct 19 and in the space 26. As a result of this, the piston 22 of the control valve 21 is forced to the left to the seat 32 against the pressure in the fourth space 28, which space is in open communication with the auxiliary container 31, and against the force of the compression spring 33, and auxiliary container 31 is communicated with the vapour space of storage container 3, via vapour duct 4.

Since in the auxiliary container 31 a pressure prevails which is slightly higher than the atmospheric pressure, the excessive pressure causes an immediate transport of liquid nitrogen from the storage container 3 through the siphon 2 to the container 1.

When the liquid level in the container 1 reaches the vapour pressure bulb 7, the nitrogen therein begins to condense and the pressure drops from 7 to 1 atmosphere. The pressure in the space 16 will also drop as a result of which the total force exerted on the end face 15 on the piston 9 becomes smaller than the force exerted on the end face 12 by the nitrogen in the space 13. As a result of this the control valve 8 is closed.

By suitably chosen nitrogen pressures, surface areas of the end faces 12 and 15, and compression springs 20, this closure occurs so rapidly that of the 7 atmosphere pressure in the duct 19 and the space 26, a sufficient residual pressure remains to ensure that the position of the control valve 21 remains unchanged, that is to say that the piston 22 remains pressed to the left against the seat 32. The transport of liquid from the storage container 3 via siphon 2 to the container 1 remains intact. When the liquid level in the container 1 reaches the vapour pressure bulb 6, the nitrogen condenses herein and the pressure drops from 4 to 1 atmosphere. A pressure of 1 atmosphere will now prevail both in the space 16 and in the space 13. Compression spring 20 now exerts a sufficiently large force on the piston 9 to push said member upwards as a result of which the nitrogen gas in the duct 19 and the space 26 obtains the opportunity of flowing, via duct 17, to the vapour pressure bulb 7 and condensing therein. So the pressure in the space 26 drops to 1 atmosphere. Compression spring 33 and the excessive pressure of auxiliary container 31 which prevails in the space 28, ensure that the piston-like member 22 of the second control valve 21 is pressed to the right against seating 32. The first and the second control valve assume a position as is shown in the Figure. Auxiliary container 31 is cut off from both the vapour duct 4 and the vapour outlet 5 which now communicate with each other. The latter has for its result that the excessive pressure still present in the storage container 3 is released via the vapour outlet. Because of the fact that atmospheric pressure prevails again in the vapour space of the storage container 3, the siphoning action and hence the transport of liquid is discontinued.

Conversely, when the liquid level in the container 1 drops and comes below the vapour pressure bulb 6, the pressure therein rises again to 4 atmosphere and the control valve 8 is closed; control valve 21 then remains in the position shown in FIG. 1, since the pressure in space 26 does not vary. So there is no transport of liquid. When the liquid level in the container 1 drops to below the vapour pressure bulb 7, the pressure therein will rise again to 7 atmospheres, as a result of which the control valve 8 is opened and the pressure in the space 26 which has increased from 1 to 7 atmospheres then ensures that the piston 22 is pressed to the left against seating 32, as a result of which the communication between the vapour duct 4 and the vapour outlet 5 is interrupted, and the said duct is communicated with the auxiliary container 31, so that the siphoning action starts again.

In the device described, the liquefied gas is liquid nitrogen, while the vapour pressure bulbs also contain nitrogen. Of course, the control device may equally be used for other liqudfied gases, for example, hydrogen, helium and neon and the like, while the filling gas of the vapour pressure bulbs need not be the same as the liquefied gas. For example, oxygen may be used as a filling gas while the liquefied gas is nitrogen. The vapour outlet may open into the atmosphere. In certain circumstances, however, it may be suitable to connect a receiving container to the vapour outlet, for example, when comparatively expensive and rare gases are used.

In the control device shown in FIG. 1, the second control valve 21 has the drawback that during switching the communication between the vapour duct 4 and the vapour outlet 5 to the communication between the said vapour duct and the auxiliary container 31 vice versa an open communication exists for a short period of time between the auxiliary container 31 and the vapour outlet 5. This is the case when the piston like member 22 is in or near its central position. All this results in loss of pressure medium and in unnecessary pressure drop in auxiliary container 31.

This drawback is not present in the control device shown in FIG. 2, in which in addition to the second control valve, the first is also constructed slightly differently. For the rest the operation of this device is the same as that shown in FIG. 1, so that description of the operation may be omitted. For corresponding components as in FIG. 1 the same reference numerals are used in FIG. 2.

