PATENT SPECIFICATION

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(21) Application No. 52844/77 (22) Filed 19 Dec. 1977
(31) Convention Application No. 7 638 827
(32) Filed 23 Dec. 1976 in
(33) France (FR)
(44) Complete Specification published 29 April 1981
(51) INT CL³ F17C 9/02
(52) Index at acceptance F4P 856 ED

(19)

(54) IMPROVEMENTS IN OR RELATING TO METHODS OF AND APPARATUS FOR DISTRIBUTING GASES UNDER PRESSURE

(71) We, L'AIR LIQUIDE, SOCIETE ANONYME POUR L'ETUDE ET L'EXPLOITATION DES PROCEDES GEORGES CLAUDE, a French Body Corporate, of 75, Quai d'Orsay, 75007 Paris, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention concerns methods and apparatus for distributing gases, and particularly though not exclusively, industrial gases under pressure.

In the majority of applications for industrial gases, it is necessary to have the gas available at a relatively high pressure, generally of the order of 8 to 14 bars, in a distribution circuit. With many gases, when the throughputs involved are considerable it is usual to have a store of gas in the liquified state at low temperature and to evaporate it as demand requires. At the present time, this evaporation takes place at the high distribution pressure by heating either with purely atmospheric heaters or with auxiliary energy supply means. Whatever the methods of heating, in such a case the whole of the distributing circuit and the storage tank are thus at all times maintained at the high distribution pressure, which makes it necessary for the storage tank to be designed for this high pressure. Designing the tank in this way proves particularly costly in the case of cryogenic tanks which are formed by two shells which leave between them an insulating space under high vacuum with a filling of an insulating material such as "perlite". The result is that the inner shell has to be made of a pressure-resistant material. Installations of this kind are generally replenished at regular intervals by specialised vehicles fitted with transfer means such as pumps which allow the cryogenic liquid to be transferred from the low pressure tank carried by the vehicle to the high pressure distribution storage tank. This calls for a large outlay on means for pressurising the liquid together with a by no means neglible expediture of energy for the transfer.

There has already been proposed a method of distributing gases at high pressure in which there is a stored volume of a gas available in the liquid state at low pressure, a portion of the said stored volume being extracted when the distribution pressure falls below a threshold value and being transferred to a confined enclosure at the said low pressure in which all communication between the said confined enclosure and the said stored volume is cut off and in which the distribution circuit at high pressure is placed in communication with the said enclosure. In this proposal, the confined enclosure is thermally insulated from the exterior and the communication with the distribution circuit is made by simultaneously balancing the pressure both in the gaseous phase and in the liquid phase in the confined enclosure, and the cryogenic liquid drains by gravity to a heating evaporator. Such an arrangement, although it enables the abovementioned drawbacks to be overcome by allowing the storage tank to be designed for a low storage pressure, is relatively complex since it means not only that the confined enclosure has to be situated below the storage tank but also that the heating evaporator too has to be below the confined enclosure, which is a serious disadvantage from the point of view of bulk. Furthermore this arrangement, in addition to making it necessary for the confined enclosure to be thermally insulated, also requires a double connection to the heating evaporator through piping and valves. In addition, the draining of the liquid from the confined enclosure to the heating evaporator simply by gravity is a relatively time-consuming process.

It is an object of the invention to provide a method for distributing gases under pressure which is quickly put into effect, and also apparatus for carrying out this method which is small in bulk and of simple and inexpensive design.

From a first aspect the invention consists in a method of distributing a gas by means of a high pressure distribution circuit comprising storing a volume of the gas in a liquified state, extracting a portion of the stored volume when the distribution pressure in the distribution circuit falls below a threshold value and transferring said portion to part of a confined enclosure in which the transferred portion is thermally insulated, the enclosure also having a thermally conductive wall, preventing any further communication between the enclosure and the stored volume, placing the high pressure distribution circuit in communication with said enclosure so that the pressurised gas in the distribution circuit contacts the liquid gas stored in said enclosure whereby at least a part of the liquid in the enclosure is placed in a heat exchanging relationship with the conductive wall of said enclosure, thus causing partial evaporation which transfers liquid gas under pressure from the enclosure to the distribution circuit.

From a second aspect the invention consists in apparatus for distributing gases comprising a distribution circuit for distributing gas under pressure, a storage tank for storing liquified gas at a pressure lower than the pressure of said distribution circuit, an enclosure having a thermally conductive wall and housing a receptacle which is thermally insulated, said enclosure being capable of withstanding the maximum gas pressure which can prevail in said distribution circuit, duct means respectively interconnecting said storage tank and said receptacle, and said receptacle and distribution circuit, valve means for opening and closing said duct means so as to place said receptacle either in communication with said storage tank or in communication with said distribution circuit, and means operative to control said valve means so as to place said storage tank in communication with said receptacle when the pressure in said distribution circuit falls below a predetermined threshold value, and when the level of liquid gas in said receptacle rises above a selected value to block communication between said storage tank and said container and to place said receptacle in communication with said gas distribution circuit.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings, which show certain embodiments thereof by way of example and in which:—

Fig. 1 is a schematic view of an embodiment of a cryogenic installation according to the invention for distributing gases under pressure,

Fig. 2 is a graph showing the changes in the pressure in the distribution circuit as a function of time, and

Fig. 3 is a partial view of a modified embodiment.

Referring now to the drawings, and particularly to Fig. 1, an installation according to the invention contains a low pressure storage tank 1 which is formed by two shells 2 and 3 which leave between them a thermal insulating space 4 which is filled with insulating particles 5 such as particles of perlite 4. This tank is fitted with filling means (not shown). As was explained above, the storage tank 1 is maintained at a low gas pressure of the order of 1 to 3 bars. This storage tank 1 is connected by a duct 6 having a valve 7 to a confined enclosure 8 of small capacity which is designed to withstand the high distribution pressure and which to this end is formed by an outer shell 9 of thick material. Within the container 8 is positioned a receptacle 10 which is aranged vertically below the outlet of the duct 6 and which is made of a thin material. This inner receptacle 10 is connected by a pipe 11 to a high pressure distribution circuit 12 via a valve 13. This distribution circuit 12 incorporates an atmospheric heater 14, a buffer container 15, a pressure regulator and reducer 16 and a distribution duct 17, the whole being designed to withstand the high distribution pressure. A regulating arrangement which is indicated diagrammatically at 20 allows the valves 7 and 13 to be opened and closed respectively, or vice versa. The arrangement 20 is controlled on the one hand by a pressure sensor 24 which measures the pressure in the distribution circuit at 25 between the buffer container 15 and the regulator and reducer 16, and on the other hand by a level monitoring device 27 which is positioned in the receptacle 10 inside the confined enclosure 8.

