P. HEYLANDT.

PROCESS FOR FILLING HIGH PRESSURE VESSELS WITH LIQUEFIABLE GASES.

APPLICATION FILED JAN. 3, 1921.

1,414,359. Patented May 2, 1922.

Fig. 1.

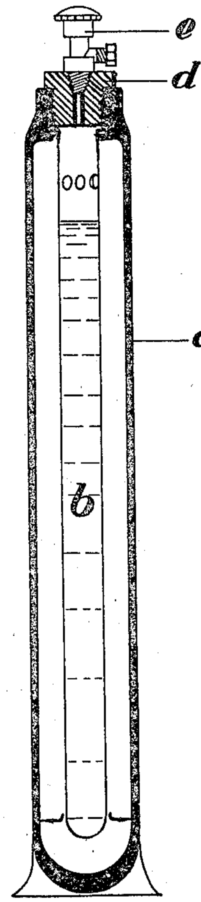



Fig. 2.

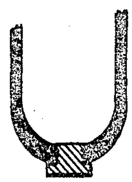
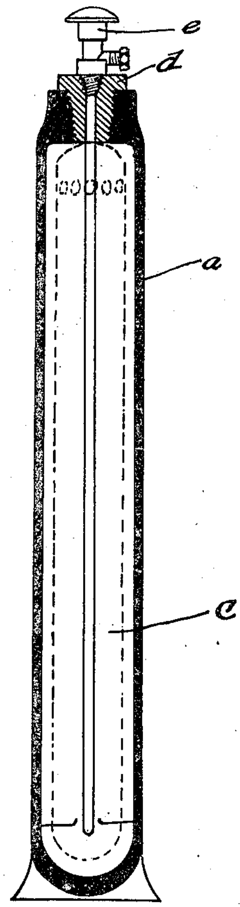


Fig. 3.




INVENTOR

Paul Heylandt

By Wm Wallace White

ATTY.

# UNITED STATES PATENT OFFICE.

PAUL HEYLANDT, OF SÜDENDE, NEAR BERLIN, GERMANY.

## PROCESS FOR FILLING HIGH-PRESSURE VESSELS WITH LIQUEFIABLE GASES.

1,414,359. Specification of Letters Patent. Patented May 2, 1922.

Application filed January 3, 1921. Serial No. 434,825.

*To all whom it may concern:*

Be it known that I, PAUL HEYLANDT, a citizen of the German Republic, residing at Südende, near Berlin, Germany, have invented certain new and useful Improvements in Processes for Filling High-Pressure Vessels with Liquefiable Gases, (for which I have filed an application in Germany under date of May 8, 1919, No. H 48,252,) of which the following is a specification.

The present invention relates to a process for filling vessels capable of resisting high pressures with oxygen, nitrogen, hydrogen, air or other liquefiable gases by introducing the gas, such as oxygen, in a liquid state into steel cylinders and by then allowing the oxygen which evaporates from the liquid to gradually and automatically raise the pressure in the closed vessel until the desired pressure of say 150 atmospheres is reached.

A previously proposed method for filling the high pressure vessels now in vogue consists in first conducting the liquefied gas, such as oxygen, into a special measuring vessel separate from the steel cylinder and in then transferring it by pressure into the high pressure vessel (steel cylinder), the idea being that the liquid oxygen shall first flow of its own weight through the very narrow passage of the valve of the vessel and shall subsequently be forced in by the pressure of the gas evaporating in the measuring vessel.

But practical trials have demonstrated the impracticability of this process, for on touching the substantial body of the valve, which is of metal and is a good conductor of heat, the liquefied gas immediately evaporates in the passage of the valve and the small quantities that percolate in a liquid state into the high pressure vessel also evaporate immediately they reach the bottom of the vessel so that the increased pressure of the evaporated gas opposes the further influx of liquefied gas and urges it back into the measuring vessel. Hence the liquefied gas does not evaporate in the high pressure vessel but in the measuring vessel, and that at a very rapid rate, and in the entire apparatus consisting of high pressure vessel, valve, pipes, and the measuring vessel, a uniform pressure is produced which steadily rises up to a pressure of 150 atmospheres.

Therefore the measuring vessel must also be capable of resisting a pressure of at least 150 atmospheres and at each charge the quantity of oxygen gas that remains in the measuring vessel—and which, at a pressure of 150 atmospheres and with a measuring vessel whose contents are about 10 litres, amounts to 1 to 5 cubic metres—is lost.

To render this process practicable it was proposed that the high pressure vessel should be put into a bath of liquid air so as to cause the liquid oxygen to evaporate only very slowly in flowing into the vessel. But in the first place this requires large quantities of liquid air, 20 to 25 litres being lost for every steel cylinder charged. Besides, a process like this is extremely dangerous, because the steel of which the high pressure vessels are made, when cooled down to —190° Celsius loses all ductility and becomes as brittle as glass, so that a knock of moderate severity, which will frequently occur in practical working, will suffice to smash it. To secure safety in working with high pressure vessels a certain lowest limit of ductility must be maintained and therefore if the above-described process were adopted serious explosions would be inevitable.

In the novel method proposed by me all these sources of trouble and danger are avoided. This method will be explained with reference to the drawing Fig. 1 of which represents a vertical section of a steel cylinder with an internal, thin-walled auxiliary vessel. Fig. 2 is a fragmentary section of the lower end of the shell illustrating a modification; and Fig. 3 is a view similar to Fig. 1, but showing the inner vessel formed from a tube of expansible material inserted through the stopper, the dotted lines indicating the diameter of the tube after expansion.

The principal feature of the invention consists in filling a vessel *b* in the interior of the steel cylinder or bottle *a* with liquefied gas, as oxygen. The wall of the internal vessel, which is closed at the bottom, must be made thin so that it can be cooled quickly. It must not touch the lateral wall or bottom of the steel shell or cylinder so that it may be insulated by a layer of quiescent gas from the shell's warm wall. Only a few small struts are provided for centering the inner vessel. At the upper end, immediately under the valve head, a row of holes is made so as to obtain a balancing of the pressure in the spaces inside the inner vessel and around it.

A thin-walled vessel of this kind can be filled with liquefied gases without difficulty because, on account of its small mass, it consumes only a very small quantity of the liquid in being cooled down to the low temperature of liquefied gas. The liquefied gas in this vessel evaporates only slowly because it is insulated, by the air (between *a* and *b*) that surrounds it, from the heat of the atmosphere, and it receives the heat required for evaporating it only from the head of the cylinder and through the thin wall. The influx of further liquid gas will be prevented only when the inner vessel is filled up to the holes, so that liquid flows down onto the bottom of the steel shell. This part of the liquid will then be evaporated and so much vapour will form that a further influx of liquid through the valve will be prevented. This will also indicate the completion of the charge.

The capacity of the thin-walled vessel from its bottom to its holes must be correctly adapted to the size of the steel cylinder in order that the quantity of the liquid poured in may correspond to the contents of the entire steel cylinder when said contents are subsequently converted into a gaseous state and compressed.

The charging of the thin-walled vessel is carried out in the usual way by means of a siphon or a funnel. The inlet for filling the vessel is opened by unscrewing the small valve head, or the filling is done through a special valve with a bore of a corresponding width.

The internal vessel may be inserted into the cylinder in various ways: the large conical stopper (*d*) may be screwed out of the cylinder and then screwed in again after the vessel has been attached to it, or a conical screw stopper may be arranged in the thickened bottom of the steel cylinder, this stopper being taken out and screwed in again after the inner vessel has been inserted through the bottom. As in either of these two cases the manipulation of screwing the stopper out and in needs only to be carried out once, the stopper can be screwed in again perfectly tight and soldered in place. Finally, the upper conical screw stopper may be left in its place in the neck of the cylinder and a pipe of soft expansible metal may be inserted through the hole provided for the cylinder valve, which pipe is then widened by inflating it by air or hydraulic pressure to such an extent that a long vessel (*c*) of the desired capacity is obtained. The inner vessel can be made of such size that its liquid contents will suffice to fill several steel cylinders with compressed gas in one operation, but it must not be so large that it touches the inner wall of the steel shell. When the valve of the steel cylinder is closed, the evaporation of its liquid contents (oxygen etc.) proceeds slowly without any sudden changes of pressure and without any considerable cooling of the steel cylinder. During the charging process and during the subsequent evaporation of the liquefied gas, the steel cylinder is preferably put into a water bath so that the walls of the cylinder may cool down as little as possible. Excessive cooling of the cylinder must be avoided under all circumstances so as not to go below the lower limit of ductility of the steel.

Another considerable advantage of my novel process is that the oxygen, etc., which compresses itself in the steel cylinder is entirely devoid of moisture and oily vapours. It is well known that in charging the cylinders by means of a compressor, the compressed gas, on its way through the compressor, gets mixed with large quantities of moisture and oily vapour, which cannot be completely extracted by the oil separator, whose action is purely mechanical. Hence in the course of several charges dirty water or oil collects in the steel cylinders, the quantity of this water or oil amounting in some cases to several litres. When the liquid oxygen, which, as we know, is perfectly dry, is conducted into a steel cylinder in accordance with my process, the gas also remains perfectly dry in the cylinder and no moist air can enter into it during subsequent charging operations because a small current of evaporating gas issues from the cylinder whilst it is being charged, this current keeping the moist air in the neighbourhood away from the contents of the cylinder.

I claim:

1. The process of filling compressed gas containers, which consists in placing a given quantity of liquefied gas in a vessel of low specific heat capacity suspended within the container, closing the container, and maintaining the walls of the container at a temperature above 0° C. until the enclosed substance has been converted into gaseous form.

2. The process of filling compressed gas containers, which consists in placing a given quantity of liquefied gas in a vessel of low specific heat capacity suspended within the container and spaced therefrom, closing the container, and maintaining the walls of the container at a temperature above 0° C. until the enclosed substance has been converted into gaseous form.

3. The process of filling compressed gas containers, which consists in placing a given quantity of liquefied gas in a vessel of low specific heat capacity suspended within the container, closing the container, and subjecting the container to the action of a water bath thereby to maintain the walls of the container at a sufficient temperature to convert the enclosed substance into gaseous form.

4. The process of filling compressed gas containers, which consists in placing a given

quantity of liquefied gas in a vessel of low specific heat capacity suspended within the container and spaced therefrom, closing the container, and subjecting the container to the action of a water bath thereby to maintain the walls of the container at a temperature above 0° C. until the enclosed substance has been converted into gaseous form.

5. A container for compressed gases, comprising a necked shell capable of resisting high pressure, a stopper in the neck of the said shell, and an inner thin-walled vessel within said shell, the inner vessel being spaced from the walls and bottom of the said shell.

6. A container for compressed gases, comprising a necked shell capable of resisting high pressure, a conical stopper in the neck of the said shell, and an inner thin-walled vessel provided with perforations adjacent to its upper end, said vessel being inserted into the shell spaced from the walls and bottom of the said shell.

7. A container for compressed gases, comprising, a shell capable of resisting high pressure and provided with conical openings at its opposite ends, a removable stopper in each of said openings, and an inner thin-walled vessel inserted in the shell through one of said openings, said vessel being spaced from the wall and bottom of the shell.

8. A container for compressed gases, comprising a necked shell capable of resisting high pressure, a conical stopper in the neck of the said shell, and an inner tube of soft expansible metal capable of inflation after insertion of the vessel into the shell to a predetermined diameter.

In testimony whereof I have signed this specification in the presence of two witnesses.

PAUL HEYLANDT.

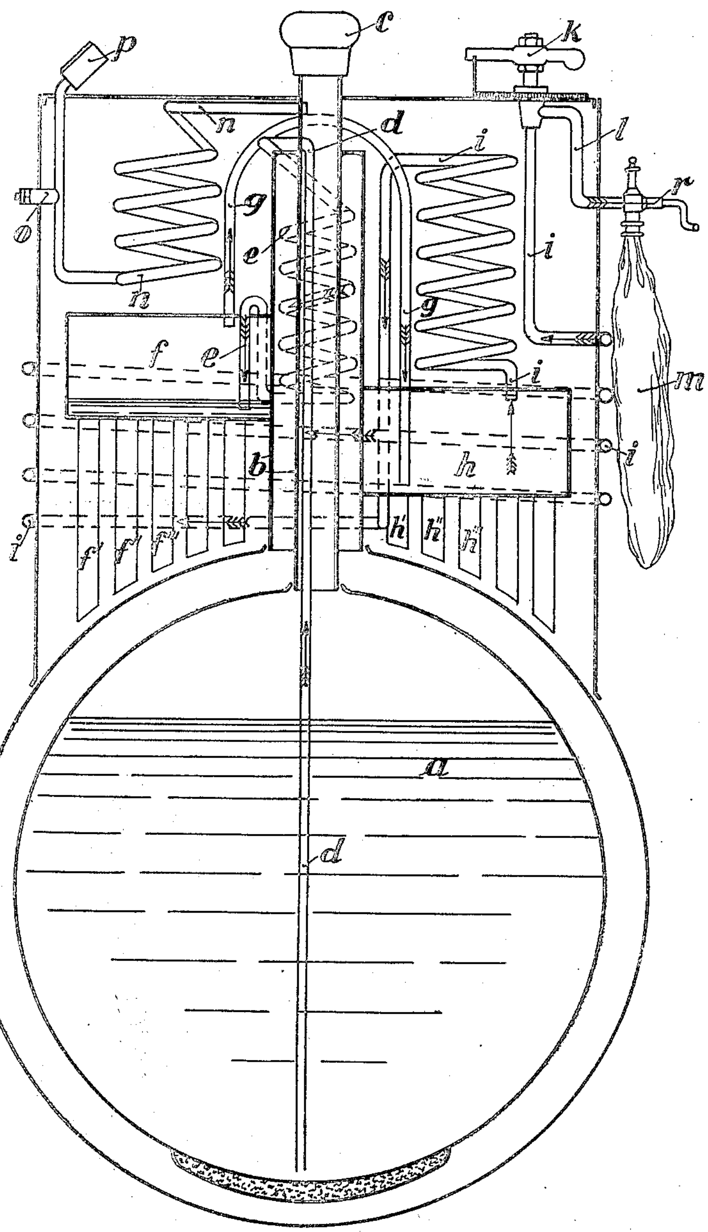
Witnesses:
KÄTHE SEECK,
MAX JABLOUSKI.

Aug. 7, 1923. | 1,464,319

P. HEYLANDT

DEVICE FOR SUPPLYING OXYGEN

Filed Jan. 3, 1921




INVENTOR:

Paul Heylandt

By Wm Wallace White

ATT'Y.

Patented Aug. 7, 1923. 1,464,319

# UNITED STATES PATENT OFFICE.

PAUL HEYLANDT, OF SUDENDE, NEAR BERLIN, GERMANY.

## DEVICE FOR SUPPLYING OXYGEN.

Application filed January 3, 1921. Serial No. 434,824.

(GRANTED UNDER THE PROVISIONS OF THE ACT OF MARCH 3, 1921, 41 STAT. L., 1313.)

*To all whom it may concern:*

Be it known that I, PAUL HEYLANDT, a citizen of the German Republic, residing at Sudende, near Berlin, Germany, have invented certain new and useful Improvements in Devices for Supplying Oxygen, for which applications for patent have been filed in Germany, December 1, 1916, and November 2, 1917; Sweden, on June 26, 1919; Norway, on June 28, 1919; and Great Britain, on July 12, 1920, and of which the following is a specification.

It is well known that when an aircraft rises higher than 4000 metres the physical efficiency of the crew is greatly diminished by the want of oxygen. Similarly the power of the motor is also reduced by the scarceness of oxygen in the rarefied air, the mechanical output being diminished according to the altitude, and sinking to as much as one half of the power obtained on the ground. The fact that the deficiency of oxygen affects both the crew and the motors is in itself a suggestion that means should be provided for enabling aircraft to take along with them a sufficient quantity of oxygen for both purposes.

An outfit for enabling the aircraft to take along oxygen gas that is compressed in steel receptacles to a pressure of 150 atmospheres is quite out of the question, because a steel bottle whose own weight is 75 to 80 kgs. only contains 6 cubic metres or 8.4 kgs. of oxygen. Therefore, if the quantity of oxygen gas required on the air craft were 25 to 100 cubic metres the dead weight of the bottles amounting to 300 to 1200 kgs. would have to be taken along and this would be impossible not only for an aeroplane, but also for a large airship.

Hence the oxygen has to be conveyed in a liquid state and the net weight of the vessel used for carrying the liquid oxygen must be very small. But in addition to this, a process for giving off oxygen must be applied which is extremely economical in operation and which only gives out a little oxygen at small heights but which gives out the more oxygen the more the air pressure drops at greater altitudes. This giving out of varying quantities of oxygen must take place automatically without continually readjusting or regulating the apparatus. An excellent solution of this problem is presented by the present invention:

The process employed in accordance with the invention consists in continually keeping the liquid oxygen in the carrying vessel under a certain uniform superpressure and thus giving rise to a difference between the pressure upon the liquid oxygen and the atmospheric pressure. The means used for obtaining this difference of pressures consists in a specially adapted valve, or more specifically, a kind of safety valve. The said difference of pressure grows larger when the aircraft rises to greater altitudes and becomes smaller when it sinks to smaller heights. Hence the difference of pressure changes automatically, and in accordance with the invention, the reduced pressure of the atmosphere in the higher regions and its increased pressure in lower regions is utilized for automatically regulating the amount of oxygen given off.

The liquid oxygen is cut off from the outer air by a throttling valve so as to prevent the acceleration and retardation of the boiling of the oxygen when the aeroplane ascends and decends respectively, because if the surface of liquid oxygen were in direct contact with the atmosphere, or in indirect communication with it through coiled pipes or other interposed apparatus, the decrease of the atmospheric pressure during an ascent would immediately cause a great acceleration of the boiling of the oxygen, and the result would be that in ascending more liquid oxygen would evaporate, i. e. more oxygen gas would be developed, than is required. At the same time the liquid oxygen would cool down to the lower boiling point which corresponds to the lower pressure. Inversely, during a descent, or, in other words, when the atmospheric pressure increases, a retardation in the boiling of the oxygen takes place, which is so considerable that not only does the giving off of oxygen cease, but the air of the atmosphere is even drawn into the apparatus and condensed in the undercooled liquid. This drawback of the boiling of the oxygen being retarded or accelerated is removed by the throttling valve.

In addition to the said valve the receptacle for liquid oxygen is equipped with coiled pipes and other devices in which the liquid oxygen evaporates and is brought up to the temperature of the surrounding air. The throttling valve is preferably placed adjacent to the outlet of the warmed oxygen gas so that the throttled gas occupies the whole length of the passages of the apparatus up to the throttling valve that cuts it off from the atmosphere. In addition to the warming effect of the said passages the oxygen for the motor may be preheated in a coiled pipe wound round the motor exhaust.

It is thus seen that the afore-mentioned process is designed to automatically and completely adapt itself to the shortage of oxygen that varies as the altitudes, so that it is very economical in operation. Hence this process renders it possible to supply just the amount of oxygen in which the air of the atmosphere is deficient.

The quantity of liquid oxygen required for the respiration of the crew of the aircraft per man and hour amounts to as much as $\frac{3}{4}$ of a litre. To increase the power of the aircraft motors by supplying them with oxygen, experiments were carried out after previous calculations. By these experiments it has been found that with the aid of the process according to this invention the mechanical output of the motor can be increased to almost its normal figure, and that the weight of the liquid oxygen required can be carried by the aircraft without any overloading:

A Mercedes motor that develops 160 horse power at ground level only gives 89.5 horse power at an altitude of 6000 metres above the earth's surface on account of the deficiency of oxygen at this height. If 33 per cent of the lacking quantity of oxygen is supplied to the motor in accordance with the process of this invention the output of the motor is increased to 116 horsepower and if 50% of the deficient oxygen is supplied the motor output rises to 130 h. p. Hence by supplying additional oxygen 26 or 40 h. p. is gained, and to accomplish this 24.7 or 33.3 kgs. respectively of oxygen is required per hour. But the total amount consumed during the whole flight is still smaller, because the aircraft is not continually at a height of 6000 metres and an initial period of 20 to 30 minutes for the ascent and about 15 minutes for the gliding period have to be deducted.

If the vessels used for carrying the oxygen are the extremely light and well insulated vessels of the Heylandt type, it is possible to convey 37 kgs. of liquid oxygen in a vessel weighing 12 kgs. This quantity of 37 kgs. of oxygen is sufficient to supply a deficiency of 50% of oxygen for almost 2 hours of working. Hence at the start the aeroplane would have to carry a surplus load of 37 plus 12 kgs.=49 kgs., and as oxygen is consumed during the flight the average surplus load will only amount to

$$\frac{37}{2}+12=30.5 \text{ kgs.}$$

The increase of output of the motor at an altitude of 6000 metres, and when 50% of the deficient oxygen is replenished, then amounts to 130−89.5=40.5 h. p. The extra power required for the carriage of the extra average weight of 30.5 kgs. is

$$\frac{30.5}{5}=6.1 \text{ h.p.}$$

so that the actual increase of output is 34.4 h. p. This increase of output may be utilized for putting the aeroplane up to a greater height or for increasing its speed.

The process according to the invention may be used in all cases where it is necessary for the amount of the oxygen gas produced to be varied automatically as the working pressure changes. Hence this process is not only adapted for use in aircraft, but also for fire brigades and hospitals.

For the practical application of the invention light vessels are required which are capable of holding comparatively large quantities of liquid oxygen. In the present state of the art, the most suitable vessels for this purpose are the well known double-walled, evacuated, metal vessels of the Heylandt type whose vacuum is maintained by an air-absorbing substance, and which are described in the United States Patent No. 1,033,398. For the purposes of this invention these vessels are provided with a siphon pipe that extends almost to the bottom of the vessel. When the vessel has been filled with liquid oxygen it is closed, and the oxygen gas that then gradually evaporates and exerts a pressure on the enclosed liquid oxygen presses this latter up and out of the siphon pipe. This ejected liquid oxygen is then evaporated by the warmth of the surrounding atmosphere and either inhaled in a gaseous state or conducted into a motor. The novel feature of the present invention is the following: The liquid oxygen pressed out of the vessel is first vaporized in a system of small evaporating vessels and coiled tubes, and warmed up to the temperature of the surrounding air. During this action a constant superpressure is maintained both in the vessel and in the coiled pipes and evaporating vessels, because the safety valve of the vessel is regulated for a certain superpressure. This super-pressure urges the oxygen gas through a throttling valve arranged at the end of a tortuous exit passage, the throttling valve allowing more gas to pass out as the difference between the super-pressure in the vessel and atmospheric pressure decreases. If, for example, the superpressure in the vessel is 0.2 atmosphere so that the total pressure is 1.2 atmospheres, the throttling valve will keep the said superpressure the same, even when the aeroplane ascends to high altitudes. At an altitude of 7500 to 8000 metres the air pressure is only about 0.3 atmospheres, at 6000 ms. it is about 0.5 and at the level of the ground the external atmospheric pressure is generally 1 atmosphere. Thus the differences between the pressure in the vessel and the external atmospheric pressure in the said three examples is 1.2—0.3=0.9, and 1.2—0.5=0.7, and 1.2—1.0=0.2 atmospheres respectively. This variation of the difference of pressure will, if the valve is constantly kept opened to the same extent, cause different quantities of gas to pass out through the valve, and the arrangement according to the invention is such that these quantities are proportional to the lack of oxygen at the various altitudes. Thus at whatever height the airman might happen to be, he will always receive the quantity of oxygen he requires. Therefore the valve is only set once, before the aerial trip is commenced, for the quantity of oxygen required for respiration and for the boosting of the motor output at an average altitude of about 5000 metres. When this has been done the valve will let a larger amount of gas pass out at greater heights where there is less oxygen and a smaller amount at lesser altitudes where there is more oxygen.

A constructional form of a device for carrying out the invention is diagrammatically shown in the drawing.