The control valve 8 differs from that shown in FIG. 1 in that the first piston 9 is not connected to the housing 10 via a bellows, but comprises an O-ring 34 as a seal, as a result of which the space 13 together with the duct 14 and vapour pressure bulb 6 constitute a closed assembly. Furthermore, the piston 9 comprises an O-ring 35 as a seal. During the reciprocating movement of said piston, aperture 36 is alternately closed and released and hence the communication between the space 16 and the duct 19 is interrupted and produced. The second control valve 21 comprises an O-ring 37 as a seal between the second piston 22 and the housing 23.

Piston 22 comprises a cylindrical central section which can cooperate in a sealing manner with the cylindrically constructed seating 32, via O-ring seals 38 and 39 which are present mutually at a distance smaller than the axial dimension of the seating 32 and are incorporated in grooves in the wall of the central section.

As a result of the central section of the piston 22 present between the seals 38 and 39 and the seating 32, a slit-like annular duct 40 is formed which, via vapour

duct 4, is in open communication with the vapour space of the storage container 3.

During the reciprocating movement of the piston 22, the annular duct 40 is alternately communicated with either the fourth space 28 or a fifth space 41 with which the vapour outlet 5 communicates, while during the switching there is at no instant an open communication between the fourth and the fifth space. So pressure medium from the auxiliary container 31 cannot reach the vapour outlet 5 via the fourth space 28, annular duct 40, and fifth space 41 and be lost in vain. All this is explained with reference to FIG. 3, in which the piston 22 is shown in three different positions. In the extreme left position shown in FIG. 3*a* the annular duct 40 is in open communication with the fourth space 28. Both the annular duct 40 and the fourth space 28 are separated from the fifth space 41 by O-ring seal 39.

FIG. 3*b* shows the central position. Annular duct 40 is cut off from the fourth space 28 and the fifth space 41. Seals 38 and 39 prevent pressure medium from flowing out of the fourth space 28 to the fifth space 41.

FIG. 3*c* shows the extreme right position. Annular duct 40 communicate with the fifth space 41. Seal 38 ensures that pressure medium cannot flow from the fourth space 28 to the fifth space 41.

FIG. 4 shows a further embodiment of the first control valve 8. As compared with the control valve shown in FIG. 2, the annular member 9 is connected to the housing 10 via a bellows 42 in a manner analogous to that of the first control valve shown in FIG. 1. For the rest the same reference numerals are used as in FIG. 2.

FIG. 5 shows a further embodiment of the second control valve 21. The only difference with the construction shown in FIG. 2 is that the piston 22 in the present case is connected to the housing 23 via a bellows 43. For the rest the same reference numerals are used.

What is claimed is:

1. A control device for maintaining the level of a liquefied gas in a container between two different limits, the container communicating via a siphon, with the liquid space of a storage container, the vapour space of which can be made to communicate with a vapour outlet, said control device comprising a first vapour pressure bulb arranged at the higher limit and a second vapour pressure bulb arranged at the lower limit, the bulbs containing a medium under pressure which condenses at the temperature of the liquefied gas, the medium pressures being capable of actuating first and second control valves in such a manner that the communication of the vapour space of the storage container with the vapour outlet is interrupted by the said valves when the level of the liquefied gas in the container drops below the lower limit, and is released when the level exceeds the higher limit, characterized in that the first control valve is constituted by a first piston-like member which is incorporated in a first housing and can reciprocate therein in the axial direction and which constitutes with its one end face a wall of a first space which is in open communication with the first vapour pressure bulb and is otherwise closed, and constitutes with its other end face also the boundary of a second space which is in open communication with the second vapour pressure bulb, the second space furthermore comprising a communication which, when the first piston-like member reciprocates, is alternately closed and released by said member, the second control valve being constituted by a second piston-like member which is accommodated in a second housing with some amount of play and can reciprocate therein in the axial direction, and which constitutes with its one end face a wall of a third space which communicates with the communication with the second space and is otherwise closed and with its other end face also constitutes the boundary of a fourth space which communicates with an auxiliary vessel containing a pressure medium, the second piston-like member upon reciprocation being capable of communicating the vapour space of the storage container alternately with the fourth space and the vapour outlet, the medium pressures in the vapour pressure bulbs, the pressure medium pressure in the auxiliary vessel, and the surface areas of the end faces of the piston-like members being furthermore chosen to be so that, when the level of the liquefied gas in the container lies below the second vapour pressure bulb, the resulting force on the first piston-like member causes said member to assume a position in which the second space is in open communication with the third space and the resulting force on the second piston-like member causes the said member to assume a position in which the vapour space of the storage container is in open communication with the fourth space, in which, when the said level rises due to siphoning action, when the second vapour pressure bulb is reached the resulting force on the first piston-like member causes said member to interrupt the communication between the second and the third space with a remaining medium pressure in the third space, in which the second piston-like member maintains the open communication between the vapour space and the fourth space, in which, when the said level reaches the first vapour pressure bulb, the resulting force on the first piston-like member causes said member to assume a position in which the open communication between the second and the third space is restored, and, as a result of the falling medium pressure in the third space, the second piston-like member interrupts the communication between the vapour space and the fourth space and produces an open communication between the vapour space and the vapour outlet.