The installation operates as follows, reference now being made to Fig. 2 also. The initial situation as regards pressure is characterised by the fact that the distribution network has not been used for a time, so that the pressure in the distribution circuit at the measuring point 25 is for example a maximum P_{max}. If gas is now extracted from the distribution duct 17, this gas will be supplied mainly by the buffer container 15 and the pressure measured at 25 by the pressure sensor 24 will drop gradually from P_{max} to a pressure P_c or threshold pressure of 9 bars for example, whereas the pressure P_r supplied by the reducer 16 to the distribution duct 17 is regulated to 8 bars. As soon as the pressure P reaches the pressure P_c, the regulating arrangement 20 causes the valve 7 to open and the valve 13 to close, whereas previously they were closed and open respectively. Because of this, a portion of liquified gas is transferred from the storage tank 1 to the inner receptacle 10, which is initially empty of any liquid, in the confined enclosure 8. The space in the confined enclosure 8 is brought to ambient pressure by means of a valve 30 which is controlled by the regulating arrangement 20 to take up an open or closed position identical to that of valve 7. By means of this valve 30, the pressure in the confined enclosure 8 is maintained at atmospheric pressure and the cryogenic liquid is able to fill the inner receptacle 10. The cryogenic liquid which gradually builds up in the inner receptacle 10 is maintained substantially in the liquid state, by virtue of the thermal insulating effect produced by the gap 40 formed between the inner receptacle 10 and the wall of the confined enclosure 8. Although this wall of the confined enclosure 8 is in constant heat exchange with the outside atmosphere, there is only a small amount of evaporation, which is led off to the exterior through valve 30, and if required is collected by means which will not be described. As soon as the level of the cryogenic liquid has reached a maximum N, as shown in Fig. 1, the level device 27 causes the regulating arrangement 20 to change over the valves in sequence: valve 7 is first closed and then valve 13 is opened. The effect of valve 13 opening is to cause a sudden influx of gas from the distribution circuit 14, 15 to the confined enclosure 8. The effect of this is first of all to cause at least a portion of the incoming gas to be condensed by the liquid. Furthermore the incoming gas causes the enclosure 8 to contain liquid at a higher pressure than before the admission of the gas from the distribution circuit. Furthermore a portion of this liquid spills out of receptacle 10 so that some of the liquid comes into contact wtih the uninsulated outer shell 9 and evaporates. This causes the liquid in receptacle 10 to be transferred to the heater 14 via pipe 11, where it evaporates completely and heats up before arriving at the buffer container 15.

In the course of the first phase of operation, which is concerned with the filling of the receptacle 10 with a portion of the cryogenic liquid, i.e. in the course of the interval $t1$-$t2$ shown in Fig. 2, the pressure P in the distribution circuit, i.e. the pressure measured at point 25, continues to drop until it reaches a minimum pressure P_{min} at time $t2$. At time $t2$, as described above, valve 7 closes and valve 13 opens, which causes a portion of cryogenic liquid to be evaporated and the pressure P to rise from the pressure P_{min} to the pressure P_{max} if nothing is extracted from the distribution duct, or to intermediate pressures which are shown at P1 and P2 if greater or lesser amounts are extracted from duct 17. It should be noted that the whole arrangement is so designed that the pressure P_{min} is always higher that the pressure P_r in the network. It will be appreciated that, as soon as the pressure P decreases again in such as way as to reach pressure P_c, the same process is repeated. For example, if the pressure P2 reaches pressure P_c at time $t3$, during an interval $t3$-$t4$ the same process as is described above during the interval $t1$-$t2$ is repeated.

In the modification shown in Fig. 3, the duct 6 which connects the storage tank 1 to the confined enclosure is now surrounded by another duct 6′ which is co-axial with duct 6 and which opens into the vapour phase in the tank 1. A double valve 7′ is now responsible either for allowing the liquid and vapour phases in the tank 1 to communicate simultaneously with the enclosure or to be isolated therefrom simultaneously. The air duct 30 shown in Fig. 1 is unnecessary and is therefore not provided.

The present invention is applicable to the distribution of cryogenic gases under pressure such as oxygen, nitrogen, and argon.

WHAT WE CLAIM IS:—

1. A method of distributing a gas by means of a high pressure distribution circuit comprising storing a volume of the gas in a liquified state, extracting a portion of the stored volume when the distribution pressure in the distribution circuit falls below a threshold value and transferring said portion to part of a confined enclosure in which the transferred portion is thermally insulated, the enclosure also having a thermally conductive wall, preventing any further communication between the enclosure and the stored volume, placing the high pressure distribution circuit in communicaton with said enclosure so that the pressurised gas in the distribution circuit contacts the liquid gas stored in said enclosure whereby at least a part of the liquid in the enclosure is placed in a heat exchanging relationship with the conductive wall of said enclosure, thus causing partial evaporation which transfers liquid gas under pressure from the enclosure to the distribution circuit.

2. A method as claimed in claim 1, wherein the liquid gas from the stored volume is introduced via valve means into the upper end of a thermally insulated receptacle located within said enclosure and the pressurised gas from the distribution circuit is introduced into the lower end of said receptacle also via valve means.

3. Apparatus for distributing gases comprising a distribution circuit for distributing gas under pressure, a storage tank for storing liquified gas at a pressure lower than the pressure of said distribution circuit, an enclosure having a thermally conductive wall and housing a receptacle which is thermally insulated, said enclosure being capable of withstanding the maximum gas pressure which can prevail in said distribution circuit, duct means respectively interconnecting said storage tank and said receptacle, and said receptacle and distribution circuit, valve means for opening and closing said duct means so as to place said receptacle either in communication with said storage tank or in communication with said distribution circuit, and means operative to control said valve

means so as to place said storage tank in communication with said receptacle when the pressure in said distribution circuit falls below a predetermined threshold value, and when the level of liquid gas in said receptacle rises above a selected value to block communication between said storage tank and said container and to place said receptacle in communication with said gas distribution circuit.

4. Apparatus as claimed in claim 3, wherein the duct means from said storage tank open into said receptacle at an upper part therof.

5. Apparatus as claimed in claim 4, wherein said duct means from said distribution circuit open into said receptacle at a lower part thereof.

6. Apparatus as claimed in any one of claims 3 to 6, wherein the enclosure and the storage tank are connected together by two ducts each containing valves, which ducts open into the storage tank at different levels, the enclosure being situated at a lower level than the storage tank and the control means being operative to open and close said valves simultaneously.

7. Apparatus as claimed in claim 6, wherein the two ducts connecting the storage tank to the enclosure are formed by coaxial tubes associated with a double control valve.

8. Apparatus as claimed in any one of claims 3 to 7, wherein said distribution circuit includes a heater and a pressure regulator and reducer, and wherein the valve means controlling the duct means interconnecting the storage tank and the enclosure are controlled by a pressure sensor mounted upstream of said pressure regulator and reducer so that the container is connected to the storage tank and isolated from the distribution circuit under the control of the pressure sensor when the measured pressure in the gas distribution circuit falls below said threshold.

9. A method of distributing gases substantially as hereinbefore described with reference to Figs. 1 and 2 of the accompanying drawings.

10. A method of distributing gases substantially as hereinbefore described with reference to Figs. 2 and 3 of the accompanying drawings.

11. Apparatus for distributing gases under pressure substantially as herinbefore described with reference to Fig. 1 of the accompanying drawings.

12. Apparatus for distributing gases under pressure substantially as hereinbefore described with reference to Fig. 3 of the accompanying drawings.

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16, Kensington Square,
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Chartered Patent Agents.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1981.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1588900 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG.1

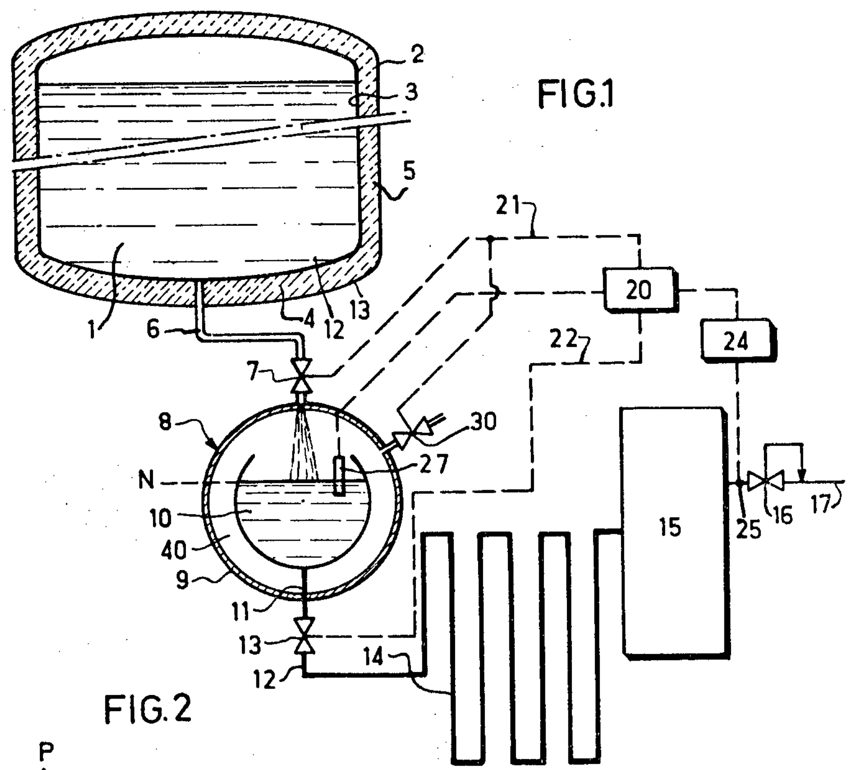
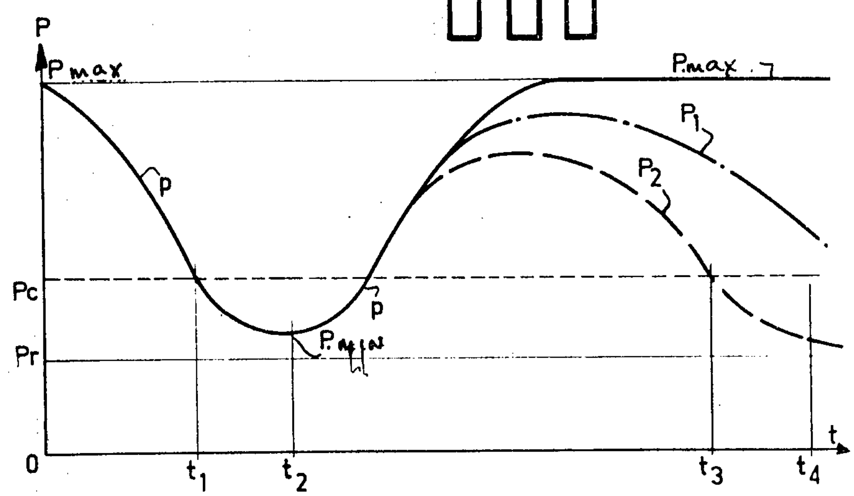


FIG.2



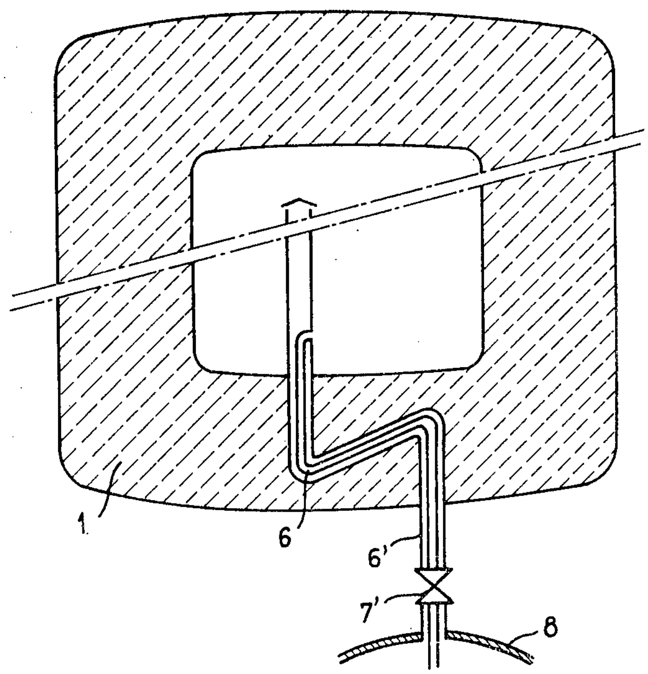


FIG. 3