In this a double-walled, ball-shaped metal vessel of the Heylandt type, with a vacuum between the two walls, and oxygen *a* in the interior vessel, is illustrated. After the oxygen has been filled into the vessel *b* it is closed with a cap *c*. In consequence of the pressure exerted by the evaporated oxygen the liquid oxygen is pressed up out of the flask through the ascension pipe *d*. The ascension pipe is first wound in the form of a helix in the evacuated space around the neck of the inner flask and is then connected by a pipe *e* to an evaporating vessel *f* which is equipped with a number of pipes *f'*, *f''*, *f'''* that serves to enlarge the surface of the evaporating vessel and to accelerate evaporation. During its passage through the evaporating vessel most of the oxygen is evaporated and it then passes through the pipe *g* into a second evaporating vessel *h*, which also has several pipes *h'*, *h''*, *h'''* attached to it. After the liquid oxygen is completely evaporated in this way the cold oxygen gas evolved from it is conducted through a long coil *i* the first part of which is located inside the apparatus and whose remainder passes round the exterior protective envelope and ultimately leads up to the valve *k*, which is a throttling valve. The entire length of the described passages is such that the oxygen is warmed up to the temperature of the atmosphere. The arrangement of the valve *k* is such that it can be set so as to deliver various quantities of oxygen gas. It is detained in its position by a spring that engages with the notches of a toothed wheel. The various quantities of oxygen are indicated by figures on the wheel. After passing the valve *k*, the oxygen flows through a pipe *l* into a bag *m* made of a gummed fabric and thence to the discharge pipe *r* to which the pipes are connected that lead to the points of consumption. The bag *m* evens out inequalities in the quantities of oxygen consumed.

In addition to the system of pipes through which the oxygen passes, first in a liquid and then in a gaseous state, to the supply pipe *l*, a separate pipe *n* is provided which leads to the safety valve *o* and the pressure gauge *p*. The pipe *n* is also coiled for the purpose of warming the oxygen and its sole function is to cause the superpressure to be indicated by the pressure gauge and to allow the surplus oxygen to escape when the pressure becomes too great.

If the apparatus is merely to supply oxygen for breathing purposes its contents on an aeroplane will amount 1.5 to 6 litres according to the length of the trip. On an airship the corresponding quantities will be 10 to 50 litres. But if the motor is also to be supplied with oxygen, in order to restore its power at high altitudes, several vessels of a capacity of 25 to 100 litres will be required.

If, in the case of a breathing apparatus for aeroplane airmen, the pointer of the regulating valve *k* is turned to the gas discharge figure 5, the apparatus will deliver 5 litres of oxygen per minute at an altitude of about 6000 metres. If the aeroplane rises to a height of 8000 metres, the delivery will be increased automatically to about 10 litres per minute. Similarly, when the aeroplane descends to lower altitudes such as 3000 metres, the quantity automatically delivered will be only that which is required at this height, viz 3 litres per minute. Thus the great advantage of the apparatus is chiefly that the areoplane or airship pilot needs only to set the valve *k* once before starting out on his trip and that he will then receive the correct amount required at any height without paying any further attention to the valve.

I claim:

1. A device for supplying oxygen, comprising a double walled flask with the space between the walls evacuated and a pipe for conducting the liquid out of the inner vessel and around the neck thereof through a

coil situated in the evacuated space around said neck.

2. In a device as claimed in claim 1, a passage joined to the said pipe and adapted to deliver the liquefied gas of the flask in a gaseous state.

3. In a device as claimed in claim 1, a passage joined to the said pipe and leading through evaporation vessels to a point of discharge where the liquefied gas is delivered at a temperature suitable for respiration or for enhancing the efficiency of a motor.

4. In a device as claimed in claim 1, an adjustable valve adjacent to the point of discharge of the vaporized liquid.

5. A device for supplying oxygen comprising an insulated flask for holding liquid oxygen, an adjustable throttling valve, evaporating passages for conducting oxygen in a liquid state out of the flask and in a gaseous state through the said throttling valve, a safety valve, and an evaporating passage leading from the flask to the said safety valve.

6. A device for supplying oxygen comprising a double-walled liquid oxygen flask with the space between the walls evacuated, an evaporating vessel, a tortuous pipe for conducting liquid oxygen from the flask to the evaporating vessel, an adjustable throttling valve, a tortuous pipe for conducting the oxygen from the evaporating vessel to the said throttling valve and adapted to warm the oxygen gas up to the temperature of the atmosphere, a safety valve, and a tortuous pipe for conducting oxygen from the said flask to the safety valve.

In testimony whereof I have signed this specification in the presence of two witnesses.

PAUL HEYLANDT.

Witnesses:

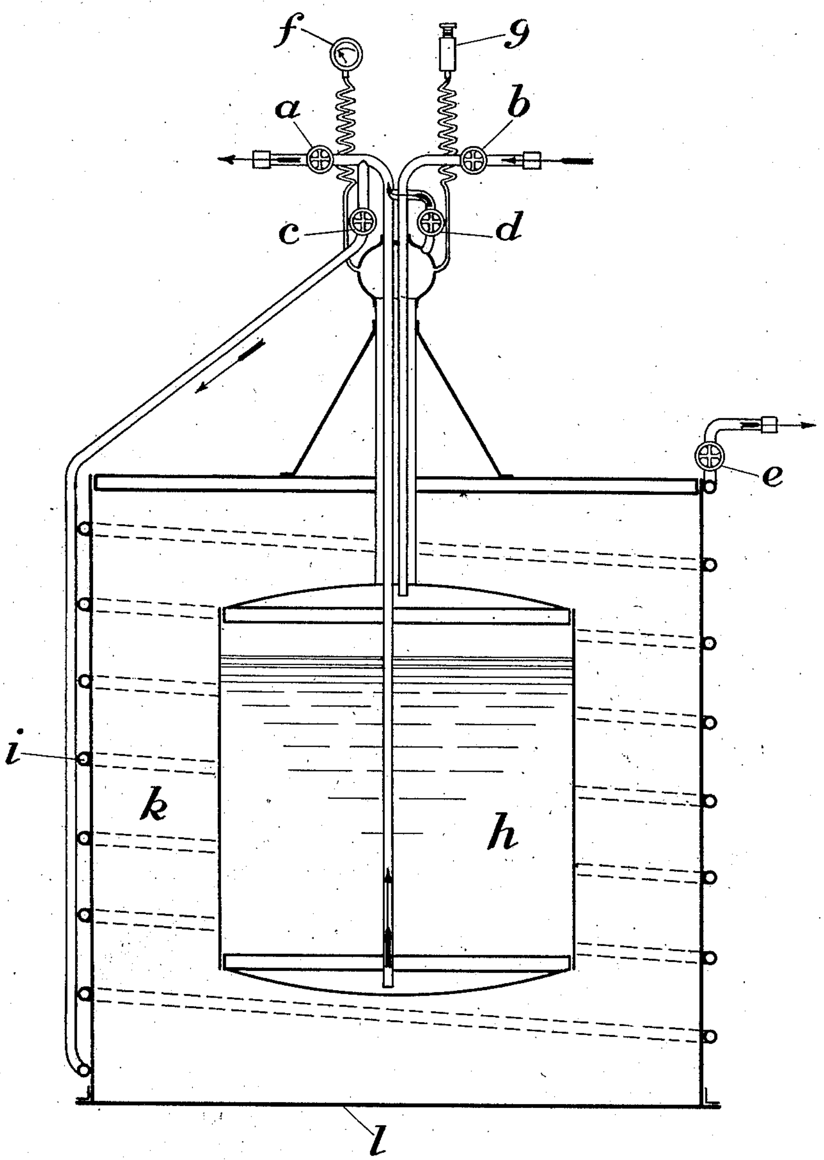
KATHE OESCH,
MAX JABLONSKI.

Aug. 19, 1924. 1,505,095

P. HEYLANDT

DEVICE FOR DEVELOPING GAS UNDER PRESSURE FROM LIQUEFIED GASES

Filed Jan. 3, 1921




INVENTOR:
Paul Heylandt
BY Wm Wallace White
ATTY

Patented Aug. 19, 1924. 1,505,095

# UNITED STATES PATENT OFFICE.

PAUL HEYLANDT, OF BERLIN-SUDENDE, GERMANY.

## DEVICE FOR DEVELOPING GAS UNDER PRESSURE FROM LIQUEFIED GASES.

Application filed January 3, 1921. Serial No. 434,823.

*To all whom it may concern:*

Be it known that I, PAUL HEYLANDT, a citizen of the German Republic, residing at Berlin-Sudende, Germany, have invented certain new and useful Improvements in Devices for Developing Gas Under Pressure from Liquefied Gases, of which the following is a specification.

This invention relates to a device for supplying industrial establishments with large quantities of oxygen or other liquefiable gases without involving the carriage of steel cylinders or bottles, and for developing gas under pressure from liquefied gases, the principal object of the invention being to provide an apparatus in which the liquefied gas may be stored and transported for long distances and the gas delivered under pressure automatically generated within the apparatus.

It has heretofore been considered impossible to make vessels capable of containing several thousand litres of liquids, the temperatures of which are as low as those of liquid oxygen, nitrogen etc., sufficiently proof against the reception of warmth from without and against the evaporation losses entailed thereby, and at the same time to make their resistance to pressure such that they would withstand a pressure as high as that required for autogenous cutting, i. e. a pressure of 8 atmospheres or more. One of the objects, therefore, of the present invention is to provide a comparatively simple device which is sufficiently protected against loss of cold and is strong enough to hold three hundred to several thousand kilograms of liquefied gas and to resist an internal pressure of over fifteen atmospheres, whereby industrial establishments may be supplied with large quantities of liquefied gases which can be taken in gaseous form, and at the required operating pressure, directly from the vessel in which it was transported, without the aid of discharging compressors.

The drawings accompanying and forming part of this specification illustrate diagrammatically a vertical section of an apparatus constructed in accordance with the present invention.

The vessel consists of an internal vessel *h* of metal into which the liquid oxygen is introduced through the inlet valve *b* from an air-liquefying apparatus (not shown). During the inflow of the liquid oxygen the valves *d* and *a* have to be kept open. The internal vessel *h* is fixed in the middle of the enveloping vessel *l*. The space between *h* and *l* is filled with a non-oxidizable substance such as slag-wool. By using slag-wool as an insulating material the evaporation of the liquid oxygen etc. is sufficiently reduced for practical purposes. *a* is a discharge valve through which liquefied gas may be taken from the reservoir *h*. When liquefied gas is to be extracted, the discharge valve *a* is opened and the valves *b*, *c*, *d* and *e* are kept closed. To take non-compressed gas from the vessel, the valves *a* and *d* are both opened, while the valves *b*, *c* and *e* are closed. Finally, gas at a pressure up to several atmospheres can be discharged by opening *c* and *e* while keeping *a*, *b* and *d* closed. In the instance last mentioned the liquefied gas rises through the ascension pipe in the vessel *h* to the valve *c* and flows through, and evaporates in, the the evaporating coil *i* which consists of one or two spirals and lies adjacent to the inner or outer surface of the enveloping vessel *l*. The liquefied gas can be taken in a gaseous state in any desired quantitites at the required working pressure (2 to 15 atmospheres) from the valve *e*. By providing two valves *c* and *e* through which the fluid flows one after the other in the same direction, *c* being passed chiefly by liquid and *e* only by gas, the working pressure can easily be regulated.

The cold liberated during evaporation is transferred by the coil *i* to the envelope *l* and the insulating substance *k* in the space between the outer and inner vessels and is thus stored in the non-oxidizable insulation during the time in which the pressure is produced. By this storage of cold in the slag-wool the evaporation of oxygen that subsequently takes place when the operations are stopped is considerably reduced. A pressure gauge *f* and a safety valve *g* are connected to the gas space above the liquid.

The whole equipment is adapted to be used both as a stationary storage vessel and as a carrying vessel for large quantities of liquid oxygen etc., and especially as a supply vessel for delivering gas at any desired operating pressure up to 15 and more atmospheres.

If the vessels constructed according to the present invention are used as stationary storage vessels, the equipment will be an effective substitute (permitting of divers uses) for the large gas storage vessels or co-called gasometers now generally used for oxygen, nitrogen, hydrogen because, while taking up much less space, the equipment has a capacity which, in conformity with the respective volumes of the gases in their liquefied and gaseous states, is about 800 times as great; for one litre of liquid oxygen when evaporated to a gas of atmospheric pressure will make at 0° or 14° or 27° about 790, 830 or 870 litres respectively of oxygen gas. The corresponding figures for a litre of liquid nitrogen are 640, 670 or 700 litres of nitrogen gas.

For the same reason the apparatus will, when used as a carrying vessel, save the greatest part of the freight charges incurred by sending compressed gas in steel bottles.

Again, if the new process is employed for the production of gas under pressure the same vessel which was first used at the gas producing factory for gathering the liquefied gas, as for example the liquid oxygen, and then served as a carrying vessel, will also serve as an automatic gas producing plant at the point of consumption.

When used for this purpose the vessel, after its arrival at the place of consumption, is first connected to the gas consuming apparatus, say, to the autogenous welding and cutting apparatus. The valve *e* is opened only when, by the automatic evaporation of the liquid oxygen, the pressure in the interior vessel has risen to the pressure required for operation. The excess of pressure is reduced and maintained at the proper operating pressure by corresponding adjustments of the valves *c* and *e*. If gas is to be supplied at several points of operation at different pressures a corresponding number of reduction valves are provided in the supply pipe behind the valve *e*. By this arrangement the carrying about of steel bottles containing highly compressed gas is rendered unnecessary in the establishment where the gas is used.

Another advantage offered by the present construction is that the evaporation of the liquid oxygen, nitrogen, air etc. diminishes when a greater pressure is exerted upon it, because as the pressure increases the boiling point of the liquefied gas rises and hence the difference between the raised boiling point and the external temperature is decreased. This fact, together with the fact that the outlet valve *e* is located in the warmest zone, causes the flow of gas to be uniform and at a uniform pressure. In other words, as soon as the pressure within the vessel *h* has, owing to the natural evaporation of the liquefied gas, risen to the desired operating pressure, the valves *c* and *e* are opened sufficiently to deliver the gas at the same pressure, it being understood that when passing through valve *c* it is still almost entirely in liquid form. However, as it begins to ascend through the coil it will become more and more gaseous until it reaches the warmest zone wherein the valve *e* is located, at which time the fluid is entirely gaseous. The continued evaporation maintains the liquid in the vessel *h* at a uniform pressure as long as the valves *c* and *e* are adjusted for that pressure, provided that the operation is not started until the desired pressure is reached within the vessel *h*. Any tendency to undue increase in pressure is offset by the continually enlarging space above the liquid in the vessel *h* due to the escape of gas through the valve *e*, and to the fact above stated, that as the pressure increases evaporation decreases, and inasmuch as the pressure is produced by evaporation, with any material increase in pressure there must come a time when there is practically no evaporation, and therefore the pressure ceases to rise. Furthermore, at the close of operations sufficient cold has been transferred to the insulating material by the expansion of the gas in the coils *i* to prevent any substantial evaporation in the vessel *h*, thereby preventing any dangerous rise in pressure when the apparatus is not in use.

The novelty of the process and its technical advantages for industrial purposes may be epitomized as follows:

In the gas-producing factory, as in the oxygen factory, the oxygen is no longer produced in a gaseous form but in a liquid form and sent in this state over long distances to the consumer where it is converted into gas of a sufficient operating pressure and consumed. By this means the high cost of the large gas vessels, gas meters, filling compressors, and steel bottles, in addition to the operating cost, are saved, and on account of the great reduction of space and weight the current cost of freight amounts to less than one half of the cost of the carriage of the steel bottles employed hitherto.

I claim:

1. A portable device for storing and transporting liquefied gas, comprising an internal metal vessel adapted to hold a liquefied gas, an envelope of insulating material adapted to prevent the radiation of cold from, and the absorption of warmth by, the said vessel, an inlet for introducing liquefied gas into the vessel, a charging valve controlling the said inlet, a discharge pipe leading from the said vessel to the exterior, a discharge valve controlling the discharge pipe, a passage leading from the vessel into the discharge pipe, and a valve controlling the said passage.

2. A portable device for storing and transporting liquefied gas, comprising an internal metal vessel adapted to hold a

liquefied gas, an envelope of insulating material adapted to prevent the radiation of cold from, and the absorption of warmth by, the said vessel, an inlet for introducing liquefied gas into the vessel, a charging valve controlling the said inlet, and means for discharging the liquefied gas in a gaseous state at a high pressure consisting of a passage leading from the interior of the vessel and lying adjacent to the said envelope, a valve at the beginning of the said passage and a valve at the end of the said passage.

3. A portable device for storing and transporting liquefied gas, comprising an internal metal vessel adapted to hold a liquefied gas, an envelope of insulating material adapted to prevent the radiation of cold from, and the absorption of warmth by, the said vessel, an inlet for introducing liquefied gas into the vessel, a charging valve controlling the said inlet, a discharge pipe leading from the said vessel to the exterior, a discharge valve controlling the discharge pipe, a passage leading from the vessel into the discharge pipe, a valve controlling the said passage, and means for discharging the liquefied gas in a gaseous state at a high pressure consisting of a passage leading from the interior of the vessel and lying adjacent to the said envelope, a valve at the beginning of the said passage and a valve at the end of the said passage.

4. A device for supplying and automatically generating gas at a predetermined operating pressure comprising an internal metal vessel adapted to hold a liquefied gas, a charging inlet for introducing the liquefied gas into the said vessel, an envelope of insulating material adapted to prevent the radiation of cold from, and the absorption of warmth by, the said vessel, and means for discharging the gas in a gaseous state at the required operating pressure after the pressure in the vessel has risen to said operating pressure by evaporation of the liquefied gas, said means comprising a discharge passage leading from the interior of the vessel and winding round the said envelope, and valves at the beginning and end of the said passage for regulating the pressure of the gas at the point of discharge.

5. A device for supplying and automatically generating gas at a predetermined operating pressure comprising an internal metal vessel adapted to hold a liquefied gas, a charging inlet for introducing the liquid gas into the said vessel, an envelope of insulating material adapted to prevent the radiation of cold from, and the absorption of warmth by the said vessel, and means for discharging the gas in a gaseous state at the required operating pressure after the pressure in the vessel has risen to said operating pressure by evaporation of the liquefied gas, said means comprising a discharge passage leading from the interior of the vessel and winding round the said envelope, valves at the beginning and end of the said passage for regulating the pressure of the gas at the point of discharge, a by-pass for leading the gas from the vessel into the said discharge passage, and a valve controlling the said by-pass.

6. A device for supplying and automatically generating gas at a predetermined operating pressure comprising an internal metal vessel adapted to hold a liquefied gas, a charging inlet for introducing the liquefied gas into said vessel, an envelope of insulating material adapted to prevent the radiation of cold from, and the absorption of warmth by the said vessel, and means for discharging the gas in a gaseous state at the required operating pressure after the pressure in the vessel has risen to said operating pressure by evaporation of the liquefied gas, and for transferring the cold of the liquid and evaporating gas to the envelop of insulating material, said means comprising a spiral pipe leading from the said vessel and passing adjacent to the said envelope, substantially as described.

7. In combination with a device of the kind described in claim 2, a distributing pipe connected to the discharge passage, and reduction valves for supplying gas simultaneously at various pressures from the said distributing pipe.

In testimony whereof I have signed this specification in the presence of two witnesses.

PAUL HEYLANDT.

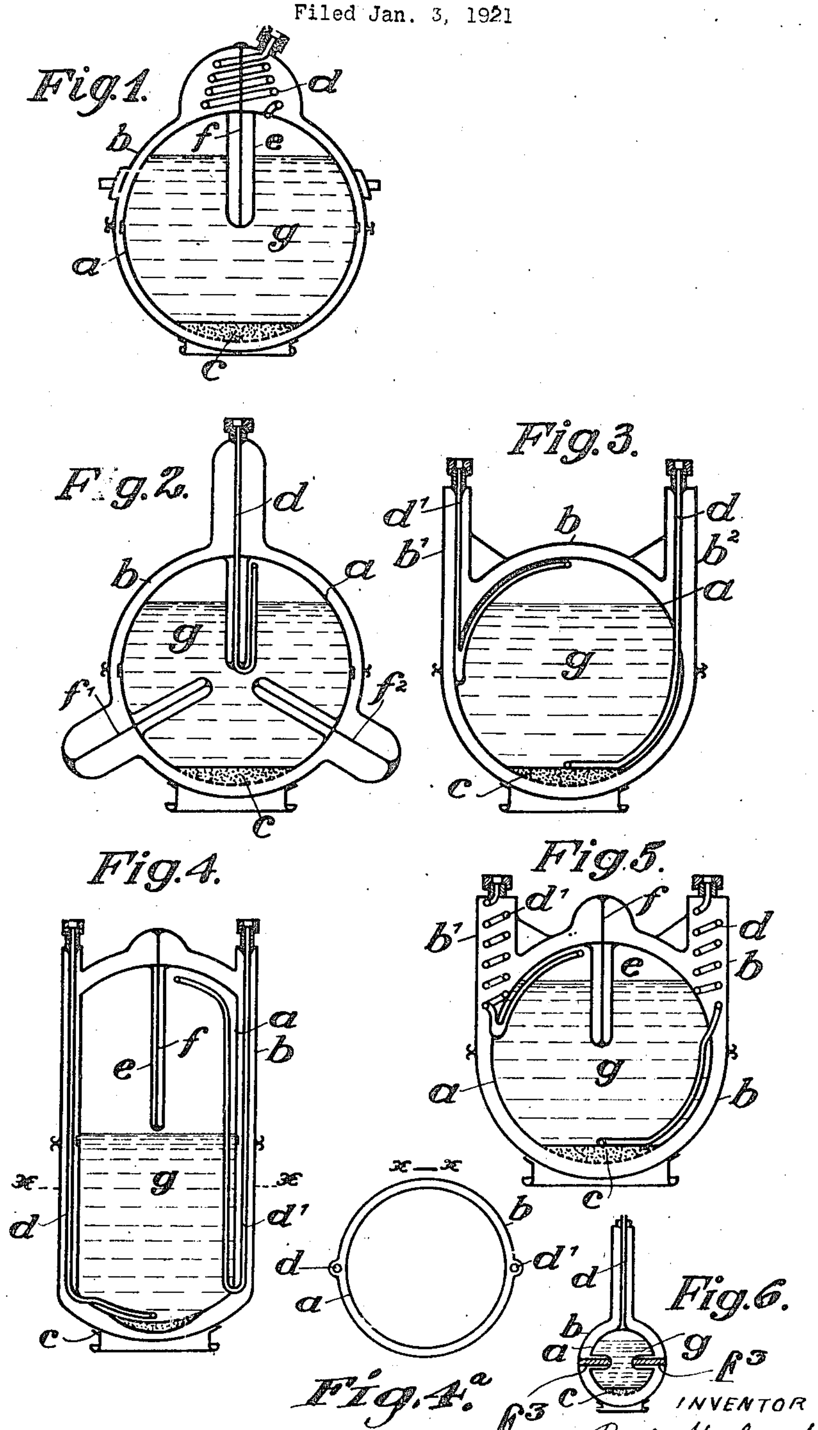
Witnesses:
KÄTHE SEECK,
MAX JABLOWSKI.

Jan. 13, 1925. 1,522,886

P. HEYLANDT

METAL VESSEL FOR STORING AND CONVEYING LIQUEFIED GASES

Filed Jan. 3, 1921




INVENTOR
Paul Heylandt
BY Wm Wallace White
ATTY

Patented Jan. 13, 1925. 1,522,886

# UNITED STATES PATENT OFFICE.

PAUL HEYLANDT, OF BERLIN-SUDENDE, GERMANY.

## METAL VESSEL FOR STORING AND CONVEYING LIQUEFIED GASES.

Application filed January 3, 1921. Serial No. 434,831.

(GRANTED UNDER THE PROVISIONS OF THE ACT OF MARCH 3, 1921, 41 STAT. L., 1313.)

*To all whom it may concern:*

Be it known that I, PAUL HEYLANDT, a citizen of the German Republic, residing at Berlin-Sudende, Germany, have invented certain new and useful Improvements in Metal Vessels for Storing and Conveying Liquefied Gases (for which I have filed applications in Austria under date of March 23, 1915, and Luxemburg under date of March 28, 1915), of which the following is a specification.

The invention relates in general to means for storing and conveying liquefied gases of all kinds, particularly liquid air. The object of the invention is to isolate the vessels used for this purpose from the effects of their surroundings to such an extent that the least possible loss of gas takes place.

The vessel according to the invention differs from the known metal vessels for storing and conveying liquefied gases (which consist of an inner vessel suspended freely by a long outflow pipe in a similarly shaped outer vessel) in that the exchanging of heat or thermal leak is considerably reduced by the neck that was used for suspending the inner vessel being replaced by a long fine wire, or by a long fine tube whose cross section is too small to enable it to be used for the filling in and pouring out of the liquefied gas and is large enough to allow only the gases to escape that are formed by unavoidable evaporation. Another distinguishing feature of the novel vessel is that the inner vessel or globe is held in place by stays or a plurality of suspension members consisting of fine wires which prevent the inner globe from coming in contact with the outer globe and thus obviate the warming of the contents of the inner globe that would thus arise, and effect a considerable decrease of the amount of gas that is unavoidably lost.

The lateral holding members used in the double-walled glass vessels of the Weinhold and Dewar type also involve the disadvantage of a too considerable thermal leak.

In other known metal vessels of the general type contemplated herein the hollow supports arranged between the inner and outer vessels serve as exits for the gases formed and are cooled by them so that the result obtained is similar to the object of the present invention, viz a reduction of the thermal leak.

But as far as the bulk or mass of the said hollow supports is concerned they are very disadvantageous in comparison with the fine wires used in accordance with this invention, and which are subjected to tensile stresses only. By using wires of this kind the amount of gas lost is reduced to a minimum.

Some constructional forms of vessels designed in accordance with the invention are shown in the drawing in which

Fig. 1 is a vertical section of a vessel or flask in which the inner chamber or globe is suspended by a thin wire,

Fig. 2 shows a flask in which radial fine wire ties are used for holding the inner vessel in addition to the suspension member,

Fig. 3 shows a flask in which the inner vessel is suspended by two fine, lateral, perpendicular tubes,

Fig. 4 shows a vertical section and Fig. 4ᵃ a cross section of a flask somewhat similar to that of Fig. 3, but with the lateral tubes lengthened in order to decrease the thermal leaks that they produce,

Fig. 5 illustrates a flask in which the long lateral tubes are brought into a small compass by making them spiral-shaped, and

Fig. 6 is a sectional view of a modified form of the flask shown in Fig. 2.

In Fig. 1 the inner vessel or globe *a* is provided at *c* with a chamber or some suitable accommodation for a gas-absorbing substance, preferably carbonate of magnesium, which serves to maintain a high vacuum in the space between the outer vessel or shell *b* and the inner vessel *a*. The shell *b* is bulged outwardly or dome-shaped at the top, the dome-shaped space being adapted to receive a spiral-shaped inflow pipe *d* for the liquefied gas to be stored in *a*, whilst the inner vessel has a long downwardly extending cavity *e* which serves to lengthen the distance from the bottom end of a fine metal suspension wire *f* of great tensile strength to the outer vessel from which the inner vessel with its liquid contents depends. It will be obvious that the great length of the supporting wire *f* and that of the still longer pipe *d* considerably impede the lineal conduction of heat.

In Fig. 2 a flask is shown in which the inner vessel *a* is held in the shell *b* by suitable ties *d*, $f'$, $f^2$ so that, contrary to the arrangements shown in Figs. 1 and 3, the inner vessel is always kept in the position illustrated in the drawing, even while liquid is being poured out. The inner ends of the wires $f'$, $f^2$ that serve as ties, and which are long and thin, and the inner end of the tube $d$, are attached for the purposes of the invention to the inner ends of long radial cavities in the inner vessel, and the outer end of each of the wires and of the tube is attached to the outer end of the dome-shaped protuberances of the outer shell $b$. In the modified form shown in Fig. 6, the same result is accomplished by means of the centering or stay members $f^3$ attached to the inner wall of the shell $b$ at diametrically opposite points and extending into recess forming portions of the vessel $a$.

The number of wires or ties used may be increased or decreased at will.

In the flask shown in Fig. 3 the outer vessel $b$ is provided with two lateral extensions $b'$, $b^2$ into which the evacuated space projects so as to surround the pipe $d$ for the pouring in and out of the liquid and the fine tube $d'$ for discharging the evaporated gas.

In order to increase to the greatest possible extent the length of the thermal conductors formed by the tubes or wires between the inner and outer vessels, the flasks can be made cylindrical in shape as shown in Fig. 5. The inner vessel $a$ that contains the liquid $g$ is held in a central position by a wire $f$ that is attached to the bottom of a deep cavity $e$, and the two tubes $d$, $d'$ are for the purpose of pouring the liquid in or out and for the exit of the evaporated gases.

In the constructional form shown in Fig. 5 the exigencies of limited space are considered, the vessel being made to contain as much liquid as possible while taking up the smallest possible space. To this end the tubes $d$, $d'$ between the inner and outer vessel are made spiral-shaped or helical. The inner vessel is held up by the wire $f$ only and the long pipes are for pouring the liquid in and out. Of course the space between the inner and outer vessel could be made much wider, especially if this space is not evacuated but merely filled with a poor conductor of heat such as sheeps' wool, eider down or the like.

In the case of flasks provided with a vacuum for the purposes of insulation, the vacuum need not be produced by a vacuum pump, but so large a quantity of the aforesaid gas-absorbing substance indicated in the drawing can be inserted that on the liquefied gas being poured in, an adequate vacuum is formed automatically. It is already known that vessels in which the insulation is formed by a vacuum must contain a gas-absorbing substance on account of the porosity of the metal.

From the foregoing it will be observed that in all forms of the flask herein shown, one, or both, of the flask forming members, is provided with a hollow portion forming a recess in communication with the space between said members and that the connecting member is attached at one end to the inner end wall of the recess so formed and at its other end to the other member, or to the recess formed in said other member, whereby the suspending or connecting member will be of considerably greater length than was heretofore possible.

I claim:

1. A metal flask for storing and conveying liquefied gases, comprising a pair of hollow members one enclosed within and spaced from the other, one of said members having a hollow portion forming a recess in communication with the space between said members, the inner end of said recess being at a point remote from the peripheries of both of said members, a connecting wire attached at one end to one of said flask-forming members and at its opposite end to the inner end wall of said recess, and an inlet tube passing through the wall of the outer member and communicating with the inner member.

2. A metal flask for storing and conveying liquefied gases, comprising a pair of hollow members one enclosed within and spaced from the other, one of said members having a plurality of hollow radially extending portions forming recesses in communication with the space between said members, the inner ends of said recesses being at points remote from the peripheries of both of said members, a connecting element in each of said recesses attached at one end to the inner end wall of the recess and at its opposite end to the other flask-forming member, and an inlet tube passing through the wall of the outer member and communicating with the inner member.

3. A metal flask for storing and conveying liquefied gases, comprising a pair of hollow members one enclosed within and spaced from the other, each of said members having a radially extending hollow portion, the hollow portion of one member extending inwardly from its periphery and the hollow portion of the other member extending outwardly, and said hollow portions being in alignment, and a connecting member attached at its opposite ends to the inner end walls of said hollow portions.

4. A metal flask for storing and conveying liquefied gases, comprising an inner vessel, a shell enclosing said vessel and spaced therefrom, a wire connecting the vessel and shell, said wire being connected to the vessel at a point within its periphery and to the shell at a point without its periphery, and an inlet tube passing through the wall of the shell and communicating with the interior of the vessel.

5. A metal flask for storing and conveying liquefied gases, comprising an inner vessel, a shell enclosing said vessel and spaced therefrom, the vessel being provided with a hollow member extending toward its axial center and the shell having a hollow member protruding therefrom away from its axial center, said hollow members being in alignment, and a connecting member attached at its opposite ends to the inner end walls of said hollow members.

In testimony whereof I have signed this specification in the presence of two witnesses.

PAUL HEYLANDT.

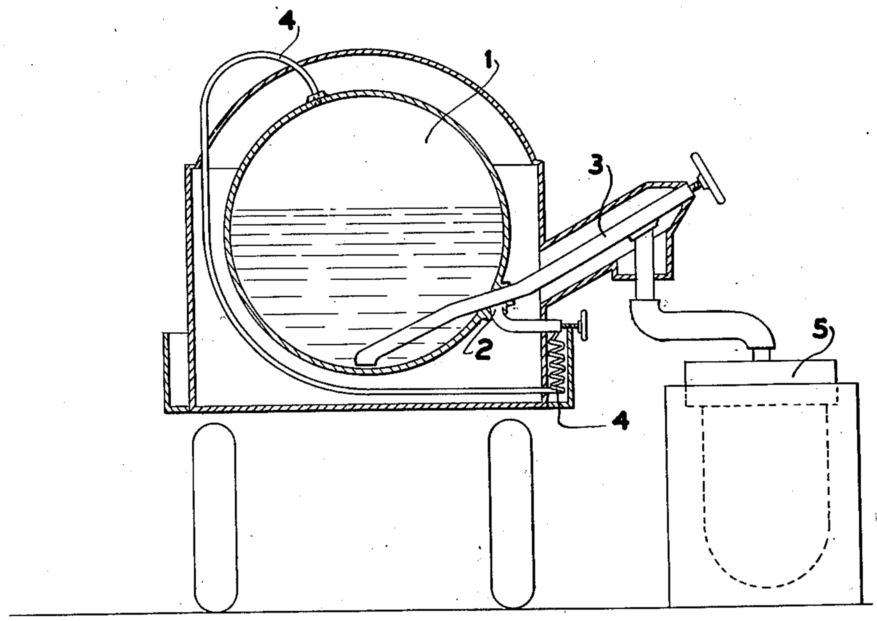
Witnesses:

KABBE LESCH F. MARTRISCHESTRASSE,
MAX JABLOWSKI.

April 8, 1930. C. W. P. HEYLANDT 1,753,785

PROCESS OF TRANSFERRING LIQUEFIED GASES FROM ONE CONTAINER TO ANOTHER

Filed March 8, 1929




INVENTOR.

C. W. P. Heylandt,

BY Runge Boyce & Blakelay,

ATTORNEYS.

Patented Apr. 8, 1930

1,753,785

REISSUED

# UNITED STATES PATENT OFFICE

CHRISTIAN WILHELM PAUL HEYLANDT, OF BERLIN-LANKWITZ, GERMANY

## PROCESS OF TRANSFERRING LIQUEFIED GASES FROM ONE CONTAINER TO ANOTHER

Application filed March 8, 1929, Serial No. 345,259, and in Germany March 2, 1928.

In transferring liquefied gases of low-boiling point from one vessel to another, and particularly when large quantities of such gases were involved, it has been the practice heretofore to permit pressure to develop automatically from the natural evaporation of the gas in a closed vessel, in order to effect a sufficiently quick transfer of the liquefied gas. Under that method, however, considerable losses by evaporation occurred during the transfer of the gas into the second container. I have found that such losses can be reduced to one fourth if the gas is continuously maintained during storing and transportation at practically ordinary boiling temperature, and at the time of making the transfer, an artificial pressure gas is introduced into the first container for a definite length of time. This can be effected from an outside source, for instance by the use of compressed gas, or by the rapid evaporation of a part of the gas to be transferred or of another liquid gas, and conducting the pressure vapors to the liquid. The liquid will then run out of the containers to be emptied at increased speed, without any substantial evaporation losses taking place.

Tests have shown that especially during the transfer of pressureless liquefied gases into pressure-developing containers, the losses which heretofore have amounted to from 2 to 4 per cent can be reduced by the present method to 0.5 to 1 per cent.

However, also in other respects does the present method offer advantages, inasmuch as the transportation containers for liquefied gases now in use, the discharge openings of which containers, for practical reasons, are usually higher than the lowest liquid level, can be maintained in use, without pressure, and then, during the periods of rest, the pressure difference for the gas stored within the container is increased so that, during rest periods, no gas is lost from such transportation containers, while, when operating the vehicle, the increased gas pressure is immediately again reduced by utilizing the same in the motor so that the liquid to be transferred in accordance with the above-mentioned method again assumes the temperature of the boiling point.

In order to carry out the process, it is advisable to transfer a small quantity of the liquid gas into an evaporator coil, the evaporation products of which, with increased pressure, are led to the vapor or steam chamber of the receptacle which contains the liquid to be emptied.

The drawing accompanying this specification illustrates diagrammatically an apparatus suitable for carrying out the present process.

In said drawing, 1 designates the inner container of a liquid tank having a filling pipe 3, said tank being mounted on a truck for transportation. At 2 this pipe 3 is tapped so that, as required, a small quantity of the liquid contents can be drawn off into a coil 4, where it will evaporate. The coil discharges into the space above the liquid level, in the container 1, and the pressure gas developing from the drawn-off quantity of liquid is sufficient for the expulsion of the desired liquid to be transferred. The transfer neck of the tank communicates in the well known manner by means of a flexible tube with the transfer vessel 5, which receives the liquid to be brought to pressure gasification by way of self-compression. The tapping tube, of course, is provided with a suitable valve for controlling the flow of liquefied gas to the coil 4.

Having thus described and ascertained the nature of my said invention, what I claim is:

1. The process of transferring liquefied gases from one container to another, which consists in maintaining the liquefied gases at their ordinary boiling temperatures in the first container, and utilizing a portion of the liquefied gases from the first container to apply an artificially increased momentary pressure to the liquefied gases thereby to cause the same to flow at increased speed into another container.

2. The process of transferring liquefied gases from one container to another, which consists in maintaining the gases at their ordinary boiling temperatures in the first con-

tainer, extracting a small quantity of said liquefied gases from said container and evaporating the same, and returning the vapors to said first container thereby to exert pressure on the liquefied gases and cause the same to flow at increased speed into another container.

3. An apparatus for transferring liquefied gases from one container to another, comprising a vessel having a filler tube, a coil disposed outside of said vessel and adapted to communicate at one end with said tube, the opposite end of said coil being in communication with said vessel above the liquid level, thereby to produce an excess pressure for discharging the liquid from said vessel.

4. An apparatus for transferring liquefied gases from one container to another, comprising a vessel having a filler tube, a coil disposed outside of said vessel and adapted to communicate at one end with said tube, the opposite end of said coil being in communication with said vessel above the liquid level, thereby to produce an excess pressure for discharging the liquid from said vessel, and detachable means for placing said vessel in communication with a second vessel.

In testimony whereof I have signed my name to this specification.

CHRISTIAN WILHELM PAUL HEYLANDT.

Aug. 19, 1930. C. W. P. HEYLANDT 1,773,140

METHOD OF PREPARING COMPRESSED GASES

Filed Aug. 24, 1928

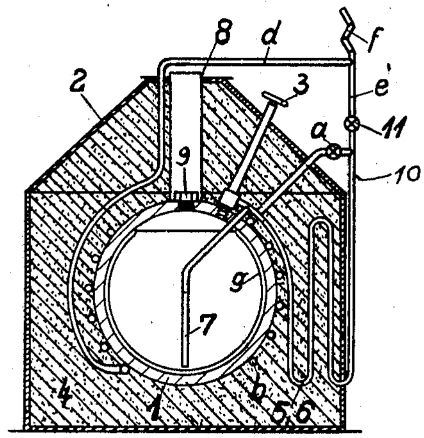



Fig. 1

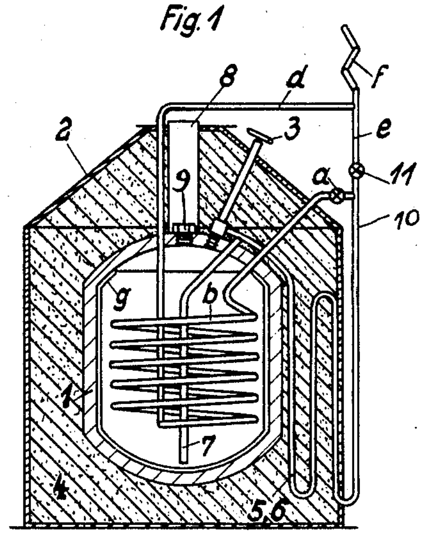



Fig. 2

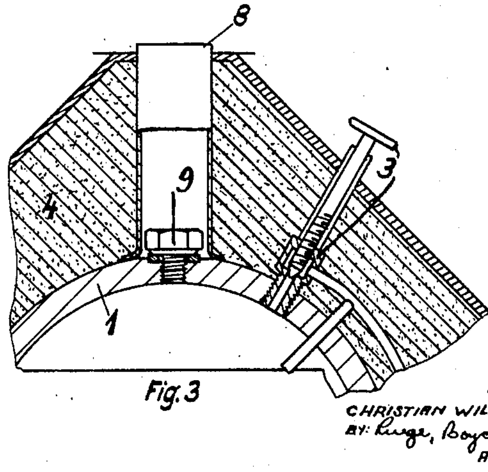



Fig. 3

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Patented Aug. 19, 1930 1,773,140

# UNITED STATES PATENT OFFICE

CHRISTIAN WILHELM PAUL HEYLANDT, OF LANKWITZ, NEAR BERLIN, GERMANY

## METHOD OF PREPARING COMPRESSED GASES

REISSUED

Application filed August 24, 1928, Serial No. 301,886, and in Germany September 20, 1927.

This invention relates to a method of preparing compressed gas of high pressure from a body of liquid enclosed in an insulated pressure vessel, the principal object of the invention being to provide a method by means of which uniform and adequate generation of gas at a pressure higher than the critical pressure of the gas is obtained.

A further object of the invention is to provide a method whereby the gases given off by a body of liquid within an insulated pressure container may be heated and then brought into heat-interchanging relation to said body of liquid thereby to raise the pressure in the container and accelerate evaporation of the liquid.

The pressure vessel usually employed in preparing compressed gases operates satisfactorily up to the critical pressure of the particular liquefied gas which is to be evaporated and converted into compressed gas, so that any desired quantity of compressed gas can be withdrawn at constant pressure either continuously or intermittently. Such pressure vessels, however, are built and used to withstand a working pressure which lies below the critical pressure of the particular liquefied gas to be evaporated. The reason for this is, that below the critical pressure there is in the inner container, during the whole period of evaporation, liquid such as is required for preparing the compressed gas.

The conditions change, however, immediately it is decided to produce highly compressed gas at about 150 to 200 atmospheres; since it then becomes necessary to exceed the limit of critical pressure (52 atmospheres for oxygen) having regard to the dimensions of the vessel for the compressed gas necessitated by the pressure. In this case a constant working pressure cannot be maintained, as the pressure chamber is not filled with liquid, and only very cold vapours having a high saturation point pass into the evaporating coil. In such case no more liquid is evaporated in the heating coil, but only cold gas will still continue to be superheated. If, therefore, the pressure is not to fall, notwithstanding the consumption, provision must be made for the supply of additional heat, as the superheating of the saturated cold gas in the pressure vessel would otherwise not proceed rapidly enough.

The object of the present invention is to overcome the disadvantages above pointed out and to provide a method by means of which the generation of the gas at the desired pressure can be maintained uniform and adequate.

In the drawing accompanying this specification,

Fig. 1 is a central vertical section through an apparatus suitable for carrying out the improved method;

Fig. 2 is a similar view of a modified form of apparatus; and

Fig. 3 is a fragmentary sectional view illustrating on an enlarged scale the controlling valve.

Referring to the drawing, 1 designates the pressure vessel, which is provided with a thin-walled inner receptacle $g$ for the reception of the liquefied gas. This receptacle, owing to its thin wall is cooled off comparatively quickly by the liquefied gas so that the evaporation during the filling is small. The pressure vessel 1 is disposed within and spaced from an outer container 2, the space between the container and pressure vessel being filled with a suitable insulating material 4. The pressure vessel is provided at one point with a filling opening normally closed by a suitable screw plug 9, said opening being enclosed by a neck or pipe 8 extending from the pressure vessel and communicating with the atmosphere outside of the container 2, whereby the insulating material is prevented from covering the closing plug. When the vessel is to be filled, the plug 9 may be removed by means of a socket wrench or other suitable tool inserted through the neck 8. Within the inner receptacle $g$ is disposed a vertical pipe 7, the lower end of said pipe being in close proximity to the bottom of the receptacle while its upper end passes through the walls of said receptacle and the pressure vessel 1 and communicates with a pipe which is bent to form coils 5, 6, disposed within the insulation material, a portion of said pipe extending through the wall of the container 2 to the outside thereof, while the inner end of the pipe is in communication by way of a needle valve 3 with the upper portion of the receptacle *g*. The outer exposed portion 10 of this coiled pipe communicates with a conduit *e* adapted to communicate with a gas receiver (not shown), a valve 11 being disposed between said conduit and the pipe 10.

In Fig. 1 a heating coil *b* is shown disposed within the insulating material in encircling relation to the pressure vessel 1, said coil at one end communicating with a pipe *d* which in turn communicates with the conduit *e* at one side of the valve 11, the opposite end of the coil communicating with the exposed portion pipe 10 at the opposite side of said valve, the latter communication being controlled by a valve *a*. It will thus be seen that the coil *b* communicates with the conduit *e* at both sides of valve 11.

In Fig. 2, the coil *b* is disposed within the thin walled receptacle *g* instead of encircling the outer pressure vessel 1. Otherwise the construction and connections are the same as described in connection with Fig. 1. In both forms the conduit *e* may be provided with a reheating coil, as indicated diagrammatically at *f*.

In operation, with the valve 11 closed and the valves *a* and 3 open, the gas above the level of the liquid in the receptacle *g* will flow into the coil pipe 5, 6 and, after being heated by passing through the exposed portion 10 of said pipe, passes through valve *a* into the coil *b* thereby heating the pressure vessel 1, or the contents of the receptacle *g* directly, depending on whether the coil *b* is disposed as shown in Fig. 1 or Fig. 2. The gas, after thus giving up its heat, passes from the coil *b* through pipe *d* to the conduit *e*, whence it may be passed directly to its desired destination, after reheating by passage through the coil *f*. On the other hand, with the valves 11 and 3 closed and the valve *a* open, vaporization will occur within the receptacle owing to the leaking of heat through the insulation. The vapor thus produced will create pressure within the receptacle, whereby the liquid will be forced out through pipe 7, coils 5, 6 where it is converted into vapor, which passes into exposed pipe 10, where it is superheated by the heat of the atmosphere, and passes through valve *a*, coil *b*, pipe *d* and conduit *e* as above set forth.

Should it become necessary to discontinue the operation of the apparatus, it is necessary only to close the valve *a* and open valves 3 and 11, whereupon only a very small normal evaporation of the liquefied gas will occur.

The method herein described is particularly well adapted for the handling of oxygen. This statement, however, is not to be understood as a limitation, as I am well aware that the method can be applied to all liquefiable gases.

I claim:

1. The method of preparing compressed gases of high pressure from a body of liquid enclosed in an insulated pressure container which consists in heating gases given off by said liquid, then bringing said heated gases into heat interchanging relation to said body of liquid, whereby the pressure in the container is raised and the evaporation of the liquid is accelerated, and then further heating said gases and conducting them under the high pressure to the point of use.

2. The method of preparing compressed gases of high pressure from a body of liquid enclosed in an insulated pressure container which consists in subjecting gases given off by said liquid to the temperature of the surrounding atmosphere thereby to heat the gases, then conducting said heated gases into heat interchanging relation to said body of liquid thereby to raise the pressure in the container and accelerate evaporation of the liquid, and then further heating said gases and conducting them under the high pressure to the point of use.

In testimony whereof I have signed my name to this specification.

DR. PAUL HEYLANDT.

Sept. 30, 1930. C. W. P. HEYLANDT 1,777,040

PROCESS AND APPARATUS FOR THE LIQUEFACTION OF GASES

Filed Nov. 29, 1927

Fig. 1.

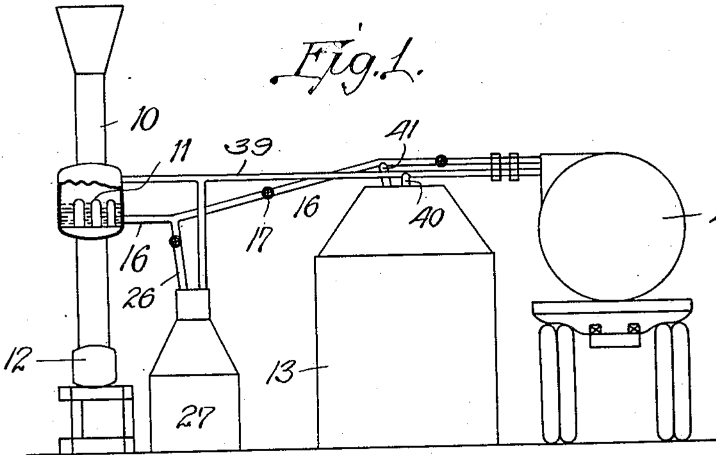



Fig. 2.

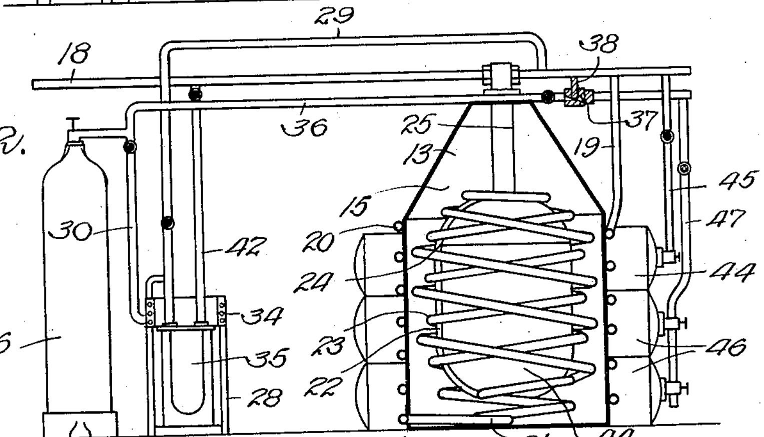
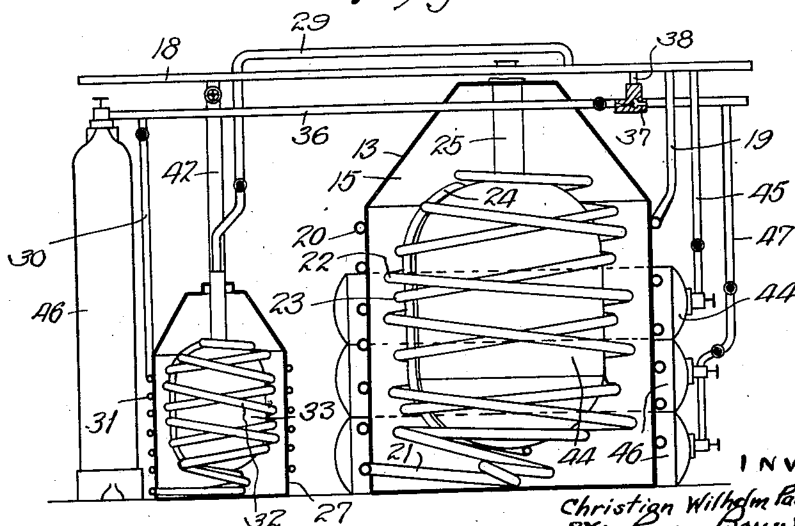



Fig. 3.




INVENTOR.
Christian Wilhelm Paul Heylandt
BY: Ruge, Boyer & Baker
ATTORNEYS.

Patented Sept. 30, 1930 1,777,040

REISSUED

# UNITED STATES PATENT OFFICE

CHRISTIAN WILHELM PAUL HEYLANDT, OF LANKWITZ, GERMANY, ASSIGNOR TO FLÜGA AKTIEN-GESELLSCHAFT, OF ST. MORITZ, SWITZERLAND

## PROCESS AND APPARATUS FOR THE LIQUEFACTION OF GASES

Application filed November 29, 1927, Serial No. 236,401, and in Germany December 29, 1926.

The present invention relates to a process and apparatus for the liquefaction of gases, the principal object of the invention being to provide a process for the re-liquefaction of evaporation products resulting from the withdrawal of gases from and refilling of containers in the operation of air-liquefying plants.

In the operation of air-liquefying plants, as for instance for obtaining pure liquid oxygen, it has been customary heretofore to draw the liquid from the air-liquefying apparatus into large storage receptacles and then to take the liquid from the latter and fill it into other containers to be used as desired. However, in order to prevent as far as possible the escape of the gases, the liquefied gas was kept in low-pressure gasometers and were later compressed by means of compressors into suitable containers. The present invention has for its object the elimination of this inconvenient, undesirable and expensive manner of handling the gases, by providing a process whereby all escaping gases are carried back at a suitable place to the liquefying apparatus to be reliquefied, the refrigerating capacity of the apparatus being brought to such a point that the gas on being so returned will be liquefied. This can be effected by increasing the pressure, for instance, from the usual 200 atmospheres to 250 atmospheres, which causes the refrigerating capacity, especially of an expansion machine, to be very much increased, so that the final temperature is decreased from −130° C. to −170° C. In this manner the complete re-liquefaction of all additional waste gases returned to the column condenser is effected and it becomes unnecessary to store such gases at the producing plant. Moreover, the process is carried out in such manner that the refrigeration is brought to a point where, for instance in air liquefaction plants, there is a surplus of cold over and above the refrigeration potential which is normally required for liquefying the entire oxygen content of the air being treated.

In the drawings accompanying and forming part of this specification,

Fig. 1 is a diagrammatic side view of an apparatus adapted to carry out the process herein described;

Figs. 2 and 3 are similar views illustrating modified forms of apparatus.

In each of the forms here shown there is provided an air liquefying and separating column 10 which is shown in one form in detail in Figure 1, the operating parts being encased in Figures 2 and 3 and therefore not shown. However, this column, as shown in Figure 1, is provided with a condenser 11 and an evaporator 12. Also in each of these forms there is provided a storage receptacle having an outer shell 13 within which is mounted a flask 14, spaced from the shell 13 so that the flask is surrounded by an insulating space 15 preferably of the ordinary vacuum type. In Figure 1 there is shown a pipe 16 provided with a valve 17 which leads to the flask 14, this flask not being shown in Figure 1 but being within the housing or casing 13. In Figures 2 and 3 there is a supply pipe 18 which leads from the liquefying column 10 and is provided with a branch 19 which communicates with a coil 20 surrounding the casing 13, branch 19 connecting with the upper end of this coil while from the lower end of the coil leads a pipe 21 which enters the casing 13 and connects to the lower end of a coil 22. This coil 22 surrounds the flask 14 in spaced relation thereto and leads up to the top of the flask where it is connected to an inner coil 23 wound closely around the flask and having its lower end communicating by a pipe 24 with the top of the flask 14. Also a draw off pipe 25 connects the top of the flask with the pipe 18. A valve branch extends from the pipe 16 at 26 to some form of vaporizer, of which one type is shown in Figures 1 and 3 and another type in Figure 2, the former being indicated as having a casing 27 while the latter is provided with a casing 28. It will be noted that a corresponding valved pipe 29 affords communication between the pipe 18 and this vaporizer in the form shown in Figures 2 and 3. Also in these last forms a valved pipe 30 leads from the apparatus 10 to a coil 31 in Figure 3 which surrounds the casing 27 and communicates with a double coil 32 surrounding a flask 33 of the same general construction as the flask 14 and its coil.

In the form shown in Figure 2 the pipe 30 communicates with a coil 34 surrounding the upper part of the casing and in this casing is a flask 35. Leading from the pipe 30 in Figures 2 and 3 is a valved pipe 36 which communicates with an injector 37 having an intake 38 leading to the pipe 18. In Figure 1 there is shown a pipe 39 having certain functions in common with the pipe 18 and communicating with the flasks through the pipes 40 and 41 respectively. In Figures 2 and 3 there are provided pipes 42 affording communication from the flasks of the vaporizers to the respective pipes 18, these pipes 42 being valved as shown. In Figure 1 is disclosed a portable container 43 wherewith the pipes 16 and 39 communicate while in Figures 2 and 3 there is shown a primary container 44 communicating by a valved pipe 45 with the pipe 18. In these figures there are also shown secondary containers 46 communicating by a valved pipe 47 with the pipe 36. Thus in each of the forms shown there is essentially the liquefying column, a large storage flask, a vaporizer, and other means for final storage either portable as shown in Figure 1 or stationary as shown in Figures 2 and 3.

In the apparatus as shown in Figure 1 any evaporation which takes place in the tank 43 or in the storage flask in the casing 13 is returned to the column 10 where such evaporated gases are again liquefied. In Figures 2 and 3 any gases produced by evaporation in the flasks 14 passes to the tanks 44 and then according to the particular requirements of the case, by means of the injector 38 and the high pressure gases developed in the vaporizer as at 27 or 28, together with the gases from the column 10, are caused to flow into the tanks 46, being thus stored under high pressure in these tanks so that a gas of high pressure may be obtained from the pipe 47. It is to be understood that liquefied gas necessary for producing high pressure gas in the evaporator can be taken from the flask 14 through the pipe 18 and the valved pipe 42. Any undesired vaporization arising during this process passes through the pipe 29, pipe 18 and pipe 45 into the receptacle or tank 44. Evaporation from the flask 14 passes through the several coils into the pipe 19 and thus again to the tank 44 where storage takes place. The vaporizer in Figure 2 is what is commonly termed a warm vaporizer and is filled from the flask 14 through the usual pipes, any undesirable vaporization passing to the tank 44 through the pipe 29, or if the valve in this pipe be closed, into the column 10. It will be noted that in Figure 3 the vaporizer is what is commonly known as a cold vaporizer and the action is similar to that previously described.

The device 28 consists substantially of a steel bottle or jacket with an inner thin-walled vessel 35. This inner vessel receives the liquid, which is immediately evaporated so that in the vessel there may be produced a pressure of no less than 150 atmospheres. The high evaporating pressure which is automatically produced in the device 28 is utilized for operating the injector 37 (Fig. 2) which is connected with the distributing system or main for the purpose of drawing off the contents of the container 44 and so that a compressed gas can be produced in the secondary containers 46 that is compressed to at least 40 atmospheres, whereas on the other hand the primary container 44 is almost completely emptied by suction and is employed for the reception of further products of evaporation from the vessel 15.

From the foregoing it will be apparent that the provision of a withdrawal flask, a reservoir for liquefied gases and a transportable storage tank for liquefied gases, all of which are connected with the liquefying and separating column by means of return pipes is an essential characteristic of an apparatus for carrying out the process described. It will also be apparent that by this process the necessity for storing the waste gases in gasometers and later to compress them into pressure gases by the use of compressors is entirely eliminated.

I claim as my invention:

1. The process of liquefying evaporation products resulting from the operation of liquefied-gas containers, which consists in returning said products into a separating and liquefying apparatus, and increasing the pressure and refrigerating capacity of said apparatus.

2. The process of liquefying gases evaporated within closed pressure tanks, which consists in introducing said gases into a distributing system operating under different degrees of pressure, and utilizing the increased pressure resulting from the transition from the liquid to the gaseous state for raising the tension of low-pressure gases and vice versa.

3. An apparatus for liquefying evaporation products resulting from the operation of liquefied-gas containers, comprising a gas-supplying system adapted to operate under different pressures, gassifiers, pipe lines communicating with said system and gassifiers, injectors disposed in said pipe lines, pressure tanks connected with the high and low pressure sides of said gassifiers, and means for causing the high-pressure gases from the gassifiers to actuate said injectors thereby to reduce the pressure in the low-pressure tanks and increase the pressure in the high-pressure tanks.

4. An apparatus for liquefying evaporation products resulting from the operation of liquefied-gas containers, comprising a gas-

supplying system adapted to operate under different pressures, gassifiers, pipe lines communicating with said system and gassifiers, injectors disposed in said pipe lines, pressure tanks connected with the high and low pressure sides of said gassifiers, means for causing the high-pressure gases from the gassifiers to actuate said injectors thereby to reduce the pressure in the low-pressure tanks and increase the pressure in the high-pressure tanks, and means for storing up in said low-pressure tanks the gases generated in the gassifiers by natural evaporation.

5. An apparatus of the character described, comprising a gas-liquefying apparatus, a filling flask communicating therewith, a storage tank for liquefied gas in communication with said filling flask and apparatus, and a movable storage tank for liquefied gas also in communication with said filling flask and apparatus.

6. An apparatus of the character described, comprising a gas-liquefying apparatus, a liquefied-gas container and a re-fill device in communication with said apparatus, pressure tanks connected with said container, means for utilizing the automatic evaporation of the liquid contents of said container for generating high pressure in said re-fiill device, and means for utilizing said high pressure for increasing the gas pressure in some of said pressure tanks and reducing the pressure in the remainder of the tanks.

7. An apparatus of the character described, comprising a gas-liquefying apparatus, a low-pressure tank and a high-pressure tank in communication with said apparatus, pressure tanks connected with said low-pressure tank, the communications being such that the evaporation products from said low-pressure tank are operative to generate high-pressure in said high-pressure tank, and injectors disposed between said pressure tanks and said high-pressure tank and adapted to be operated by the high-pressure generated in the latter to produce increased pressure in some of said pressure tanks and reduced pressure in the remainder of said tanks.

In testimony whereof I have signed my name to this specification.

CHRISTIAN WILHELM PAUL HEYLANDT.

Dec. 23, 1930. C. W. P. HEYLANDT 1,786,159

TRANSFERRING LIQUEFIED GASES

Filed Feb. 9, 1929

Fig. 1.

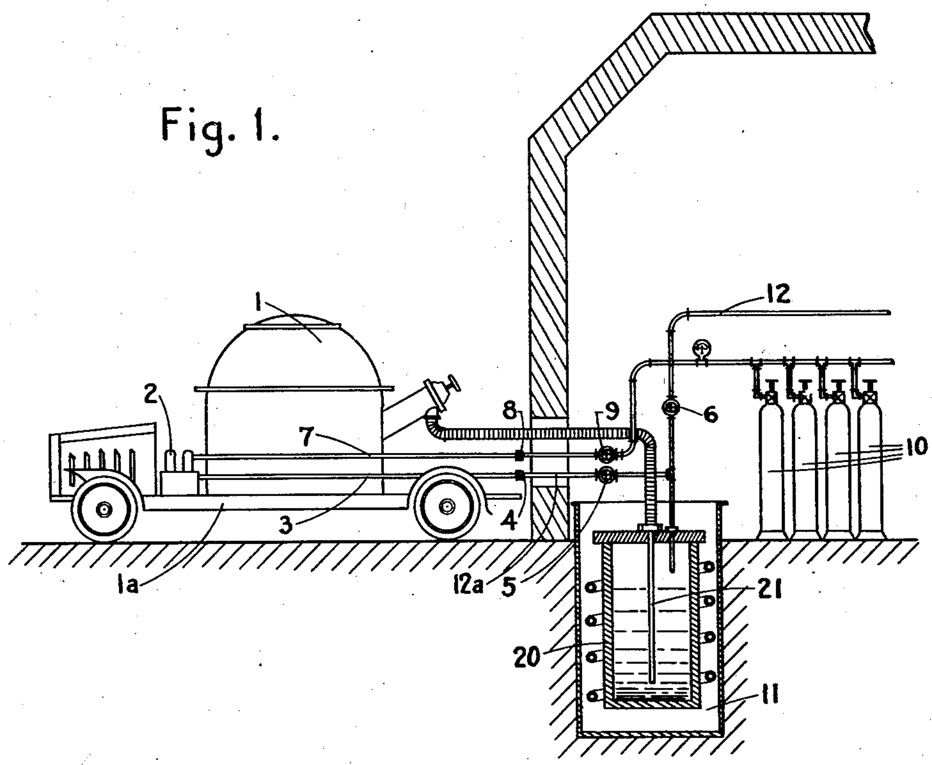
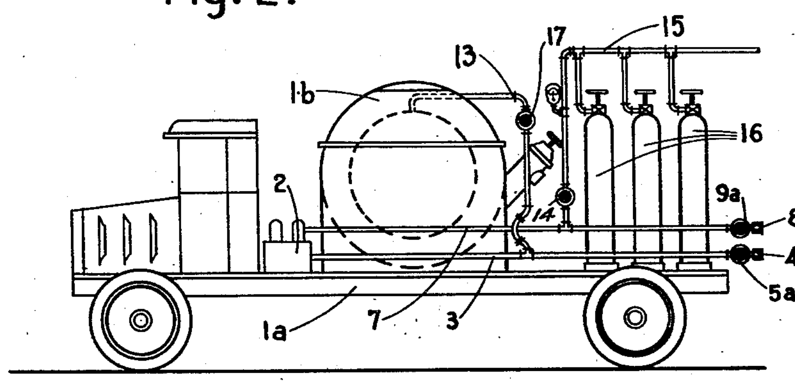



Fig. 2.

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INVENTOR

BY ATTORNEYS
Ruege, Boyce + Bakelar

Patented Dec. 23, 1930 1,786,159

# UNITED STATES PATENT OFFICE

CHRISTIAN WILHELM PAUL HEYLANDT, OF BERLIN-LANKWITZ, GERMANY

TRANSFERRING LIQUEFIED GASES

REISSUED

Application filed February 9, 1929, Serial No. 338,653, and in Germany February 16, 1928.

The present invention relates to a process and apparatus for the utilization of the gases ordinarily lost and remaining during the emptying, filling and transferring of liquefied gases of a low boiling point, said process having the distinctive feature that the liquefied industrial gases are transported to the place of consumption and there brought to the desired pressure by mechanical compression in order to avoid losses caused during transferring, while fully utilizing the inherent advantages of the transportation of liquefied gases.

The process has furthermore the characteristic feature that the residual gases which are not brought by self compression to the desired working pressure at the place of consumption, are brought to high pressure by means of mechanical compression, for instance by compressors in order to avoid losses. Finally, the subject matter of the invention is characterized by the fact that gases developing in the liquid containers during the gas consumption intervals and causing excess pressures, in said liquid containers, are brought to high pressures in the high pressure gas storage containers, by means of mechanical compression agents, as distinguished from self compression.

Liquefied gases of low boiling point such as, oxygen, nitrogen, hydrogen, methane, and the like, used for industrial purposes, are usually compressed into steel cylinders at the place of production and from there shipped to the places of consumption located at a distance, or they may be conducted there in pipe lines. Both of these methods of supply are costly, because the average weight of steel cylinders capable of taking only 0.5 kgs. of hydrogen or 8 kgs. of oxygen is 75 kgs., and of course the laying of pipe lines is expensive. The same conditions prevail in connection with the shipping of other similar gases.

More favorable results are obtained, if the gases are first of all liquefied and then transported in liquid condition.

The purpose of economy will be still further served if the gases, conveyed to the place of consumption in liquefied condition, are compressed at the place of use in suitable devices, by self-compression, to the desired pressure, i. e. under given circumstances up to 150 atm. and more.

In this connection difficulties, however, are encountered inasmuch as in the conveying of the liquefied gas from the vessel in which it is transported into the high pressure gasifier there are always certain unavoidable losses due to the transfer. Furthermore, the present high pressure gasifiers together with the low temperatures occurring in the evaporation process and in particular in connection with the production of very high pressures, do not meet the necessary requirements. I have found that these difficulties can be eliminated by bringing the gases, after transportation in liquid condition to the desired pressure at the place of consumption, by mechanical compression agents, whereby the advantages of transportation in liquefied condition are fully utilized while losses occurring during the transfer are almost entirely avoided.

The process in accordance with the invention therefore consists of the combination of processes partly already known. The technical effects, however, bring about a reduction in costs which is approximately equivalent to one half of the present production price. On account of the fact that gases, for instance the constituents of the coke furnace gases difficult to bring to a boiling point, or oxygen and nitrogen, are used in liquid condition,—one can figure on a much greater shipping radius or zone with the same investment of capital as compared with the use of pipe lines or shipment in steel cylinders.

The producer factories can therefore be maintained as large plants. The proven saving on account of this measure is about 50 per cent of the present manufacturing costs. As a further advantage theremust be taken into account the considerable reduction of the costs in connection with shipments also for large distances. In the practice of the present invention, the shipping costs are only 15 per cent of the costs resulting from shipment of the gases in steel cylinders. A further advantage is the delivery of the liquefied gases to the consumer with absolutely no loss, for the reason that all evaporation losses during the emptying and transfer period and during operation are completely avoided by providing for the mechanical compression of such evaporation products. In this connection it is very important that the mechanical compression be carried out not at the place of production but at the place of consumption.

Finally the process can be carried out in such a manner that a part of the liquefied gas is carried directly from a low pressure tank to the place of consumption, by transferring into a high pressure tank for automatic gasification and high pressure compression, while the other part, i. e. the arising so-called waste gases, by means of mechanical compression work, are brought to such a high pressure as can only be obtained with great difficulty by self-compression for practical reasons.

In this manner, liquefied gases can be stored for quite long periods of time without any losses so that in a time of non-consumption the resulting evaporation products are brought continuously, by mechanical compression means, into suitable pressure containers at the place of consumption, in this way avoiding a loss of gas to the outside.

The expenditure of work for such a compressor which in such event has to compress gas of about 75 ats. to 150 ats. is very small. In connection with about 100 cubic meters per hour, it is only about 2 H. P. In the latter case, the revolving compressor is arranged at the place of consumption.

In the drawings accompanying this specification,

Fig. 1 is a partly sectional diagrammatic side view of an apparatus adapted to carry out the process herein described; and

Fig. 2 is a similar side view illustrating a modified form of the apparatus.

In Fig. 1 of the drawing, 1 designates a vessel adapted to contain liquefied gases, said vessel being mounted on a motor truck $1^a$. On the truck is also mounted a compressor 2, which may be operated by the truck motor. Communicating with said compressor are a pair of pipe lines 3 and 7, which may be formed of pressure hose and provided with connections 4 and 8 respectively. At the place of consumption is constructed a chamber 11 in which is disposed a gasifier 20, having a filling tube 21 communicating with a liquid conveyor line 22 which communicates with the outlet from the transporting vessel 1. The gasifier 20 is also provided with a gas outlet pipe line 12 having a valve 6 for controlling the flow of gas therefrom, said pipe line having a branch $12^a$ which communicates with the main pipe 12 at a point between the valve 6 and the vessel 20, said branch being provided with a valve 5 and having a connection at its free end adapted to be coupled with the connection 4 of the pipe 3. Also disposed at the place of consumption are a plurality of steel cylinders 10, each in communication with a pipe line 23 provided with a valve 9 and having at its free end a connection adapted to be coupled with the connection 8 of the pipe line 7.

With the apparatus above described, the storage and supply cylinders 10 may be charged with gas at a given high pressure by transferring the substance in the liquid condition from transport vessel 1 to the vessel 20 in chamber 11. After transfer to the latter vessel, the liquid is allowed to warm up and vaporize, thus producing a high pressure, and upon opening the valve 6 the gas flows into and charges the cylinders to the required pressure. After all the pressure gas has passed from the vessel 20, the valve 6 is closed and valves 5 and 9 opened, whereupon the residue of gas remaining in the vessel 20 which is at a pressure below that of cylinders 10, may be drawn off by the pump 2 and forced into the cylinders at the required pressure. This operation takes place prior to the introduction of a fresh charge of liquid into the vessel 20. In this manner, the gas remaining in vessel 20 after each operation, instead of being lost as heretofore, is compressed mechanically and may be forced into one of the steel cylinders 10 or into a low-pressure receptacle ready for consumption when required.