2. A control device as claimed in claim 1, characterized in that the second piston-like member can cooperate in a sealing member over at least a part of its length with a cylindrical seating present between the third and the fourth space via at least one first and at least one second seal, which seals, viewed in the axial direction, are located one behind the other at a mutual distance which is smaller than the axial dimension of the seating and are each incorporated in a groove in the wall of the second piston-like member and which seals separate the fourth space from a fifth space which is in open communication with the vapour outlet, the slit-like annular duct present between the said seals and constituted by the relevant wall parts of the second piston-like member and the seating being in open communication with the vapour space of the storage container and the seals, upon a reciprocating movement of the second piston-like member, being capable of alternately communicating the annular duct with either the fourth or the fifth space.

3. A control device for maintaining the level of a liquid between high and low levels in a first container, this

device operable with a storage container having therein liquid with a vapor space above said liquid, and an auxiliary container having therein gas at a pressure greater than atmospheric pressure, the device comprising first and second valve means, the second valve means having a vapor outlet to the atmosphere and having an open condition for interconnecting said auxiliary container with said vapor space in the storage container for flow of gas thereto, and a closed condition for interconnecting said vapor space with said vapor outlet, the first valve means having on and off conditions for actuating said second valve means to be correspondingly in its open and closed positions, sensing means for determining when the liquid in the first container is above and below both of said high and low levels, said sensing means comprising high and low vapor-pressure bulbs at said levels, each bulb having therein high pressure vapor when the liquid in said first container is below said bulb, and having low pressure therein when the liquid is above and contacting the bulb and vapor in said bulb condenses, the high and low pressures of said bulbs being communicated to said first valve means, wherein, when the liquid level is above both bulbs, their pressures are low and said first valve is actuated to its off condition and said second valve is thereby actuated to its closed condition whereby the storage container communicates to the vapor outlet and flow from the auxiliary container to the first container is precluded, and wherein, when liquid is below both bulbs and their vapor pressures are high, said first valve is actuated to its on condition, and the second valve is thereby actuated to its open condition permitting gas flow and pressure build-up from said auxiliary container to said storage container vapor space and liquid flow from said storage container to said first container.

4. Apparatus according to claim **3** wherein said first valve means comprises a housing with inlet and outlet openings and valve seat intermediate said openings, and a piston movable to closed position against said seat and open position away from said seat, a resiliant means urging said piston toward open position, said low vapor pressure bulb in communication with one side of said piston and said high-vapor pressure bulb in communication with the other side of said piston, whereby high and low pressures from said bulbs urge said piston to move correspondingly for actuating said second valve means.

5. Appparatus according to claim **3** wherein the high vapor pressure of said low level vapor pressure bulb is higher than the high vapor pressure of said high level bulb.

6. Apparatus according to claim **5** wherein the liquid in said storage and first containers is liquified gas.

7. Apparatus according to claim **4** wherein said first valve when in on condition communicates said low level bulb pressure to said second valve means.

* * * * *

PO-1050
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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,845,636 Dated November 5, 1974

Inventor(s) HARMANNUS HINDERIKUS VAN MAL ET AL

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 2, line 18, after "constitute" should be --;--

line 56, "," should be --;--

line 60, "sai" should be --said--

Col. 3, line 42 "piston" should be --pistons--

Col. 5, line 51, "like member" should be cancelled

Col. 6, line 33, cancel "like"

line 34, cancel "member"

Signed and sealed this 27th day of May 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks