June 1, 1954 J. KOBOLD 2,679,730

HANDLING OF LIQUEFIED GASES

Filed Aug. 30, 1950

Fig. 1

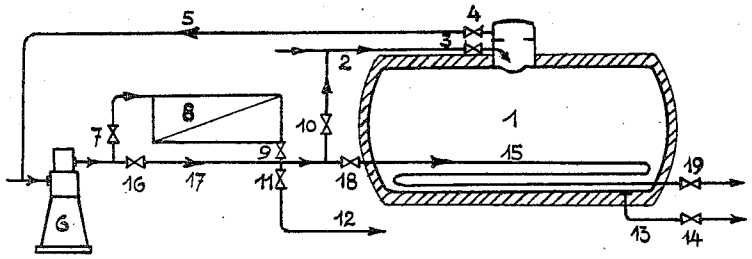
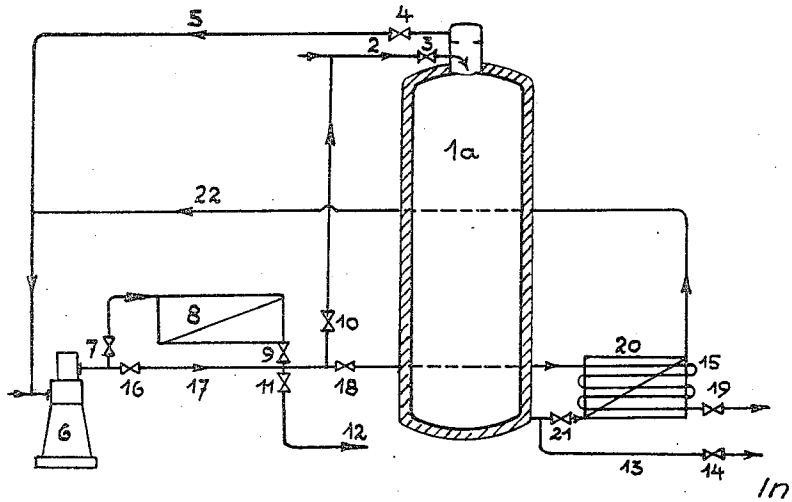


Fig. 2



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Patented June 1, 1954

2,679,730

UNITED STATES PATENT OFFICE

2,679,730

HANDLING OF LIQUEFIED GASES

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Application August 30, 1950, Serial No. 182,331

Claims priority, application Germany September 6, 1949

1 Claim. (Cl. 62—1)

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This invention relates to liquefied gases and more especially to the handling of gases which are cooled to low temperature and stored in liquefied condition.

Liquefied carbon dioxide, cooled to low temperature, has been stored in large, well insulated low-pressure tanks, but difficulties have been encountered when filling the intensely cooled low-pressure liquid from such a tank into portable containers such as for instance steel cylinders. The cylinders must first cool down to the temperature of the stored liquid and during this stage great losses are caused by evaporation. Owing to the rise in pressure the continuous passage of the stored liquid into the cylinder through the narrow valve passages is interrupted or at least greatly hindered.

It has been tried, although without complete success, to overcome these difficulties by the use of one or several intermediate containers with equalization of pressure which, for the purpose of speeding up the bottling, are temporarily placed under higher pressure, but this way of proceeding complicates matters and it has also been found that on conveying the intensely cooled low-pressure liquid through long pipes, pressure drop occurring in narrow passages may lead to a complete clogging-up by freezing, as frequently happens with carbon dioxide.

To prevent this, carbon dioxide in gas form has been evacuated from the top of the low-pressure tank by suction and liquefied anew by the normal high pressure method, to be then filled into the steel cylinders or put directly to some practical use such as the production of Dry Ice.

As a rule, liquefied carbon dioxide is stored under a pressure of 12 to 15 atm., i. e. at a temperature of 36° to 30° C. below zero. When evacuating the carbon dioxide gas from the top of the tank, there arises gradually a pressure drop accompanied by an evaporation of the stored liquid. Since owing to the insulation of the tank no entrance of heat worth speaking of is possible, the heat for evaporation is abstracted from the stored liquid until the pressure and temperature drop to the triple point which for carbon dioxide lies at 5.26 atm. and 56° C. below zero. The carbon dioxide then starts freezing and snow forms in the low pressure tank. This point, which forms the lowest limit of this evacuating procedure, is reached under the conditions aforementioned, after about 15–20% of the actual content of liquid carbon dioxide have been evacuated in gas form. Then one must

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wait until after some days through the gradual entrance of heat the pressure in the low-pressure tank has risen correspondingly. Thus only a fraction of the gas contained in the tank is effectively available under this procedure.

It is an object of this invention to improve the process hereabove described.

It is another object of the invention to provide improved means for the carrying out of the process modified in accordance with this invention which does away with the overcooling of the liquid carbon dioxide and the ensuing pressure drop in the storage tank by replacing the required evaporation heat by the heat of compression and condensation of the highly compressed evaporating gas evacuated by suction. This manner of proceeding retains all the advantages of the low-pressure storage, while the difficulties mentioned above which are connected with the filling of the overcooled liquid carbon dioxide or other gas under low pressure are avoided. Obviously this constitutes an important improvement of the low-pressure storage and filling into cylinders of liquefied gases. In addition to this, the liquefied gas also reaches the cylinders in absolute purity, for all impurities remain in the low-pressure storage tank.