In the modification illustrated in Fig. 2, the liquefied gas container $1^a$ is shown mounted on the truck $1^a$, together with the compressor 2 and a plurality of pressure vessels 16. The compressor in this instance is placed in communication with the upper portion of the liquefied gas container and with the pipe 3 by means of a pipe 13 provided with a valve 17, in addition to the pipe lines 3 and 7 hereinbefore described for communication with the vaporizer and the stationary pressure tanks 10. The valves $5^a$ and $9^a$, as well as the pipe connections $4^a$ and $8^a$ carried by the pipes 3 and 7 are in this instance disposed at the outer ends of said pipes, the tanks 16 communicating with the pipe line 7 by way of a pipe 15 provided with a valve 14. By reason of this construction, the compressed gas can be supplied directly from the truck to the consumer.

Having thus described and ascertained the nature of my said invention, what I claim is:

1. The process of supplying gases at a predetermined pressure, which consists in charging a closed vessel with liquefied gas, vaporizing the liquid in said vessel and causing the major portion of the gas to flow therefrom at the desired pressure, and mechanically drawing off the residue from said vessel and compressing it to the required pressure.

2. The process of supplying gases at a predetermined pressure, which consists in charging a closed vessel with liquefied gas, vapor-

izing the liquid in said vessel and causing the major portion of the gas to be self-compressed and to flow from said vessel at the required pressure, and pumping the residue from said vessel and forcing it at the desired pressure into a pressure container.

3. Apparatus for supplying gases at predetermined pressures, comprising in combination, a portable liquefied-gas container, a portable compressor, a vaporizing vessel, means for establishing communication between said container and vessel for delivering liquefied gas to the latter thereby to vaporize said gas, means for automatically delivering the major portion of said vaporized gas at the desired pressure, and communicating means between said compressor and vaporizing vessel for withdrawing the residue from said vessel and compressing said residue.

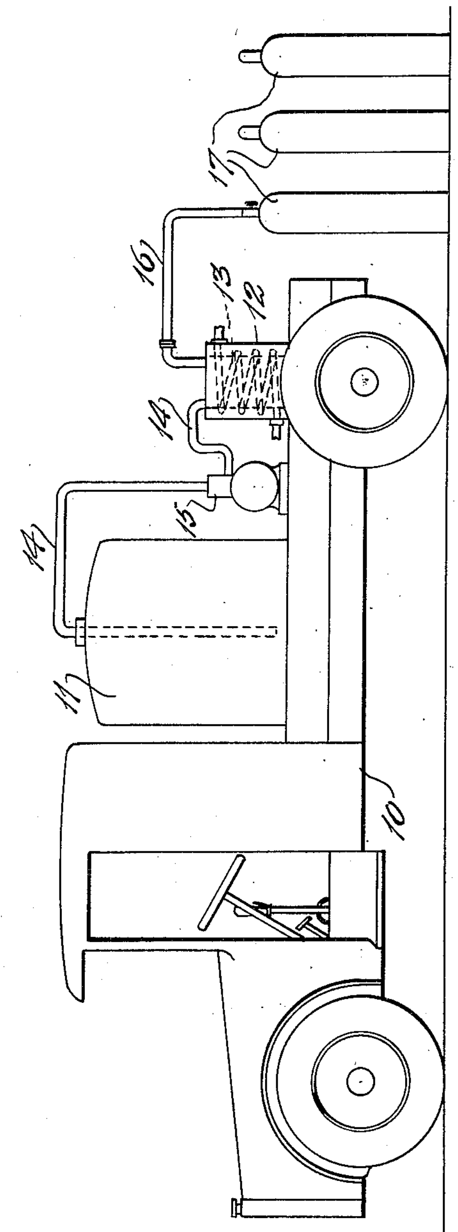
In testimony whereof I have signed my name to this specification.

CHRISTIAN WILHELM PAUL HEYLANDT.

Oct. 6, 1931. C. W. P. HEYLANDT 1,826,248

GAS SUPPLYING METHOD AND DEVICE THEREFOR

Filed Feb. 16, 1928

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Patented Oct. 6, 1931 1,826,248

# UNITED STATES PATENT OFFICE

CHRISTIAN WILHELM PAUL HEYLANDT, OF BERLIN-LANKWITZ, GERMANY

## GAS SUPPLYING METHOD AND DEVICE THEREFOR

REISSUED

Application filed February 16, 1928, Serial No. 254,912, and in Germany February 24, 1927.

This invention relates to a gas supplying method, the characteristic feature of which is, that oxygen or similar industrially useful gases having a low boiling point and which are produced otherwise than by mechanical air separation, as for instance the waste gases from chemical processes, are liquefied in a manner known in the low-temperature cooling technics and are delivered to the consumers in liquid state in receptacles for the purpose of being industrially utilized at any desired place.

In large gas producing plants, in which larger quantities of gas must be stored, although the gas consumption is small or where gases must be permitted to escape uselessly into the atmosphere, the impossibility of utilizing such gases has an important bearing on the economy of the total procedure. The same is true of such chemical processes, in which certain gases are produced for chemical synthesis (ammonia-synthesis, electrolytic-decomposition of water and the like), but where only the one or the other component of the gases can be industrially utilized, whereas the rest must be allowed to escape uselessly. It is chiefly the oxygen and the nitrogen which are liberated in certain manufacturing processes.

Now, according to this invention, such gasiform by-products are subjected to subsequent liquefication, so that they not only can be stored in liquid state and with a small requirement of space, but can, in view of their lower weight and in contradistinction to compressed gases, be conveyed in steel-bottles to great distances to be utilized where-ever required.

It has already been proposed to transport liquefied gases having a low boiling point, for instance oxygen, in large quantities and in special vessels and to convert them into pressure gas at the place of consumption. The gases, however, were filled in liquid condition at the place of consumption from the transporting vessel into so-called cold or warm vaporizers, in which the conversion into pressure gas took place, in cold vaporizers the resulting pressure being approximately 30 atmospheres and in the warm vaporizer 150 atmospheres. This method of converting the liquefied gas into pressure gas necessitates, however, for small consumers, which represent the majority of the customers, an investment of a large amount of capital, as vaporizers were required at the place of consumption.

It has also been proposed to vaporize the liquefied gas within the transporting vessel at the place of consumption and to use it as gas of the desired working pressure. This is possible in cases where at the place of consumption only low working pressures (15 atmospheres and the like) are required, since in case of higher pressures the vessels must necessarily be of exceedingly strong and heavy construction, whereby the economy of transporting the gas in the liquid state would be offset.

The aforementioned disadvantages are overcome by the present invention, which consists in providing on rolling stock an installation for the production of liquid oxygen, together with a transporting vessel for the liquid oxygen and a pressure gas producer, or only the transporting vessel together with the pressure gas producer may be mounted on said rolling stock, for instance on a motor truck. For this purpose an installation for producing liquefied gas, which may be known per se, is disposed on rolling stock, together with a storage vessel and a pressure gas producing device, into which the liquid is brought, or only a transporting vessel together with a pressure gas producer may be mounted on said rolling stock.

For conveying the liquefied gas into the vaporizer, a pump may be provided, which forces the liquid into the vaporizer, or the conveying means may be omitted and the transporting vessel connected directly to a warm or cold vaporizer.

In the accompanying drawing the figure shows an outline side elevation of an embodiment of the invention using a motor driven truck for the transporting vehicle.

In this embodiment an ordinary motor driven truck 10 is used and on this is mounted a thin walled container 11 for holding a large quantity of gas in liquefied form. To the rear of this container is shown a heavy walled vaporizing apparatus 12 of any desired form, means for supplying the necessary heat to this apparatus being typically indicated by a pipe coil 13. Piping 14 connects the container and vaporizer so that liquefied gas may be delivered to the vaporizer and suitable means are employed to effect such delivery, the means being here indicated by a small pump 15 interposed in the piping 14. A delivery pipe 16 leads from the vaporizer and is arranged for connection to any one of a plurality of storage bottles 17 located at the point or points to which delivery is to be made.

In operation the liquefied gas under substantially no pressure passes from the container to the vaporizer and is there transformed to gasiform gas under such pressure (say 2500 to 3000 pounds per square inch) as may be desired and, in that condition, is fed into the storage bottles.

The principal advantage of the present process consists in the fact that the consumer can be supplied much more quickly than heretofore with pressure gas at any desired pressure without the necessity of every consumer being provided with a special vaporizing apparatus, which requires the laying out of considerable capital. A further advantage is that such gases as are obtained as by-products in the manufacture of nitrogen and hydrogen, can by this method be used, instead of permitting them to escape into the atmosphere as heretofore.

I claim:

1. A process of handling high pressure gases which consists in passing at intervals liquefied gas from a low pressure storage container into a high pressure vaporizer, applying heat to said vaporizer and thereby converting said liquid into gas of high pressure and storing said high pressure gas in suitable containers.

2. A portable apparatus for handling gases including a wheel supported vehicle, a thin walled low pressure container mounted on said vehicle and adapted to hold a large quantity of liquefied gas and retain the same in liquid state, a high pressure vaporizer mounted on said vehicle and arranged to receive liquefied gas from the container, and piping leading from the vaporizer and adapted to be connected to a storage tank for gas under high pressure.

3. A portable apparatus for handling gases including a motor vehicle, a low pressure container carried by said motor vehicle and adapted to contain a large quantity of liquefied gas, a high pressure vaporizer mounted on said vehicle, piping connecting the vaporizer and container, other piping leading from the vaporizer and adapted to connect the same to a storage tank for high pressure gas, and means to supply heat to the vaporizer.

In testimony whereof I have signed my name to this specification.

CHRISTIAN WILHELM PAUL HEYLANDT.

METHOD AND APPARATUS FOR USE IN STORING AND TRANSPORTING LIQUEFIED GASES

Filed Nov. 12, 1927

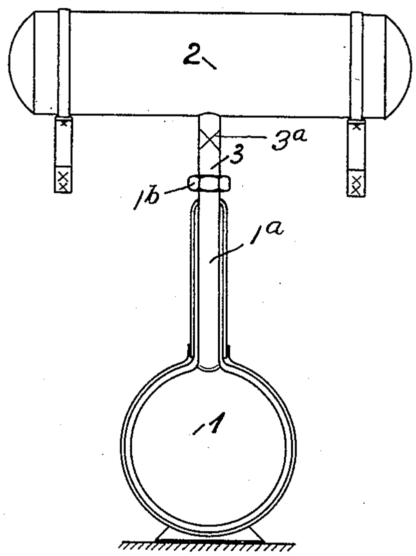


Fig. 1

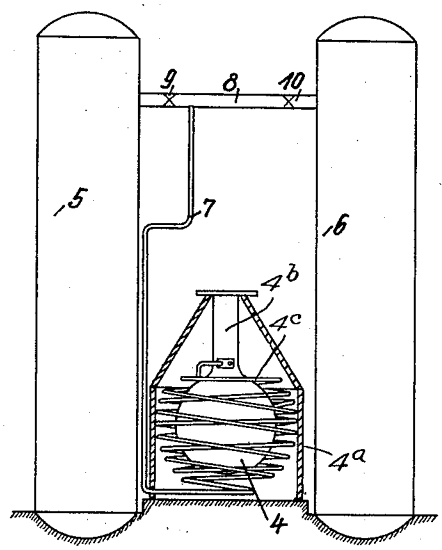


Fig. 2

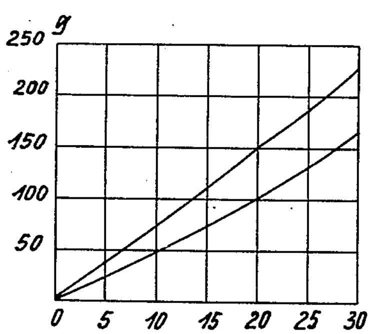


Fig. 3

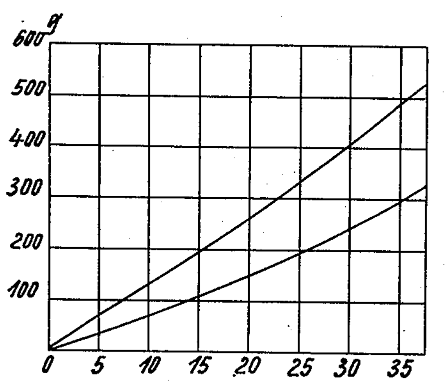


Fig. 4

INVENTOR:
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ATTORNEYS.

Patented July 5, 1932

1,866,515

# UNITED STATES PATENT OFFICE

CHRISTIAN WILHELM PAUL HEYLANDT, OF LANKWITZ, GERMANY, ASSIGNOR TO FLUGA AKTIEN-GESELLSCHAFT, OF ST. MORITZ, SWITZERLAND

## METHOD AND APPARATUS FOR USE IN STORING AND TRANSPORTING LIQUEFIED GASES

Application filed November 12, 1927, Serial No. 232,922, and in Germany November 13, 1926.

This invention relates to a method and apparatus for use in storing and transporting liquefied gases and has for its object generally the provision of an improved procedure and suitable means for carrying the same into effect, whereby liquefied gases may be retained in their containers substantially without losses due to evaporation during desired periods of time.

Heretofore, liquefied gases which have low boiling points, for example, liquefied air, oxygen, nitrogen and the like, were customarily stored and transported only in containers which were in free communication with the atmosphere, which permitted the gases evolved by evaporation to escape.

If it was desired to conserve the gases arising by evaporation, the containers were connected to gasometers which generally had water seals. The gas products so collected, however, could not readily be utilized without recompression, since the pressure in such gasometers is very low. No appreciable change in the rate of evaporation in such containers, however, is effected by the use of gasometers.

In the practice of the present invention, the containers used for storing and transporting the liquefied gases are connected to gas receivers of fixed size which are so dimensioned that they will hold all the gas evolved within a desired period of time from the container. The pressure which thus builds up to a certain maximum in the receiver has the beneficial result of reacting on the liquid in the container to reduce the rate of evaporation. This reduction in the rate of evaporation is of a relatively high order; for example, it has been ascertained from ample experimental observations that the rate of evaporation from liquefied gas containers open to the atmosphere is 80% higher than the rate in certain apparatus constructed in accordance with the invention. In our apparatus the rate at which pressure builds up is, of course, a very slow one. There are other advantages incident to our apparatus, especially when designed to employ relatively high pressures, for example, where pressures of more than 30 atmospheres are employed. This permits the use of relatively small gas receivers. Such receivers may be used in conjunction with containers which are either of the vacuum variety or of the variety having an insulated inner vessel, though the former, as a rule, are not able to withstand as high internal pressures as the latter, and hence in general are made smaller and are employed for the lower pressures.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others, and the apparatus embodying features of construction, combinations of elements and arrangement of parts which are adapted to effect such steps, all as exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

Figure 1 is a diagrammatic view showing one form of apparatus suitable for carrying out this invention.

Figure 2 is a similar view of a second form.

Figure 3 is an evaporation diagram showing a comparison between free air evaporation in a vacuum walled container and the evaporation as in the form of device shown in Figure 1.

Figure 4 is an evaporation diagram illustrating and comparing evaporation in a heat insulated vessel open to the air and in the form of apparatus shown in Figure 2.

In the apparatus disclosed in Figure 1 there is provided a vacuum walled container 1 having an elongated neck 1*a* which is connected by a coupling 1*b* with a pipe 3 leading into a gas receiver 2, said pipe being provided with a valve 3*a*. In Figure 2 there is shown a liquefied gas container 4 which is supported within an insulating casing 4*a* and has a closed neck 4*b* from which extends a pipe 4*c* which is wound spirally around the container 4 and within the casing 4*a* and then passes out through connection with a pipe 7 to a pipe 8 which is connected to a pair of receivers 5 and 6 and is provided with valves 9 and 10 to cut off communication between the pipe 7 and the respective receivers 5 and 6. Now, it will be observed that under these conditions there is produced in the form shown in Figure 1 a closed system which consists of a liquefied gas container, a gas receiving means and an elongated and valved tube affording communication between the liquefied gas container and the gas receiving means. Moreover, the greater part of the connecting tube is preferably vacuum walled.

Substantially the same arrangement is employed in Figure 2 except that the pipe connecting the container 4 and the receivers 5 and 6 is relatively much longer but is also well insulated from external heat, being held in the insulating casing 4*a*. Under these conditions a long pressure column will exist in the communicating pipe and pressure will be produced in the liquefied gas container which will in consequence decrease the rate of evaporation. Furthermore, this pressure may be regulated by the valve or valves shown.

As a result of the provision of a head of pressure in the column connecting the container with receivers 5 and 6, they may be made smaller than in the arrangement shown in Fig. 1 when providing storage for equivalent amounts of gasified liquid. Also it is seen that if the container were enlarged along its vertical dimension, it would be necessary to have the internal volume correspondingly enlarged in order that the final pressure be not increased, since the receiver connected to the container has from the start a retarding influence which checks evaporation.

This is well seen by reference to Figures 3 and 4 in which the upper curve indicates normal evaporation in the particular type of vessel with free communication to the air while the lower curve indicates evaporation under retarded conditions produced by the long pressure column in the tube connecting the liquefied gas container and the gas receiving means.

From the data thus depicted it is possible to provide gas receivers for use in connection with containers of any desired size which will conserve all of the gas that may be evolved by evaporatiton during any period contemplated for storage or transportation or both; it being a simple matter to calculate the dimensions of the receiver desired to achieve this effect under the conditions specified. For example, assume that it is ascertained that for a certain container of 50 litres capacity the rate of evaporation when open to the atmosphere is 65 grams per hour, while if the evaporation be made to take place under a continually increasing pressure, as here proposed, the rate is reduced to from 35 to 40 grams per hour, which represents about 30 litres of gas at atmospheric pressure evolved per hour; then when it is specified that the period of storage or transport shall be 2 x 24 hours, and the maximum pressure permitted is 10 atmospheres, the required volume of the receiver is calculated as follows:

$$\frac{2\times24\times30}{10}=144 \text{ litres.}$$

If any of the gas generated by evaporation during this period is to be used during the period, the volume of the receiver may be correspondingly reduced.

Since certain changes in carrying out the above process and in the constructions set forth, which embody the invention may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

Having thus described the invention, what is claimed as new is:

1. The method of conserving liquefied gases when being stored or transported, which comprises providing a gas receiver of fixed capacity to receive all the gas normally vaporized during a desired period of time and dimensioned so as to hold the same without exceeding a predetermined maximum pressure, and passing the gas normally vaporized in a container into said receiver while under a constantly increasing pressure.

2. In apparatus for use in storing and transporting liquefied gases, the combination with a liquefied gas container, of a gas receiver connected therewith of fixed size having dimensions such that it is capable of holding all of the gas normally vaporized in said container in a desired period of time and at a pressure not in excess of a predetermined maximum.

3. In apparatus for use in storing and transporting liquefied gases, the combination with a liquefied gas container, of a gas receiver connected therewith of constant volume so dimensioned that it is capable of holding the maximum amount of gas normally vaporized from said container, and insulated communicating means connecting said container and said receiver whereby the vaporization is maintained at a low rate.

4. In apparatus for use in storing and

transporting liquefied gases, the combination with a liquefied gas container, of a gas receiver of constant volume so dimensioned that it is capable of holding the maximum amount of gas normally vaporized from said container, an elongated conduit of small diameter connecting said container and receiver, and an insulating jacket encasing said container and the major portion of said conduit.

In testimony whereof I have signed my name to this specification.

CHRISTIAN WILHELM PAUL HEYLANDT.

Patented July 5, 1932

1,866,516

# UNITED STATES PATENT OFFICE

CHRISTIAN WILHELM PAUL HEYLANDT, OF BERLIN-LANKWITZ, GERMANY, ASSIGNOR TO FLÜGA AKTIENGESELLSCHAFT, OF ST. MORITZ, SWITZERLAND, A CORPORATION OF SWITZERLAND

## METHOD OF CONSERVING LIQUEFIED GASES

No Drawing. Application filed July 17, 1929, Serial No. 379,075, and in Germany August 4, 1928.

This invention relates to a method of conserving liquefied gases while in storage or transport, particularly liquefied gases of low boiling point, for example liquid oxygen, nitrogen, ammonia, methane, and the like.

The invention has for its object generally an improved procedure for charging and operating containers for liquefied gases, that are relatively highly insulated, in such manner that the heat leakage which it is not practical to avoid is absorbed without loss of gas material.

More specifically, it is an object to provide a procedure for charging and operating containers of the character indicated, in which the relatively cold body of liquefied gas within the same is arranged to absorb the heat leakage in such a manner as to increase the heat absorbing capacity of such body of liquid to an extent sufficient to accommodate all the heat leakage that normally takes place in a predetermined interval of time without increased evolution of gas.

Heretofore, it was customary to store and transport liquefied gases when handled in large quantities by providing insulated containers which were open to the atmosphere, i. e., such containers were shipped and transported with the valve open, since it was found that the losses by evaporation ensuing from this practice were less than when the containers were shipped closed and the liquefied gas transferred to another container at the place of consumption.

In the practice of the present invention, a transport vessel of the insulated variety is provided which when filled with the desired quantity of the liquefied gas is closed to the atmosphere. The heat leakage which it is not practical to avoid is permitted to become absorbed by the body of liquefied gas in the container which, in consequence, becomes partially vaporized and pressure thereupon begins to build in the container above the body of liquid. This pressure reacts in a well known manner to increase the boiling point of the liquefied gas which in turn operates to increase the heat absorbing capacity of the liquid in the vessel. The increased capacity so imparted is such as to accommodate the heat leakage by absorption as sensible heat within the body of liquid without substantial evolution of gas during the desired period of storage or transport.

The following is an example of a specific manner in which the method of the present invention may be carried out:

The liquefied gas is placed in a vessel, having heat insulating walls, while under normal atmospheric pressure and at its normal boiling point under such pressure. In the case of oxygen the temperature will be substantially −182.5° C., for nitrogen it will be substantially −195.8° C., for ammonia gas −38.5° C., and for methane −164.7° C. For other gases the boiling points will, of course, be different but the foregoing show examples of the temperatures at which the liquefied gas must be placed in the container. The vessel is then closed whereupon sufficient of the liquefied gas evaporates to raise the pressure on the liquefied gas approximately one atmosphere. This has the effect referred to above of raising the boiling point. In the case of oxygen the boiling point under this additional pressure becomes approximately −170° C. With other gases the boiling points are raised in like manner, the points attained varying with the particular gas. While the boiling point of the liquefied gas is thus raised, the temperature of the body of gas within the container is not, at the time the pressure has increased one atmosphere, appreciably raised but it is still the same as it was when the liquefied gas was at its normal atmospheric boiling point. Liquefied gases are well known to absorb heat very slowly so that it will take much time for the liquefied gas in the container to be heated sufficiently to reach the new boiling point which has been indicated by the increase of pressure in the container. Thus, practically all of the small quantity of heat leaking into the container will be absorbed by the liquefied gas. There will, therefore be such a slow increase of pressure and such slow vaporization of the liquefied gas that no excessive pressure is produced in the container and consequently the gas may be transported for long distances without loss.

After the containing vessel is closed, the pressure builds up at a continually decreasing rate. This is in part due to the decrease in specific heat of the liquid which accompanies the elevation of the boiling point with increase in pressure. For example, where the pressure increases by about 1 atmosphere, the boiling point is raised from about −182.5° C. to about −170° C. with the result that the quantity of heat that is absorbed to increase the pressure thereafter does not so readily occur as at the beginning.

The present method is particularly applicable to the storage and transport of liquefied gases such as ammonia and methane, whose latent heats of vaporization have relatively high values. When liquid oxygen or nitrogen are stored or transported in accordance with the present method, they may be retained in ordinary transport vessels for periods of several days without encountering substantial losses from evaporation and without recourse to any special heavy construction for the transport vessels.

Having described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. The method of conserving liquefied gases, while in storage or transport, which comprises charging an insulated liquefied gas container with a desired body of liquefied gas, raising the boiling point of said body of liquefied gas by increasing the pressure thereon, and thereafter absorbing the heat leakage which permeates the insulation as sensible heat within said body of liquefied gas.

2. The method of conserving liquefied gases, while in storage or transport, which comprises charging an insulated liquefied gas container with a desired body of liquefied gas, causing the gas evolved within said container to increase the pressure on said body of liquid whereby its boiling point is raised, and thereafter absorbing the heat leakage as sensible heat within said body of liquid whereby the gas evolved within said container is made relatively small during a desired period.