In the drawings affixed to this specification and forming part thereof two embodiments of an installation adapted for carrying out the new process according to this invention are illustrated diagrammatically by way of example.

In the drawings:

Fig. 1 illustrates the provision of a low-pressure storage tank with a cooler or condenser arranged inside the tank, while,

In Fig. 2 the cooler or condenser which at the same time serves as an evaporator for the tank liquid, is arranged outside of the tank.

Referring to the drawings and first to Fig. 1, the fluid carbonic acid or other liquefied gas under high pressure, in order to be stored in the tank 1, is passed from the compressor or a high pressure reservoir (not shown) through a supply pipe 2 and control valve 3 to be expanded to the storage pressure of about 12 to 15 atm. In this operation part of the carbonic acid liquid evaporates and passes as a gas under the same pressure through the shut-off valve 4 and return pipe 5 to the compressor 6 to be there compressed again to the normal liquefaction pressure of 65–75 atm., according to the temperature of the cooling water. This highly compressed carbonic acid is then passed through valve 7 into the condenser 8 cooled with normal cooling water and is lique-

fied again therein, to be then re-introduced by way of the valves 9 and 10 into the supply piping 2 and to be passed together with fresh liquid carbonic acid, through the regulating valve 3, to expand in the tank 1 to storage pressure.

This is the known way in which the storage tank is charged. Alternately the returning gas after having been liquefied again, may be fed through valve 11 and pipe 12, to the normal filling station or to the place where they are intended to be put to use, so that only part of the fresh liquid carbonic acid is stored under low pressure.

The low-cooled liquid carbonic acid stored in the low-pressure tank 1, can now be tapped in the known manner directly by conducting it through the pipe 13 and valve 14 to the place of use, this operation being accompanied by the difficulties mentioned above, caused by high losses by evaporation and by a clogging of the pipes and valves, or indirectly by evacuating the carbon dioxide in gas form by suction from the top of the storage tank 1 through valve 4 and pipe 5, the gas to be then compressed further to a high pressure in the compressor 6 and to pass through valve 7 to the condenser 8. In the condenser the highly compressed gas is liquefied again with the aid of cooling water and the liquid carbonic acid is conducted under high pressure through valves 9 and 11 and pipe 12 to the place of consumption. As mentioned above, this known process involves the drawback that of the carbonic acid stored in the low pressure tank only a fraction can be tapped each time, since it will soon be stopped by becoming frozen.

According to the invention, now, the difficulties arising during the known tapping proceedings are avoided by installing, according to Fig. 1, in the low-pressure storing tank 1 a pipe coil or pipe system 15 in such manner that it is surrounded by the low-cooled liquid in the tank. The exhausting and cylinder-filling is then carried through in the following manner: the compressor 6 evacuates through the pipe 5 and valve 4 from the top of the storage tank the quantity of carbonic acid gas corresponding to its handling capacity, compressing it again to the normal high liquefaction pressure and forcing the gas under high pressure into the pipe system 15, the gas being cooled by the low-temperature liquid in the tank and liquefied. During liquefaction a corresponding part of the tank liquid evaporates without the tank liquid being overcooled or the storage pressure dropping further. The evaporating quantity of low-cooled tank liquid and the quantity of high-pressure carbonic acid condensed in the pipe system 15 approximately balance each other, since the heat of compression and the heat of condensation to be abstracted per unit are about equal to the heat of evaporation required per unit. The comparatively small differences which may still exist, can be so regulated by partial pre-cooling in the condenser 8 or a corresponding subdivision

of the cooling surface of the system of pipes 15, that regardless of a continuous abstraction of gas from the storage tank the pressure and temperature in the tank is maintained up to complete exhaustion, and clogging by freezing of the liquid from the tank is avoided. On the other hand it is now possible to more or less overcool the carbon dioxide re-liquefied in the pipe system 15 and to conduct it at the high pressure in the compressor through the valve 19 to the steel cylinders or to the Dry-Ice station or to any other place of consumption.

It is equally possible to introduce the fresh, highly compressed liquid carbonic acid supplied through pipe 2 from the carbon dioxide producing station directly through the valves 10 and 18 into the pipe system, to there overcool it and to pass it through valve 19 to a place of consumption, while the evaporation gas from the low pressure tank is liquefied again in the manner above described by means of the compressor 6 and condenser 8.

The mode of operating the filling of the liquid in the tank into bottles, as illustrated in Fig. 2, differs from the one described with reference to Fig. 1 only by the fact that a vertical tank 1*a* is provided and the cooling and condensing pipe system 15 is not arranged inside, but outside of the low-pressure storage tank, the evaporation of the tank liquid occurring in a separate evaporator 20, which the tank liquid enters by way of the valve 21 while the evaporation gas escapes through the pipe 22 and is conducted toward the compressor 6 for another compression and re-liquefaction.

Various changes may be made in the details of operation above described without departing from the invention or sacrificing the advantages thereof.

I claim:

Apparatus for transferring low-cooled liquefied gases from low-pressure storage containers to a point of consumption, comprising in combination, a storage container containing liquefied gas under low pressure, a compressor, a suction pipe leading from the part of said container above the liquid therein to said compressor, a cooling and condensing pipe system communicating with the liquid space of said container, a pressure pipe conducting the gas compressed in said compressor into said pipe system and a pipe leading from said pipe system to a point of consumption.

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