3. The method of conserving liquefied gases, while in storage or transport, which comprises charging an insulated liquefied gas container with a desired body of liquefied gas, reducing the rate of latent heat absorption by said body of liquefied gas by reducing the temperature difference between said body and that of the external source, and absorbing the heat leakage which permeates the insulation as sensible heat within said body.

4. The method of conserving liquefied gases, while in storage or transport, which comprises charging an insulated liquefied gas container with a desired body of liquefied gas, closing the communication of the container to the outer atmosphere for substantially the period of time that said container is to be in storage or transport whereby the pressure builds up therein at a continually decreasing rate, and absorbing the heat leakage which permeates the insulation as sensible heat within said body.

In testimony whereof I have signed my name to this specification.

CHRISTIAN WILHELM PAUL HEYLANDT.

July 5, 1932. C. W. P. HEYLANDT 1,866,517

TRANSPORTATION OR PRESSURE VESSEL FOR GASES

Filed Jan. 11, 1930

Fig. 1.

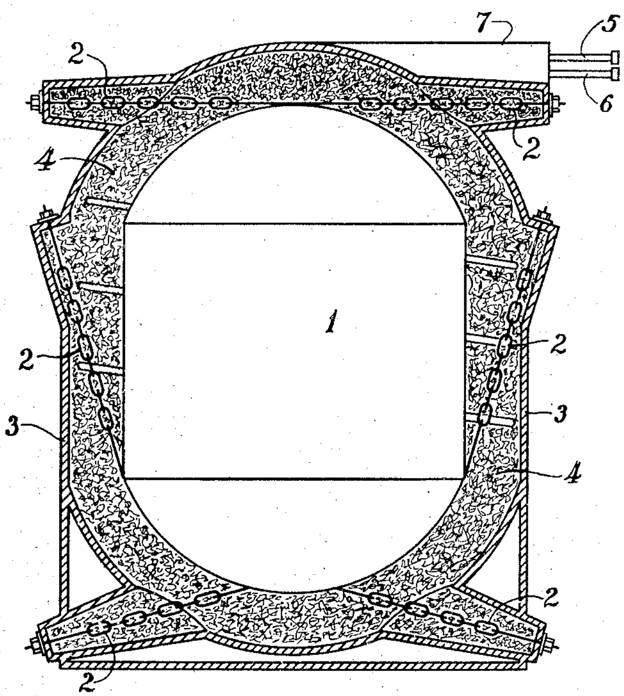



Fig. 2.

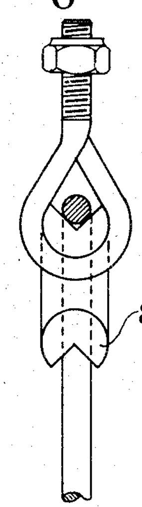



Fig. 3.

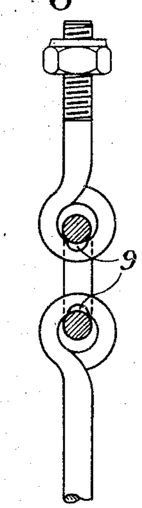
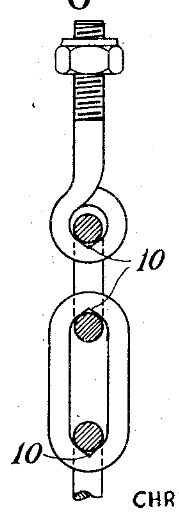



Fig. 4.




Inventor
CHRISTIAN W. P. HEYLANDT

By his Attorneys
Ruege, Boyce + Bakelar.

Patented July 5, 1932 1,866,517

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## TRANSPORTATION OR PRESSURE VESSEL FOR GASES

Application filed January 11, 1930, Serial No. 420,043, and in Germany November 13, 1926.

The present invention relates to containers for transporting liquefied gases particularly those which can be liquefied only with difficulty. The invention has for its object to provide a container for liquefied gases in which the inner vessel for the liquid is suspended and insulated from the outer jacket of the vessel in such manner as to reduce the transfer of heat from external sources into the liquid to a minimum.

More particularly it is an object to provide a container comprising inner and outer vessels separated by heat insulating material and provided with suspension means for the inner vessel which support the latter in a mechanically rigid manner with relatively little conduction of heat.

A more specific object of the invention is to provide a means for suspending the liquid-container in heat insulating relation to the outer jacket of the pressure vessel, comprising a chain so constructed that the transfer of heat from one link to another is substantially restricted.

The present application is a continuation in part of my copending application, Serial No. 232,924, filed November 12, 1927.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of construction, combination of elements, and arrangement of parts, which will be exemplified in the construction hereinafter set forth and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

Fig. 1 is a partly sectional view through a container constructed in accordance with the invention;

Fig. 2 is a fragmentary sectional view illustrating one form of the links of the chain shown in Fig. 1; and

Figs. 3 and 4 are views similar to Fig. 2, illustrating modifications of the links.

Referring now to the drawing, 1 designates a liquid container, which is suspended by means of chains 2 in a mechanically rigid manner from the outer jacket or shell 3 of a pressure vessel, in spaced relation to said jacket, the space between the container and jacket being filled with a suitable heat-insulating material 4. The container is shown in the present instance provided at its upper portion with suitable inlet and outlet tubes 5 and 6, which are embedded in insulating material within an extended portion 7 of the top of the jacket. This arrangement serves the double purpose of protecting the tubes against the influence of outside temperatures and providing a convenient terminus for the pipes that is advantageous in transportation.

The chains 2 are composed of a plurality of engaging links so connected to each other as to minimize the transmission of heat from one link to another. In order to minimize the rate of conduction of heat along the chain from the exterior, means are associated with the engaging portions of the connected links which offer greater resistance to the normal heat conduction. In the form shown in Fig. 2, a heat-insulating member of ring form is interposed between the engaging surfaces of the successive links, so that the links do not make direct contact with each other at any point. In Fig. 3 the interposed insulating member is omitted but an arrangement is used that reduces the amount of surface in contact between links. In this form a recess 9 is formed in the surface of one link, the radius of arc of said recess being less than the radius of the intersecting surface of the contacting link, so that the links contact with each other only at two points, one at each side of the recess 9. In the modification shown in Fig. 4 the links are in direct contact with each other, but in this case one link is formed with a sharp edged ridge 10 which engages the companion link only at a single point. If desired, both links may be provided at their intersecting portions with ridges so that the ridges cross each other and insure point contact.

Since certain changes may be made in the above construction and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. Apparatus for transporting liquefied gases, comprising, an outer jacket, possessing a desired degree of operative rigidity, a liquid-container within said jacket completely encompassed in spaced relation thereto, insulating material disposed between said liquid-container and jacket, and metallic chains suspending said container from the walls of said jacket, said chains being embedded in said insulating material, and comprising links having only point contacts with each other whereby transmission of heat through said chains is minimized.

2. A container for transporting and conserving liquefied gases, comprising inner and outer vessels having the intervening space filled with heat insulating material, said outer vessel having a wall of desired operative rigidity formed with outwardly extended portions, metallic chains having connected links traversing said insulating material anchored in the outwardly extended portions of said outer vessel disposed to maintain said space in its operative form and secured to the wall of said inner vessel, and means associated with the engaging portions of connected links for reducing the normal heat conduction between said links.

3. A container for transporting and conserving liquefied gases, comprising an inner vessel for holding liquefied gas and an outer supporting jacket disposed in spaced heat insulating relation without direct contact with said inner vessel, metallic chains anchored in the wall of said outer jacket and secured to the wall of said inner vessel whereby the space between said inner vessel and outer jacket is maintained in operative form, and means associated with one or more of said chains for obstructing the conduction of heat between any two consecutive links of said chains.

4. A container for transporting and conserving liquefied gases, comprising an inner vessel for holding liquefied gas and an outer supporting jacket disposed in spaced heat insulating relation without direct contact with said inner vessel, metallic chains anchored in the wall of said outer jacket and secured to the wall of said inner vessel whereby the space between said inner vessel and outer jacket is maintained in operative form, and engaging means on one link of said chain which is formed to obstruct the flow of heat and shaped to have substantially point contact with the adjacent link whereby the heat conduction to the inner vessel is minimized.

5. A container for transporting and conserving liquefied gases, comprising an inner vessel for holding liquefied gas and an outer supporting jacket disposed in spaced heat insulating relation without direct contact with said inner vessel, metallic chains anchored in the wall of said outer jacket and secured to the wall of said inner vessel whereby the space between said inner vessel and outer jacket is maintained in operative form, the engaging portion of one link of said chain having an edged ridge adapted to contact with the engaging portion of the connected link whereby the heat conduction to said inner vessel is minimized.

6. A container for transporting and conserving liquefied gases comprising, an outer jacket having a desired degree of operative rigidity, a container disposed within said jacket and spaced therefrom to provide an intervening space between the walls of said container and jacket which substantially completely encompasses said inner container, metallic chains for suspending said container from the walls of said jacket in a relatively fixed position with respect to said jacket, and means for obstructing the transmission of heat between consecutive links of said chains.

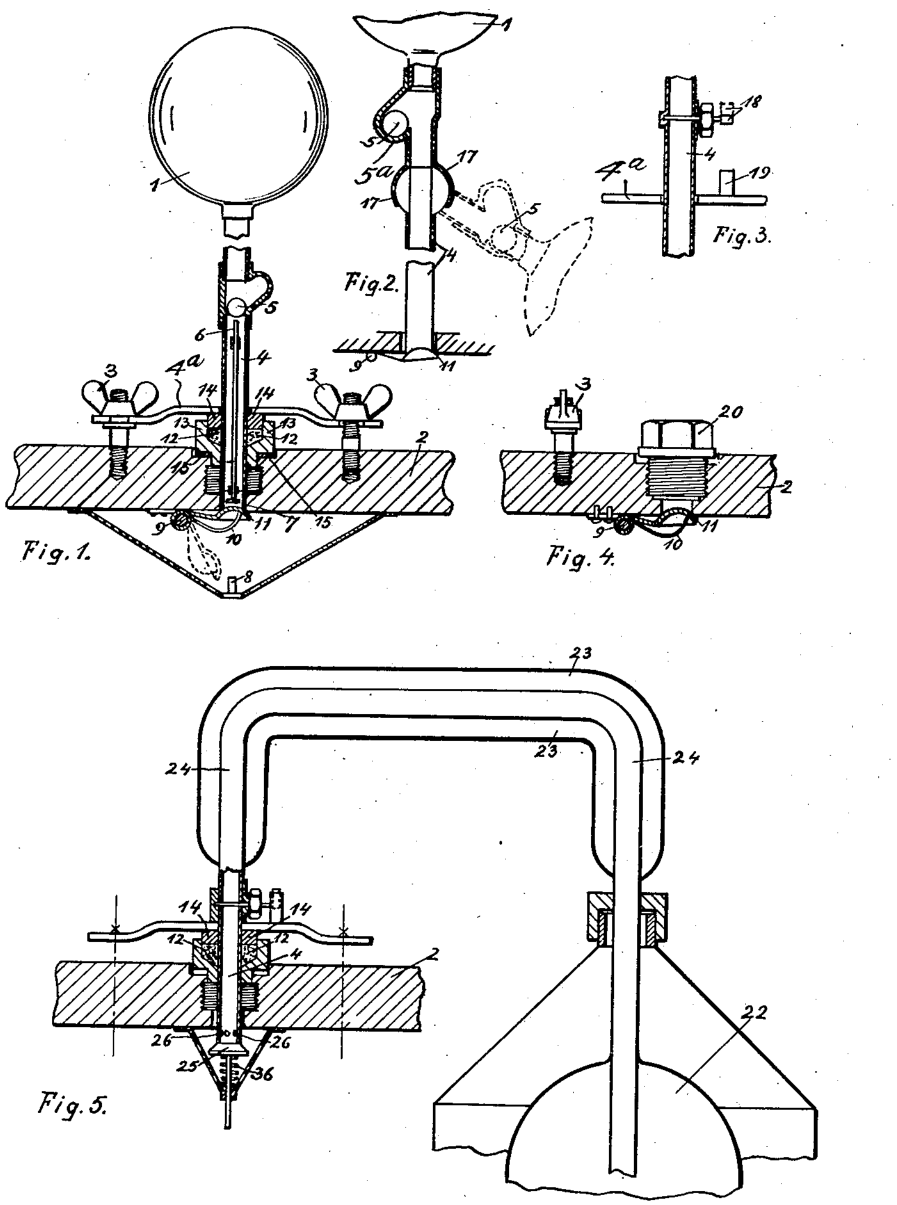
In testimony whereof I have signed my name to this specification.

CHRISTIAN WILHELM PAUL HEYLANDT.

March 14, 1933. C. W. P. HEYLANDT 1,901,445

APPARATUS FOR TRANSFERRING AND STORING LIQUEFIED GASES

Filed Nov. 12, 1927 2 Sheets-Sheet 1

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APPARATUS FOR TRANSFERRING AND STORING LIQUEFIED GASES

Filed Nov. 12, 1927 2 Sheets-Sheet 2

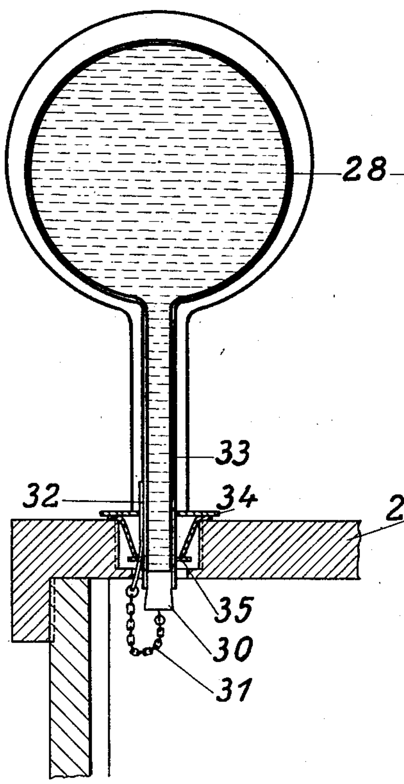


Fig. 6.

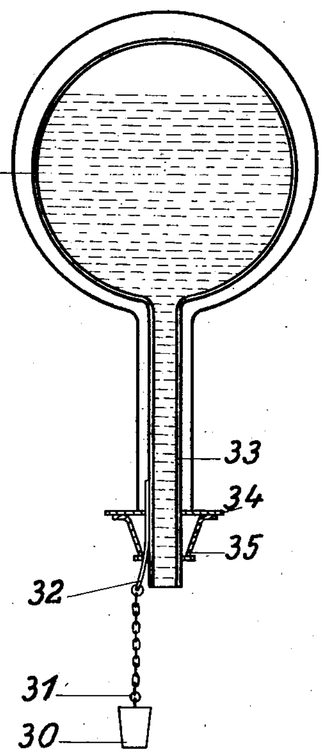


Fig. 7.

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## APPARATUS FOR TRANSFERRING AND STORING LIQUEFIED GASES

Application filed November 12, 1927, Serial No. 232,924, and in Germany November 13, 1926.

This invention relates to a method and apparatus for transferring and storing liquefied gases and has for its object generally the provision of suitable steps together with apparatus for carrying out the same whereby containers for liquefied gases may be readily and economically charged so as to avoid the waste of gas due to natural evaporation heretofore incident to a charging operation.

As is well known, whenever it is desired to transfer liquefied gases, such for instance as liquefied air, oxygen, nitrogen and the like, from one vessel into another, under the methods heretofore in use there is always considerable loss of gas by reason of the fact that the liquid must necessarily come into contact with a considerable area of the surface of the new vessel and is thereby heated and becomes vaporized, the vapors arising from the liquid being lost unless they are collected in a gasometer as these gases have little or no pressure, and before they can be utilized for useful work they must first be compressed in a suitable compressor, blowing machine or injector. This operation renders the utilization of the gases so expensive that they are usually permitted to escape into the atmosphere. The present invention, therefore, is designed to overcome the difficulties heretofore encountered in the handling of such gases in such manner that they can be stored, transported and transferred from one vessel to another practically without loss and to provide for the utilization of the waste gases produced by natural evaporation without the necessity of subjecting them to the action of a compressor.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a fragmentary view partly in section and partly in elevation illustrating the operation of filling a container for liquefied gases in accordance with the invention;

Figs. 2 and 3 are fragmentary detail views illustrating modified forms of automatically acting valves or closures for the filling means;

Fig. 4 is a fragmentary sectional view showing the container closed after being filled;

Fig. 5 is a view similar to Fig. 1, but showing the manner of filling the container from a liquid containing vessel of greater capacity than that of Fig. 1;

Fig. 6 is a vertical sectional view showing a measuring vessel provided with a modified form of closure; and

Fig. 7 is a view similar to Fig. 6, showing the closure removed from the vessel.

Referring to the drawings, and particularly to Fig. 1, a filling means, for example a double-walled vessel or measuring bottle 1 is shown mounted on the upper end of a thin-walled tube 4 which is separate from the filling means and is arranged for sliding movement in the wall 2 of a suitable container for liquefied gas, for example a vessel adapted to hold gas in a state of compression; only a portion of its top-wall being shown. The tube 4 is maintained in vertical position by means of a plate $4^a$ through which the tube passes, said plate being secured to the wall 2 in spaced relation thereto by suitable means, for example screws having wing nuts 3. A gravity controlled valve 5 in the form of a ball is provided for the measuring bottle, and means is provided for opening said valve as soon as the bottle is placed in inverted position with its symmetrical axis parallel to the direction in which gravity acts. The said valve-opening means comprises a rod 6 having a foot 7 supported within the tube 4 and arranged for longitudinal movement therein.

The opening in the wall 2, which receives the tube 4, has a cooperating valve 11 which automatically closes the same. This is here accomplished by providing the valve in the form of a flap-valve hinged to the under side of the wall 2 at 9, a spring 10 being coiled about the pintle of the hinge in order to bias the valve in closed position. By this arrangement it is seen that when the tube 4 is pushed through the opening in wall 2 under the influence of the filling means, the valve 11 is pushed back into the position indicated in dotted lines in Fig. 1.

A stop for limiting the descent of the tube 4 is also provided within the container below the opening in wall 2, which may be in the form of a frame that carries an upwardly projecting pin 8, arranged for cooperating with the foot 7 on rod 6. When the tube 4 had descended sufficiently low, the pin 8 engages the foot 7 of the rod 6 and upon further descent of the tube the rod moves upward and thus pushes the ball 5 from its seat thus permitting free passage of liquid from the vessel 1 to the container.

For preventing leakage of gas or liquid at the point where the tube 4 enters the container, a stuffing box is provided which comprises a flanged box 13 packed with a suitable packing material 12, which is compressed by a metal ring or follower 14. The box 13 is seated in an opening in the wall 2, a packing ring 15 of elastic material being interposed between the box and its seat. The packing material 12 should preferably be renewed before each filling operation, in order to guard against the hardening of the material due to freezing. For closing the opening in the wall 2 after removal of the stuffing box therefrom, the wall of the opening is threaded for the reception of a threaded plug 20, as shown in Fig. 4.

In Fig. 2 the gravity valve is shown connected with the tube 4 by means of a ball joint 17 of well known construction. In this form of the device, when a measuring bottle is raised from the position shown in dotted lines to the vertical filling position, the ball 5 will fall into the tubular portion below the pocket $5^a$ until it rests on the upper end of the rod 6, which is omitted from this figure for the sake of clearness. When the tube 4 moves downward into the compression tank 2, however, the valve 11 is first opened against the tension of its spring 10, but as soon as the lower end of the rod 6 contacts with the pin 8 further descent of the rod is prevented while the tube 4 continues its downward movement until the ball rolls off the upper end of rod 6 and falls into the packet $5^a$ and thus leaves a free passageway for the passage of liquid from the measuring bottle 1 to the container.

In Fig. 3, an automatically operative butterfly valve is shown in the tube 4 which may take the place of either of the valves shown in Figs. 1 and 2. In this form the valve is provided with a crank lever 18 which, when the tube 4 moves downward, strikes the end of a lug 19, thereby tilting the valve into open position.

In Fig. 5 there is shown a form of the device, adapted for transferring fluid from a liquid container, of greater capacity than that shown in Figs. 1 and 2. In this apparatus the vessel 22 communicates with the tube 4 by way of a siphon pipe 24, the exposed portion of which is provided with an insulating jacket 23. The tube 4 in this case is mounted in the same manner as described in connection with Fig. 1 and is provided with a valve similar to that shown in Fig. 3. In place of the valve 11 and the springs shown in Fig. 1, a valve member 25 of the poppet variety is provided and arranged to seat on the under side of the opening in the container wall 2. A spring 36 is disposed to bear against this valve member in order to bias it in closed position. The tube 4 bears downwardly on this valve member when it slides into the opening in container wall compressing the spring 36; the tube being provided with one or more openings 26 in its side, which are uncovered when the tube has reached its downward limit of motion. The butterfly valve in this tube is also so positioned that when the tube has reached this lowermost position, the trip mechanism throws the butterfly valve also into the open position, so that a free passageway for liquid from the vessel 22 is established.

In Figs. 6 and 7 there is shown a further modification which is adapted to accomplish a filling operation in a quick and simple manner. In this form of device a measuring bottle 28 is indicated inverted and provided with a neck 33 extending into a filling opening in a top-wall 29 of a container of the pressure variety. The neck 33 is normally closed by a stopper 30 secured to one end of a chain 31, the opposite end of which is secured to the free end of a spring 32 which is soldered or otherwise secured to the neck of the measuring bottle. A funnel 35 is seated in the opening in the wall 29 and serves to guide the spring 32 when the neck 33 is placed therein. By means of said funnel, the spring 32 is compressed so that it can spring out radially from the neck only to a predetermined extent. Applicant has observed during numerous tests that rubber when exposed to low temperatures, such for instance as that of liquid oxygen, contracts considerably. For this reason, the stopper 30 is made of rubber, and applicant has proven beyond question that the freezing action of the liquid above the inverted stopper will cause the same to contract, whereupon the downward pressure of the liquid will expel the stopper, as shown in Fig. 7, such expulsion being probably assisted by the contact of the liquid with the warm stopper. The action of the spring 32 is such as to carry the stopper to one side and out of the path of the descending liquid so as to avoid spraying said liquid.

In all these forms of device, it will be seen that the arrangement, by which the filling tube or neck of the charge containing vessel is guided and introduced into the filling orifice, is such as not only to reduce the escape of compressed gas from the orifice when a filling operation is about to take place, but also to insure against the conduction of substantial amounts of heat to the charge of liquefied gas; since the operative engagement between the wall of the container and the neck is reduced to a very small area or permitted only at a very few points. This is particularly true of the forms shown in Figs. 1 and 5, where the tube 4 engages with a packing 12 that is of insulating material and then traverses a hollow chamber in the wall 2 before further engagement, which displaces the biased valve guarding the orifice of the container.

These arrangements, however, are merely illustrative of suitable means for carrying out an important step of the method of the present invention. By such means, the step of insuring against losses, which may be due in part to the escape of compressed gas from the orifice at the commencement of or during the filling operation and in part due to heat conduction from the wall of the container to the charge of liquefied gas being discharged into the container, is accomplished. Thus after the neck of the charge containing vessel has been introduced, the practice of this step enables one thereafter to effect the release of the charge from its vessel into the container in a manner which is substantially without loss of gas material.

Since certain changes in carrying out the above method and in the constructions set forth, which embody the invention, may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In apparatus for transferring and storing liquefied gas, the combination with a container for liquefied gas of the pressure type having a wall provided with a filling orifice and means for maintaining the same normally closed, of a filling vessel for holding a charge of liquefied gas provided with a neck adapted to extend through said filling orifice, means in said orifice for guiding said neck to operative position arranged to have thermal contact with the same over a relatively small area, and means in said neck for releasing said charge from said filling vessel when moved to operative position.

2. In apparatus for transferring and storing liquefied gas, the combination with a container for liquefied gas of the pressure type having a wall provided with a filling orifice and means for maintaining the same normally closed, of a filling vessel for holding a charge of liquefied gas provided with a neck adapted to extend through said filling orifice, means for limiting the entrance of said neck into said orifice, additional means in said orifice for guiding said neck to operative position arranged to make thermal contact therewith over a relatively small area, means in said neck for releasing said charge from said filling vessel, and means associated with said neck for automatically operating said releasing means when said neck has moved to the limiting position.

3. In apparatus for transferring and storing liquefied gas, the combination with a container for liquefied gas of the pressure type having a wall provided with a filling orifice and means for maintaining the same normally closed, of a filling vessel for holding a charge of liquefied gas provided with a neck adapted to extend through said filling orifice, means in said orifice for making gas-tight engagement with said neck, valved means associated with said neck controlling the release of fluid from said vessel and means associated with the closure of said orifice whereby when said neck is introduced to operative position said valved means is opened.

4. In apparatus for transferring and storing liquefied gases, the combination with a container for liquefied gases having a wall provided with a filling opening and a valve associated therewith and biased to maintain normally a closed position, of a filling means having an orifice and valve controlling the same whereby a quantity of liquefied gas may be supplied to said container, a tubular connection cooperating with said filling means and adapted to slide into said filling opening and move said biased valve to valve-open position, valve opening means arranged to operate the valve controlling said filling means, and slide-limiting means associated with said filling opening for arresting said connection in a predetermined position when said biased valve is open; said slide-limiting means having an associated part for actuating said valve opening means when said connection has attained the limiting position.

5. In apparatus for transferring and storing liquefied gases, the combination with a container for liquefied gases having a wall provided with a filling opening and a valve associated therewith and biased to maintain normally a closed position, of a filling means having an orifice and valve controlling the same whereby a quantity of liquefied gas may be supplied to said container, a removable packing disposed in said filling opening, a tubular connection adapted to slide through said packing into said opening and move said biased valve to valve-open position, an actuating member associated with said connection for operating the valve controlling said filling means, slide-limiting means associated with said filling opening for arresting said connection in a position where said biased valve is opened and where communication between said container and said filling means may be established, and a tripping member associated with said filling opening for operating said valve actuating member when said tubular connection has attained the limiting

position, whereby the valve controlling said filling means is also opened and communication established.

6. In apparatus for transferring and storing liquefied gases, the combination with a container for liquefied gases having a wall provided with a filling opening and a valve associated therewith and biased to maintain normally a closed position, of a filling means having a ball valve normally biased by gravity to shut off communication with the outside, a tubular connection cooperating with said filling means and adapted to slide into said filling opening and move the biased valve in said filling opening to valve-open position, a rod disposed in said tubular connection arranged to slide longitudinally thereof and to engage with said ball valve and move the same to an open position, and slide limiting means associated with said filling opening and provided with a pin adapted to be engaged by said rod and move the same to dislodge said ball valve when said tubular connection has been arrested in its sliding movement.

In testimony whereof I have signed my name to this specification.

CHRISTIAN WILHELM PAUL HEYLANDT.

March 14, 1933. C. W. P. HEYLANDT 1,901,446

METHOD OF CONSERVING LIQUEFIED GASES

Filed Nov. 21, 1927

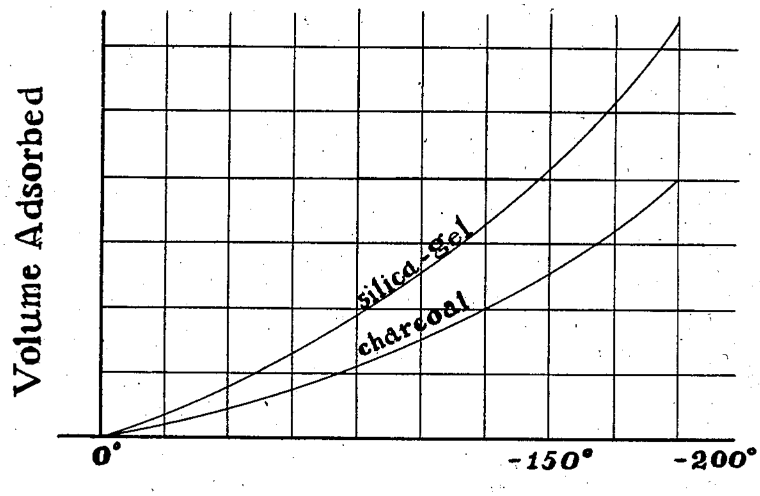


Fig. 1

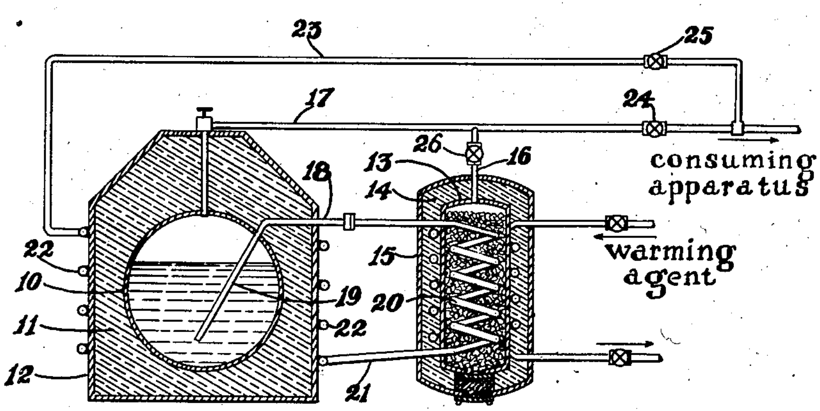


Fig. 2

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BY
Watson, Bristol, Johnson & Leavenworth
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Patented Mar. 14, 1933

1,901,446

# UNITED STATES PATENT OFFICE

CHRISTIAN WILHELM PAUL HEYLANDT, OF LANKWITZ, GERMANY, ASSIGNOR TO FLÜGA AKTIEN-GESELLSCHAFT, OF ST. MORITZ, SWITZERLAND

## METHOD OF CONSERVING LIQUEFIED GASES

Application filed November 21, 1927, Serial No. 234,914, and in Germany November 24, 1926.

This invention relates to a method of conserving liquefied gas held in containers of the insulated variety, and has for its object generally an improved procedure for collecting and storing the gas evolved in the container by normal evaporation during periods of non-consumption of gas material.

More specifically, it is an object to store the gas evolved from containers of the character indicated in a manner which does not involve high pressures and utilizes the adsorption effect produced by highly chilling a body of finely divided adsorbing material of a character which is non-combustible.

It is a further object to provide a body of adsorbent material such as silica gel in a vessel having communication with the gas space of the container and arranged to utilize the refrigerating effect of the liquefied gas withdrawn during periods of consumption to increase the adsorbent capacity of the body.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the several steps and the relation and order of one or more of such steps with respect to each of the others thereof, which will be exemplified in the process hereinafter disclosed, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

Fig. 1 is a chart exhibiting the comparative adsorbent capacities of bodies such as charcoal and silica gel at various low temperatures; and

Fig. 2 is a view mainly in vertical cross-section showing an exemplary embodiment of apparatus arranged for the practice of the invention.

In order to conserve gas material in accordance with the present invention, a body of porous material having a relatively great adsorbent capacity is disposed in a vessel and placed in communication with a container for the liquefied gas. Such container is relatively highly insulated in order to reduce heat leakage from outside to the liquid within to a comparatively small value, and may be of any suitable form, for example that shown in my co-pending application Serial No. 224,268, filed October 5, 1927.

Charcoal is a well-known material having a high adsorbent capacity, but it oxidizes readily and therefore makes it possible for dangerous conditions to arise. The adsorbent capacity of charcoal and like carbonaceous materials is low, however, as compared with certain other materials such as silicic acid gels.

It has been ascertained by experiment that certain gels at temperatures near the boiling point of liquefied gases such as liquid air, oxygen and the like, have in general a much higher adsorbent capacity than corresponding amounts of charcoal, and will consequently occupy less space than the latter when arranged to provide equal amounts of adsorbent capacity. The advantage in the use of such gels, however, arises mainly from the fact that silicic acid gel is noncombustible and hence when brought in contact with a combustion supporting substance such as oxygen, whether directly or indirectly, is substantially inactive and avoids the dangers and possibility of explosion incident to the use of charcoal.

The silicic acid gel here preferred in the practice of the invention is that which has been separated out in gel shape from a water glass solution, for example that obtained when carbon dioxide is passed through such a solution. Such gel when chilled to relatively low temperatures, for example to a temperature of −183° C. the boiling point of liquid oxygen, has an adsorbent power which is more than 50% over that of an equal amount of charcoal. Moreover, the adsorbent capacity grows considerably as the temperature is lowered below 0° C.

A body of silica gel when connected to the container for liquefied gases, as here proposed, assumes the action of a pump without having moving parts such as valves and pistons to draw over and store the gas evolved by natural evaporation from the container during periods of non-consumption. By referring to the curve for silica gel in Fig. 1 of the drawing, where the comparative adsorbent capacities of charcoal and silica gel are depicted, one can ascertain the desired amount of silica gel that is to be provided according to the invention in communication with a container for liquefied gas when the rate of evaporation during periods of non-consumption is known.

According to the method of the present invention, the body of silica gel used for providing adsorption is utilized at its highest practical capacity. This is accomplished by chilling the gel by means of the refrigerating effect of the liquefied gas withdrawn and supplied to consuming apparatus during periods of gas consumption. An arrangement of apparatus suitable for accomplishing this is shown in Fig. 2, where 10 denotes a vessel for holding liquefied gas having a mantle of insulating material 11 enclosed in an envelope or casing 12. A vessel 13 having a mantle of insulation 14 and a casing 15 is provided having communication by way of the conduits 16 and 17 with the gas space above the surface of the liquefied gas in the vessel 10. A liquid phase withdrawal conduit is shown at 18 having its inner end 19 depending below the liquid level in the vessel 10. This conduit leads through the wall of the container and is arranged to communicate with a chilling coil 20 disposed in the vessel 13 and arranged to be in thermal contact with the adsorbent material contained therein. The coil 20 has an outlet connection 21 leading to a heating coil 22 which may be supported on the exterior of the container for liquefied gas in the manner shown. From the far end of the heating coil 22 a connection 23 leads to a point in the gas supply conduit 17 beyond that at which the vessel 13 communicates by way of conduit 16. Suitable flow-controlling means are provided in these conduits, for example valves, as shown at 24, 25 and 26.

The gas stored in the vessel 13 by adsorption under low temperatures and at slight pressures may later be released for consumption by warming the adsorbent material in the vessel 13. Accordingly, a coil is shown surrounding the vessel 13, through which a suitable agent may be circulated for warming the gel beyond the zero point to supply gas at a pressure equal to or slightly above that in the conduit 17.

In operation during periods of consumption, the gas supply conduit 17 is opened by means of the valve 24 to permit the passage of gas material in the gas phase from the container 10 to the consuming apparatus. When the gas pressure has been sufficiently reduced by withdrawal through the conduit 17, the further supply of gas material is obtained by withdrawal of gas material in the liquid phase through the conduit 18. This liquid first traverses the space in the vessel 13 chilling the adsorbent material therein and thereby becomes heated and vaporized, the final heating being accomplished by means of the heating coil 22, the vaporized gas material passing to the consuming apparatus by way of the connection 23 when the valve 25 is opened.

The adsorbent material in the vessel 13, when cooled by the passage of the cold liquid being withdrawn from the container 10 by way of conduit 18, has its adsorbent capacity greatly increased during periods of consumption. The gas which vaporizes in the container 10 during a period of non-consumption, is, in consequence, drawn over into the vessel 13, where it is adsorbed by the material therein, the valves 24 and 25 being closed during this period, the valve 26 in the conduit 16 being open except when it is desired to cut the vessel 13 out of operation. This adsorption permits the gas evolved during periods of non-consumption to be stored and conserved without unduly raising the pressure in the container 10. It is sometimes advantageous to keep the valve 26 closed during the period when liquid is being withdrawn, so that the adsorbent will have a capacity to adsorb a larger volume of gas when consumption of gas material ceases. When it is desired again to supply gas to consuming apparatus, the gas stored in the vessel 13 is withdrawn and utilized by heating the vessel 13, as indicated above, until substantially all the stored gas is evolved and passed into the conduit 17 and supplied to the consumping apparatus. After this, the gel or material in the vessel 13 is cooled by the passage of liquid through the conduit 18 until the period of consumption terminates, when another period of non-consumption accompanied with adsorption and storage of gas from the container 10 will ensue.

Having described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. The method of conserving liquefied gas held in a container which comprises cooling an adsorbent by passing the liquefied gas in thermal contact with the adsorbent during periods of consumption of the liquefied gas, and adsorbing the gas evaporated from the liquefied gas in the adsorbent during periods of non-consumption.

2. The method of conserving liquefied gas held in a container which comprises passing the liquefied gas in thermal contact with a body of silica gel adsorbent during periods of consumption of the liquefied gas, and adsorbing the gas evaporated from the liquefied gas in the said silica gel adsorbent during periods of non-consumption.

3. The method of conserving liquefied gas held in an insulated container which com-

prises cooling a body of silica gel adsorbent with the liquefied gas during periods of consumption of the liquefied gas, adsorbing the gas evaporated from the liquefied gas in the said silica gel adsorbent during periods of non-consumption, and thereafter heating said adsorbent to evolve the gas therefrom.

In testimony whereof I have signed my name to this specification.

CHRISTIAN WILHELM PAUL HEYLANDT.

March 14, 1933. C. W. P. HEYLANDT 1,901,447

APPARATUS FOR PREPARING PRESSURE GASES

Original Filed Oct. 5, 1927

Fig. 1.

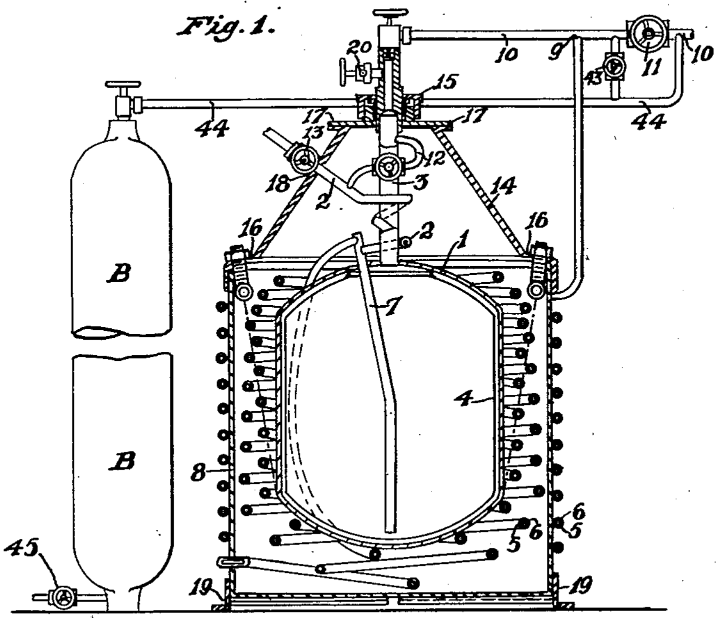
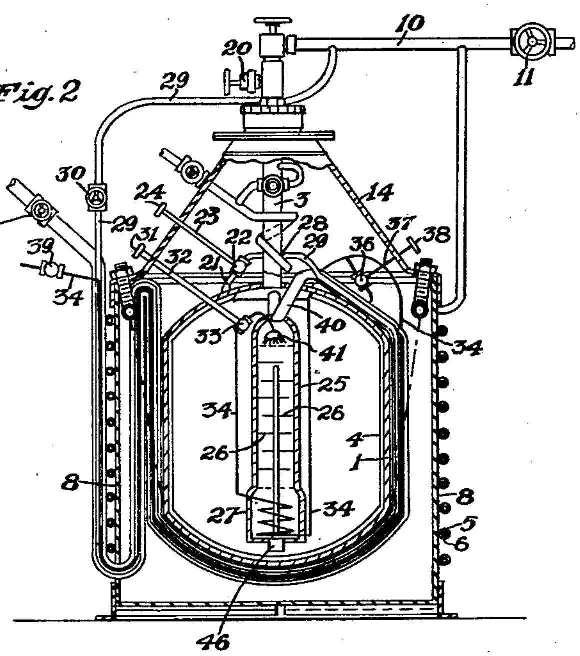


Fig. 2



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Patented Mar. 14, 1933

1,901,447

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## APPARATUS FOR PREPARING PRESSURE GASES

Original application filed October 5, 1927, Serial No. 224,268. Divided and this application filed June 8, 1932. Serial No. 616,044.

The present invention relates to apparatus for containing liquefied gases of a character which is adapted to supply the same in the gas-phase at different desired pressures. The invention has for its object generally an improved arrangement for gasifying liquefied gases in their containers in a quick and expeditious manner with relatively small losses caused by heat leakage and the like.

More specifically, it is an object of the invention to provide a container for liquefied gas having draw-off connections which are so arranged with reference to their environment and the walls of the container that a relatively small amount of heat is transferred from the outside to the liquid in the container.

A further object of the invention is to provide a container of the character indicated which is provided with inner and outer vessels constructed of a material in which the expansion does not vary appreciably even at the lowest temperatures.

A still further object of the invention is to provide a container of the character indicated, with internal means for conserving the refrigerating effect of the gas which may be withdrawn or evaporated within the container.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

This aplication is a division of my copending application Serial No. 224,268, filed October 5, 1927, now matured into Patent No. 1,866,514.

The invention accordingly comprises the features of construction, combination of elements, and arrangement of parts, which will be exemplified in the construction hereinafter set forth and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

Fig. 1 is a view mainly in vertical central section of an apparatus constructed in accordance with the invention; and

Fig. 2 is a similar view in vertical central section of a modified form of apparatus.

Referring now to the drawing and particularly to Fig. 1, 1 denotes a vessel for holding liquefied gas, the outer wall of which, sometimes designated a "pressure vessel", is made sufficiently strong to resist relatively high internal pressures; the vessel having a relatively long narrow neck 3. Within the vessel 1 is preferably disposed an inner receptacle or basket 4 which is made of a suitable ductile metal, for example tin, is relatively thin and is spaced from the inner surface of the vessel 1 to provide a relatively narrow chamber or gas space about the receptacle in order to reduce the amount of heat that would otherwise pass thereto. The receptacle 4 is open at the top so as to communicate with the gas space; care being taken when filling the receptacle with liquid to avoid any overflow of liquid into the gas space. By this arrangement it is seen that the pressures on the two sides of the wall of the receptacle are always substantially in equilibrium and strain in the thin metal of the wall of the receptacle avoided.

The vessel 1 is enclosed within and supported in spaced relation to the walls of a casing 8 that has a base 19 and a cover 14; the latter being shown as frusto-conical in form. The space between the vessel and the walls of casing 8 is substantially filled with a suitable non-combustible insulating material, for example slag wool or infusorial earth, in order to provide an insulating envelope for the liquid holding vessel.

A filling and withdrawal tube 7 is passed through the wall of the vessel 1 and extends to a point near the bottom of receptacle 4. For filling purposes this tube has a branch pipe or tube 2, which is preferably passed directly through the cover 14 and is arranged to be connected to a source of liquid supply (not shown in the interests of clearness). A valve 13 is provided to control the passage of liquid through the pipe 2, which may be coiled about the neck 3 of the vessel 1 in order to effect heat exchange between the gas in neck 3 and the liquid when passing in pipe 2. A controlled by-pass connection 12 is also advantageously provided between the pipe 2 and the neck 3 so that any gas that may be evolved by evaporation of the liquid when passing through pipe 2 may be immediately withdrawn and supplied to the body of gas in the neck 3 without passing through the liquid in the receptacle 4.

A second branch pipe or tube for withdrawal purposes is also arranged to communicate with tube 7. This second branch pipe is here shown as a double coil 5—6 that is arranged to have a portion leading from the top of tube 7 down over the side of vessel 1 to a point near the base 19 from which point it again is led upwardly in a series of convolutions having increasing diameters as the top of the casing 8 is approached, the convolutions at first being disposed close to the vessel 1. From the top, still within the insulating space of casing 8, the coil descends in a second series of convolutions which have increasing diameters (with the exception of the lowermost turns) until a point near the bottom of the casing 8 is reached. From this point the coil is then led through the casing wall and thence upwardly in a third series of convolutions secured on the outside of the casing 8. The outer end of this coil communicates at 9 with a gas withdrawal conduit 10, leading from the neck 3 and provided with a discharge control valve 11; the outside portion of neck 3 being preferably arranged to minimize the conduction of heat to the vessel 1 as far as practical and in consequence is shown as having a separable portion secured in place by means of a stuffing box 15 on the crown of cover 14 and provided with a vent valve 20. In addition to the stuffing box 15, the casing 8 has its other joints preferably made airtight and accordingly is shown with packings 16, 17 and 18 inserted at the joints in the manner illustrated.

The gas withdrawal conduit is adapted to supply gas directly to a consuming device at any desired pressure, the pressure had depending of course on the adjustment of the valve 11. As the rate of gas withdrawal from the conduit 10 may at times exceed that at which gas is evolved from the vessel 1, it is desirable to have a supply of gas under relatively high pressure in reserve. This is accomplished by providing a gas receiver or cylinder B having a pipe connection 44 leading to the conduit 10 from which it is filled when the gas demand is nil or less than the rate at which gas is evolved in the container of the present invention. To permit the receiver B being conveniently filled when the gas demand is nil and the valve 11 closed, a valved by-pass is preferably provided, as shown at 43, connecting pipe 44 with conduit 10. The receiver B may also have an independent valved outlet, as shown at 45, at its lower end.

The operation of the liquid containing apparatus above described is as follows: Liquefied gas is first introduced to the vessel 1 by the conduit means 2 and 7. The gas which is evolved during the filling process is first raised by self-compression to a desired pressure and then led to the gas receiver B by way of conduit 44, in case there is no demand for compressed gas at the time of the filling operation. During this filling operation, the by-pass at 12 may be opened to convey the gas evolved during the initial cooling of the filling means. The normal withdrawal of gas from the container here provided may be had either through the neck 3 from the gas space above the liquid in vessel 1, or from vaporization of liquid withdrawn through the coil 5—6.

If it is desired to withdraw gas from the coil, communication between pipe 10 and the gas space above the liquid level is shut off so that there is produced an excess pressure in the vessel, at the end of the coil within the vessel 1. In this manner the liquid is driven into the coil under pressure so that upon withdrawal of gas from the coil through pipes 9 and 10 the liquid contents of the vessel are forced into the coil to take the place of the gas removed therefrom. The evaporation of the liquid is not in excess of the quantity of gas removed. If it is desired to draw off from the space above the liquid level, this gas space is opened to communication with the pipe conduit 10. At this time, although the coil enters the consumption conduit at 9, nevertheless no liquid will evaporate from the coil, for the reason that the pressure on the liquid in the vessel is the same as that on the liquid in the coil. This pressure equalization takes place at 9.

In this connection, it may be stated that the coil may be constructed of any desired length and may also be of any definite diameter. These constructional dimensions depend upon the character of the liquid to be gasified. For instance, the evaporation heat required for methane is about 2½ times as great as that for oxygen. It follows, therefore, that it would be necessary to make the coil for the gasification of methane longer, from point to point, in the vessel, than for oxygen.

It will be seen that the arrangement of the coil 5—6 in the insulating space about the vessel 1, in which the inner turns are in close proximity to the vessel, while the outer turns progressively increase their diameter as they approach the casing 8, is such as to utilize the heating effect of the insulating envelope. It will be perceived that there is a more or less constant flow of heat in the insulating envelope from the outside of casing 8 to the outer wall of the vessel 1. Such heat as the insulating envelope contains may, therefore, be absorbed by the liquid withdrawn through the coil 5—6 as it progressively enters the warmer zones in its advance from the inner end of the coil to the outside atmosphere, that is, the farther the liquid progresses along the turns of the coil toward the outside, the more the liquid will be heated from the outside, with consequent greater evolution of gas.

While the withdrawal of cold gas material from the vessel 1 involves heating in order to supply the same as compressed gas, at a predetermined desired pressure, in the apparatus shown in Fig. 1, which involves dissipating the refrigerating effect initially obtained by the process of liquefaction, it is contemplated conserving this effect in certain forms of practicing the present invention, the containing apparatus for the liquefied gas in such instances being modified to conserve the refrigerating effect by means of heat exchangers associated with the withdrawal conduits. An arrangement for carrying out this form of the invention is shown in the apparatus illustrated in Fig. 2.

In Fig. 2, the apparatus illustrated employs a vessel 1 having a restricted neck 3 supported and surrounded by a casing 8, having the intervening space substantially filled with insulating material, which construction may be substantially the same as that disclosed in Fig. 1, with the exception that a by-pass 21 is shown for providing communication between the neck 3 and the gas space about the receptacle 4, the by-pass being controlled by a valve 22 actuated from without by the stem 23 and hand wheel 24; the filling and withdrawal means comprising conduits 2, 7, and coils 5—6 being also the same, but are partially omitted from illustration for the sake of clearness.

Supplementary gas withdrawal means are here provided in the form of a conduit 29 communicating at its inner end with the neck 3, as indicated at 28, this conduit having successive portions disposed in the insulating material so that the temperature rise therealong coincides approximately with the temperature increase in the insulating material in substantially the same manner as described above in connection with coil 5—6, the outer end of this conduit discharging into the conduit 10, and being provided with a flow control means here shown as a valve at 30. The heat exchanging means associated with this supplementary gas withdrawal conduit comprises a conduit 34, here shown as having a sufficiently small diameter, to be disposed within the conduit 29 and to traverse the same along the axis thereof until a point is reached near the outer end of the conduit 29, from which the conduit 34 is led out independently and provided with a valve 39 for controlling the ingress of compressed air or other gas thereto; the conduit 34 preferably having by-pass communication with the conduit 40, which is here shown as controlled by a valve 36 actuated by a stem 37 and hand wheel 38.

In carrying out the further conservation of the refrigerating effect here desired, the inner end of the conduit 34 depending into the vessel 1 is shown leading to a distributor 41 of a rectifying column 25. This latter is shown as housed within the vessel 1 and provided with the usual counter-current contacting means 26 and an evaporator or kettle 27 in the lower end, vaporization being effected in the kettle by a coiled portion of the conduit 34, which is preferably made to pass therethrough, the discharge of fluid from the coil 34 through the distributor 41 being preferably controlled by valve 33, shown as actuated by stem 32 and hand wheel 31. The non-condensable constituents of the products of rectification within the column 25 are withdrawn through a conduit 40, which is passed through the top of the vessel 1 and also arranged in heat exchanging relation with the supplemental withdrawal conduit 29. The conduit 40 is of relatively large diameter and is preferably arranged to envelope the conduit 29, following the same to a point on the outside of the casing 8 where exit of the withdrawn products is controlled by a valve 42. The rectified product which collects in the bottom of the column 25 may be passed directly into the vessel 1 through a suitable outlet from the column here shown at 46.

The operation of this modified form of apparatus is the same as that shown in Fig. 1, except as the use of the triple conduit system 29, 34, 40 and the rectifying column 25 are involved. When compressed gas is withdrawn through the conduit 29, the refrigerating effect of this gas is conserved by admitting compressed gas to the conduit 34, which is accomplished by opening the valve 39. The compressed gas being withdrawn in order to supply a consuming device, is passed in heat exchanging relation with the warm gas entering through the conduit 34, so that the refrigerating effect of the cold gases initially passing out through the conduit 29 has been substantially transferred to the gas entering the rectifying column 25. Here, a further refrigerating effect is practiced in the rectifying column, so that a liquefied product such as liquid oxygen is supplied to the vessel 1. The conduit 40 serves as the means for drawing off nitrogen and other uncondensable gases from the column 25, and follows the conduit 29, so as to transfer its refrigerating effect to the gas material entering the rectifying column 25. By opening the by-pass valve at 36 and closing the valve 33, the rectifying column may be short-circuited by way of the by-pass, whereupon the gas material supplied by the conduit 34 will pass directly into the conduit 40, thereby increasing the rate of evaporation.

Having described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. Apparatus for the production of pressure gases of different adjustable pressures out of their liquid state of aggregation by intermittent evaporation comprising a pressure vessel provided with a thin walled inner receptacle for receiving the liquefied gas, said pressure vessel being surrounded by a pipe entering the liquid, characterized by the inclusion of a rectification column disposed within the pressure vessel, and double-walled coils about said pressure vessel, in the outer coil of which the vaporized gas flows, for precooling another medium in the inner coil thereby to assist in liquefying said medium.

2. Apparatus for supplying gas material in the gas phase converted from liquefied gas, comprising an insulated container for the liquefied gas, a receiver for gas in the gas phase, a gas phase withdrawal conduit leading from said container to a consuming device, flow controlling means in said conduit, a liquid phase withdrawal conduit leading from said container and communicating with said first named conduit in advance of said flow controlling means, and a connection leading from said receiver to said conduit for supplying gas conserved from said container.

3. Apparatus for supplying gas material in the gas phase converted from liquefied gas, comprising an insulated container for the liquefied gas, a receiver for gas in the gas phase, a liquid phase withdrawal conduit leading from said container to a consuming device, heating means in said conduit, flow controlling means in said conduit adjacent said heating means, a gas phase withdrawal conduit connected to said first named conduit in advance of said flow controlling means, and a connection leading from said receiver to said conduit for supplying gas conserved from said container.

4. Apparatus for supplying gas material in the gas phase converted from liquefied gas, comprising an insulated container for the liquefied gas, a receiver for gas in the gas phase, a liquid phase withdrawal conduit leading from said container to a consuming device, heating means in said conduit, flow controlling means in said conduit following said heating means, a gas phase withdrawal conduit including additional flow controlling means communicating with said first named conduit between said heating means and said first named flow controlling means, and a connection leading from said receiver to said conduit for supplying gas conserved from said container.

5. Apparatus for supplying gas material in the gas phase converted from liquefied gas, comprising an insulated container for the liquefied gas, a receiver for gas in the gas phase, a liquid phase withdrawal conduit leading from said container to a consuming device, heating means in said conduit, flow controlling means in said conduit following said heating means, a gas phase withdrawal conduit communicating with said first named conduit at a point in advance of said flow controlling means, and a connection leading from said receiver to said conduit communicating at a point in advance of said flow controlling means.

6. Apparatus for supplying gas material in the gas phase converted from liquefied gas, comprising an insulated container for the liquefied gas, a receiver for gas in the gas phase, a liquid phase withdrawal conduit leading from said container to a consuming device, heating means in said conduit, flow controlling means in said conduit following said heating means, a gas phase withdrawal conduit including additional flow controlling means communicating with said first named conduit between said heating means and said first named flow controlling means, and a connection leading from said receiver to said conduit also provided with flow controlling means and communicating with said first named conduit at a point in advance of said first named flow controlling means.

In testimony whereof I affix my signature.

CHRISTIAN WILHELM PAUL HEYLANDT.

July 18, 1933.

C. W. P. HEYLANDT

1,918,335

CONTAINER FOR LIQUEFIED GASES

Original Filed Nov. 21, 1927

Fig. 1

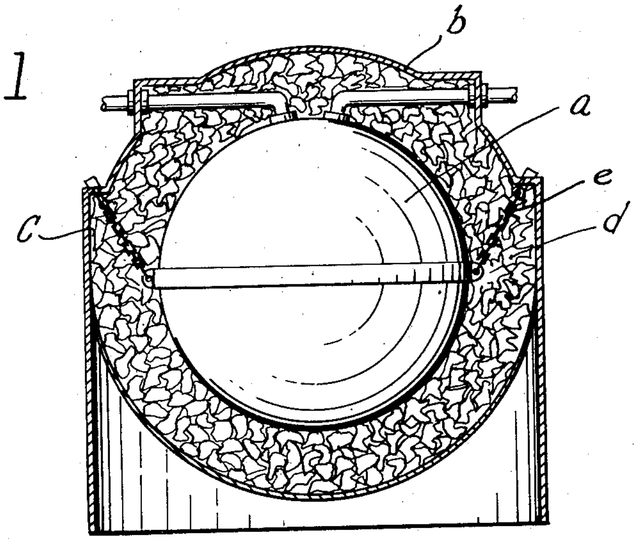
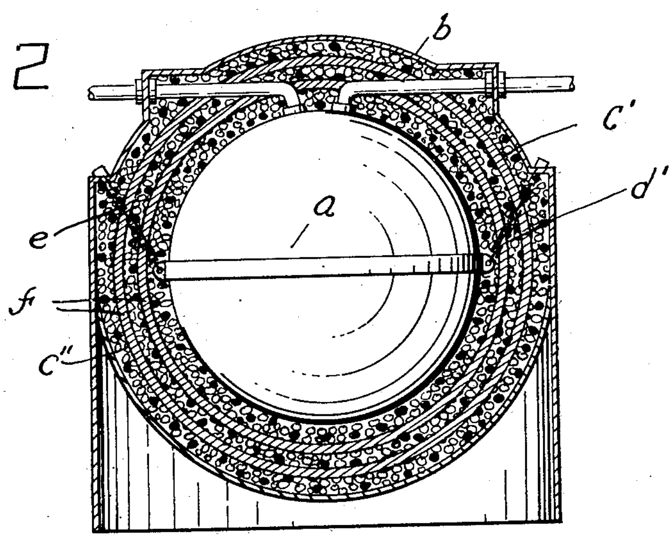



Fig. 2




INVENTOR
Christian Wilhelm Paul Heylandt
BY
Watson, Bristol, Johnson & Leavenworth
ATTORNEYS

Patented July 18, 1933 1,918,335

# UNITED STATES PATENT OFFICE

CHRISTIAN WILHELM PAUL HEYLANDT, OF LANKWITZ, GERMANY, ASSIGNOR TO FLÜGA AKTIENGESELLSCHAFT, OF ST. MORITZ, SWITZERLAND, A CORPORATION OF SWITZERLAND

## CONTAINER FOR LIQUEFIED GASES

Original application filed November 21, 1927, Serial No. 234,914, and in Germany December 27, 1926. Divided and this application filed May 21, 1929. Serial No. 364,956.

This invention relates to containers for liquefied gases and particularly to containers in which liquefied gas may be stored.

The invention has for its object generally the provision of a container of the character indicated, which is efficient, economical, and readily manufactured.

More specifically, it is an object to provide a container of the character indicated which has an improved construction and disposition of the insulating material disposed around the liquid containing vessel.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

This application is a division of my copending application Serial No. 234,914, filed November 21, 1927.

The invention accordingly comprises the features of construction, combination of elements, and arrangement of parts, which will be exemplified in the construction hereinafter set forth and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

Fig. 1 is a view mainly in vertical cross section showing a container constructed in accordance with the invention; and

Fig. 2 is a view similar to Fig. 1, but illustrating a modified arrangement of insulating material.

Tests have been made and the data plotted in order to ascertain the nature of the temperature gradient of various insulating materials, together with the rate of evaporation for liquefied gases when insulated with various insulating materials. The plotted curves when drawn for such insulating materials as kieselguhr, infusorial earths, slag wool, mineral wool, and the like, if arranged in the order of their respective insulating values, are found to be in the order of their relative porosities, the material having the highest porosity corresponding to the material having the highest insulating value.

The curves which exhibit the lower porosities, for example that drawn for slag wool, exhibits a characteristic whereby it starts with a relatively high insulating value, then quickly drops and thereafter remains quite constant. Kieselguhr on the other hand, which has a relatively high porosity, does not show this characteristic and maintains a relatively constant value of the insulation for all thicknesses.

In the practice of the present invention, insulating envelopes are provided in containers for liquefied gases and the like, in which the envelope is constructed of porous insulating material that has the desired uniform insulating characteristic. The container in general comprises an inner vessel for holding the liquefied gas and an outer casing enclosing a space about and supporting the inner vessel. The inner vessel is preferably spherical in shape, though other shapes may be employed which provide a relatively high value of the ratio of cubic content to surface employed. The casing will in general be similar in shape to the inner vessel; as a consequence, the enclosed space is bounded by a large amount of surface which is inclined (i. e. has its tangent planes making oblique or acute angles with the vertical). The upper inclined surface of the inner vessel and the lower inclined surface of the casing are utilized as supports for the insulating material which is loosely laid-in in the space about the inner vessel so as to avoid packing and to trap air in the interstices. In this manner, the original porosity of the insulating material is preserved and the resultant insulating effect is that had from the low thermal conductivities of both the insulating material and of the air retained in the pores and openings of the insulating envelope. The insulating material employed may have any suitable form, for example, it may be granular or in small pieces and laid-in in layers about the inner vessel. Also, it may or may not have the layers separated and supported by non-conducting insulating material of different structural properties, such as cellophane. The effect of thus building up the insulating material so as to provide small closed spaces in which air is caught, is to condense or contract the air by the refrigerating effect of the liquid in the inner vessel whereby stagnant bodies of chilled air in the interstices surround the inner vessel.

When placing the insulating material in the space about the liquid containing vessel, it is preferred that this material be not laid-in so tightly that the average specific gravity of the space when filled is in excess of that of the raw unused insulating material. The insulating material in the lower part of the container can sustain its own weight of material and the weight of the material in the upper part without becoming displaced.

Referring now to the drawing and particularly to Fig. 1, *a* denotes an inner vessel adapted for holding the liquefied gas. This vessel is disposed within an outer shell or casing *b*, so that there is an intervening space *c* which is filled with insulating material *d*. This insulating material is of the porous inorganic character above indicated, and is disposed about the inner vessel *a* so that it will thus support itself, and forms a plurality of interstices whereby the refrigerating effect of the liquid in vessel *a* upon the air caught in these interstices causes the air to contract, thereby providing an atmosphere of strongly condensed stagnant air permeating the space in and about the inorganic insulating material *d*. Casing *b* supports vessel *a* through chains *e*.

In the form of the container shown in Fig. 2, the insulating material is indicated at *d'*. Here the insulating material instead of being of the homogeneous porous character as indicated in Fig. 1, comprises built up layers of different materials, the bodies of one material being indicated at *c'* and act as carriers for supporting the particles of material *c*, which are designed to have higher insulating characteristics. Interposed separating layers of non-conducting insulating material are shown at *f*.

Since certain changes may be made in the above construction and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In a container for liquefied gases, the combination comprising an inner vessel for holding the liquefied gas, an outer casing enclosing a space about and supporting said vessel, the enclosing walls of said space being curved and having portions inclined at angles such as to serve as supports for inserted material, and porous heat insulating material having a relatively constant insulating characteristic inserted and disposed in said space about said vessel; said material being mainly supported by the upper wall of said vessel and the lower space enclosing walls of said casing and laid-in to form a plurality of interstices in said space which trap air providing an atmosphere of relatively dense still air whereby the lower portions of said material sustain their own weight and that of the portions thereabove without becoming displaced.

2. In a container for liquefied gases, the combination comprising an inner vessel for holding the liquefied gas, an outer casing enclosing a space about and supporting said inner vessel, the enclosing walls of said space being curved and having portions inclined at angles such as to serve as supports for inserted material, and heat insulating material inserted and disposed in said space about said vessel and consisting of alternate layers of relatively porous inorganic material in granular form alternating with layers of non-inflammable non-conducting material; said layers being mainly supported by the upper wall of said vessel and the lower space enclosing walls of said casing and laid-in to enclose a plurality of interstices whereby the refrigerating effect of the gas within said inner vessel creates an atmosphere of relatively dense air which pervades the space about said inner vessel.

CHRISTIAN WILHELM PAUL HEYLANDT.

Dec. 26, 1933.

C. W. P. HEYLANDT

MEANS FOR PREVENTING THE OVERFILLING OF WARM EVAPORATORS FOR LIQUEFIED GASES

Filed July 21, 1933

1,941,304

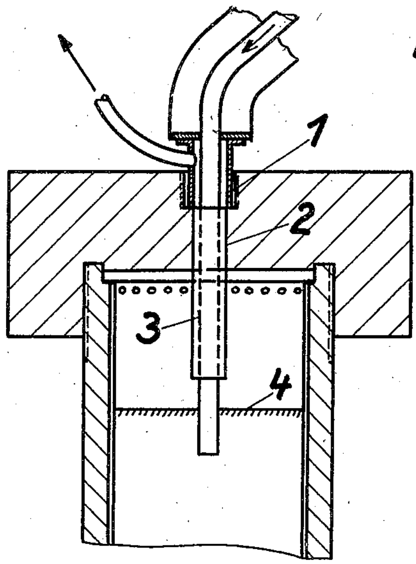



Fig. 1

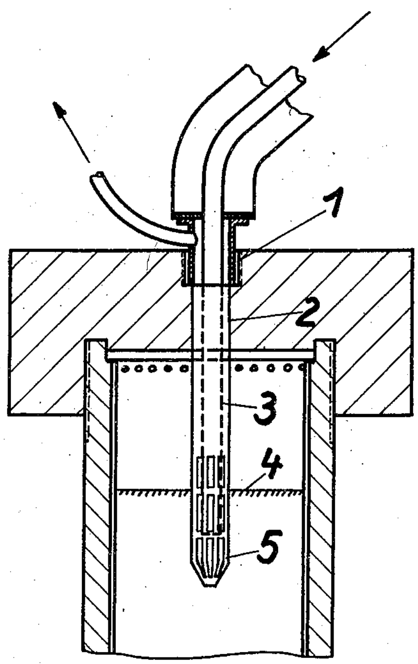



Fig. 2

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# UNITED STATES PATENT OFFICE

1,941,304

## MEANS FOR PREVENTING THE OVERFILLING OF WARM EVAPORATORS FOR LIQUEFIED GASES

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Application July 21, 1933, Serial No. 681,652, and in Germany June 24, 1932

3 Claims. (Cl. 226—119)

This invention relates to means or devices for preventing the overfilling of warm evaporators when filling the same with liquefied gases of low boiling point, for example, when filling evaporators or converters with liquid oxygen or the like and has for its object generally the provision of a simple and highly efficient device of the character indicated.

Heretofore floats have been used for indicating the liquid level of warm evaporators. Such floats have however the disadvantage that in consequence of the whirling movements of the liquid oxygen during filling they are moved to and fro, and consequently they become upset and jammed so that the indications can no longer be relied upon. The liquid container can then be easily overfilled and the liquid oxygen will flow through the holes arranged close to and around the upper edge of the liquid container into the space between the outer vessel and liquid container and accumulate on the bottom of this outer vessel. The continuous and uneven cooling of the outer vessel caused hereby will effect the setting up of strains due to the cold temperatures which have detrimental effect on the crystal structure of the metal.

Specifically it is an object of the present invention to avoid this disadvantage by allowing the filling tube to extend by a considerable amount underneath the circle of holes on the top part of the liquid container instead of stopping the filling tube in the filling opening of the evaporator cover.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of construction, combination of elements, and arrangement of parts, which will be exemplified in the construction hereinafter set forth and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

Fig. 1 is a fragmentary sectional view showing the upper portion of a warm evaporator or converter having a filling device of the present invention; and

Fig. 2 is a similar view showing a warm evaporator or converter provided with a modified form of filling device of the present invention.

Referring now to the drawing and particularly to Fig. 1, 1 denotes a filling opening located in the cover of an evaporator of the character commonly employed in vaporizing liquid oxygen. Such evaporator is seen to comprise a relatively thick-walled outer vessel commonly referred to as a "pressure vessel" and contains a relatively thin-walled inner vessel or "basket" supported in the outer vessel in a manner which provides a relatively narrow clearance space between the inner and outer vessels. The space within the inner vessel preferably communicates with the clearance space between the inner and outer vessels by means of a ring of holes disposed in the wall of the inner vessel below its upper edge. The device for preventing overfilling, and consequently the overflow of liquid into the clearance space, is shown inserted within the filling opening 1 and comprises a snugly fitted thin-walled cylindrical tube 2 in which a filling conduit or pipe 3 is concentrically disposed but out of contact with tube 2. The lower end of pipe 3 is made to depend into the pressure vessel a substantial distance below the liquid level intended to be maintained within the pressure vessel. The intended liquid level is indicated in the drawing by a line at 4 and the lower open end of the tube 2 is arranged to terminate a short distance above the liquid level 4. On the exterior of the pressure vessel above the cover, the filling conduit is connected in the usual manner with a supply of liquid oxygen, while the annular space about the filling conduit within the tube 2 is vented to the atmosphere.

If during the filling of the evaporator the intended level has been reached, upon the filling being continued liquid will rise and escape through the space between the filling tube and the smooth cylinder which tells the attendant that the normal liquid level has already been exceeded. The inflow of the liquid is then turned off whereby any appreciable loss is avoided.

The modified form of device shown in Fig. 2 consists of a thin walled cylinder 2 inserted into the filling opening 1 of the evaporator. The cylinder 2 has a pierced part 5 with a sufficient amount of openings for allowing an escape of the gases which are developed during filling. The filling tube 3 projects into this pierced part of the inserted cylinder to such an extent that the outflow of the gases takes place without any liquid from the entering jet being forced out by and along with said gas. If then however the liquid begins to rise this free sectional area of the pierced part decreases as the level rises until the escaping stream of gas takes liquid from the level and forces it out into the atmosphere. The normal filling level rises so that it will be in close proximity to this point.

In case perhaps by carelessness of the attendant the inflow of the liquid is not stopped after the normal level has been reached, increased quantities of liquid are forced along by the outflowing gas as the liquid level is rising, and in the moment the liquid level reaches the blank part of the cylinder, the whole of the further added liquid is at once thrown out into the atmosphere, and it is no longer possible to retain additional quantities of liquid in the container of the evaporator. When now the further inflow of liquid is stopped, the injection of the liquid does not cease at once, but the part which is now still filled in excess is forced out until the gas above the liquid level has found again sufficient sectional area in the pierced part 5 of the cylinder so that an excess filling beyond the normal liquid level in the liquid container of the evaporator is possible only up to this point. The possible overcharge is therefore restricted to quite a definite and reliable measure.

The bottom of the pierced part is also constricted and serves the purpose to prevent small parts of the installation, such as nuts, small spanners and the like, from falling into the liquid container and to prevent it from being damaged thereby.

I claim as my invention:

1. A device for preventing the overfilling of warm converters when filling the same with liquefied gases, comprising the combination with an outer wall of such converter having a filling opening, of a thin-walled tube vented to the atmosphere snugly fitted into said opening and depending into said converter to a point short of the desired liquid level, and a filling conduit disposed within said snugly fitted tube and out of contact therewith and extending into said converter to a point below the desired liquid level and adapted to communicate exteriorly of said converter with means for supplying liquid.

2. A device for preventing the overfilling of warm converters for liquefied gases having a pressure vessel, comprising the combination with a wall of said pressure vessel having a filling opening, of a thin-walled cylindrical tube vented to the atmosphere snugly fitted into said opening and depending into said pressure vessel, said tube being arranged to communicate with the space in the warm converter above the intended liquid level, and a filling conduit disposed concentrically within but out of contact with said snugly fitted tube and extending into said pressure vessel to a point below the intended liquid level and adapted to be connected with means on the exterior of said pressure vessel for supplying liquid.

3. A device for preventing overflow into the space between the basket and pressure vessel of warm converters when filling the same with liquefied gases, comprising the combination with a wall of the pressure vessel having a filling opening, of a thin-walled tube snugly fitted within said filling opening depending into said pressure vessel and formed with a pierced portion at its lower end communicating with the interior of said pressure vessel at a point above the intended liquid level, said snugly fitted tube being provided with connections on the exterior of said pressure vessel for venting the same to the atmosphere, and a filling conduit disposed within but out of contact with said snugly fitted tube and spaced away from the walls thereof and depending into said pressure vessel to a point below the intended liquid level, said pierced portion being constricted about said filling conduit for preventing the entry by way thereof of extraneous objects into said pressure vessel.

C. W. P. HEYLANDT.