

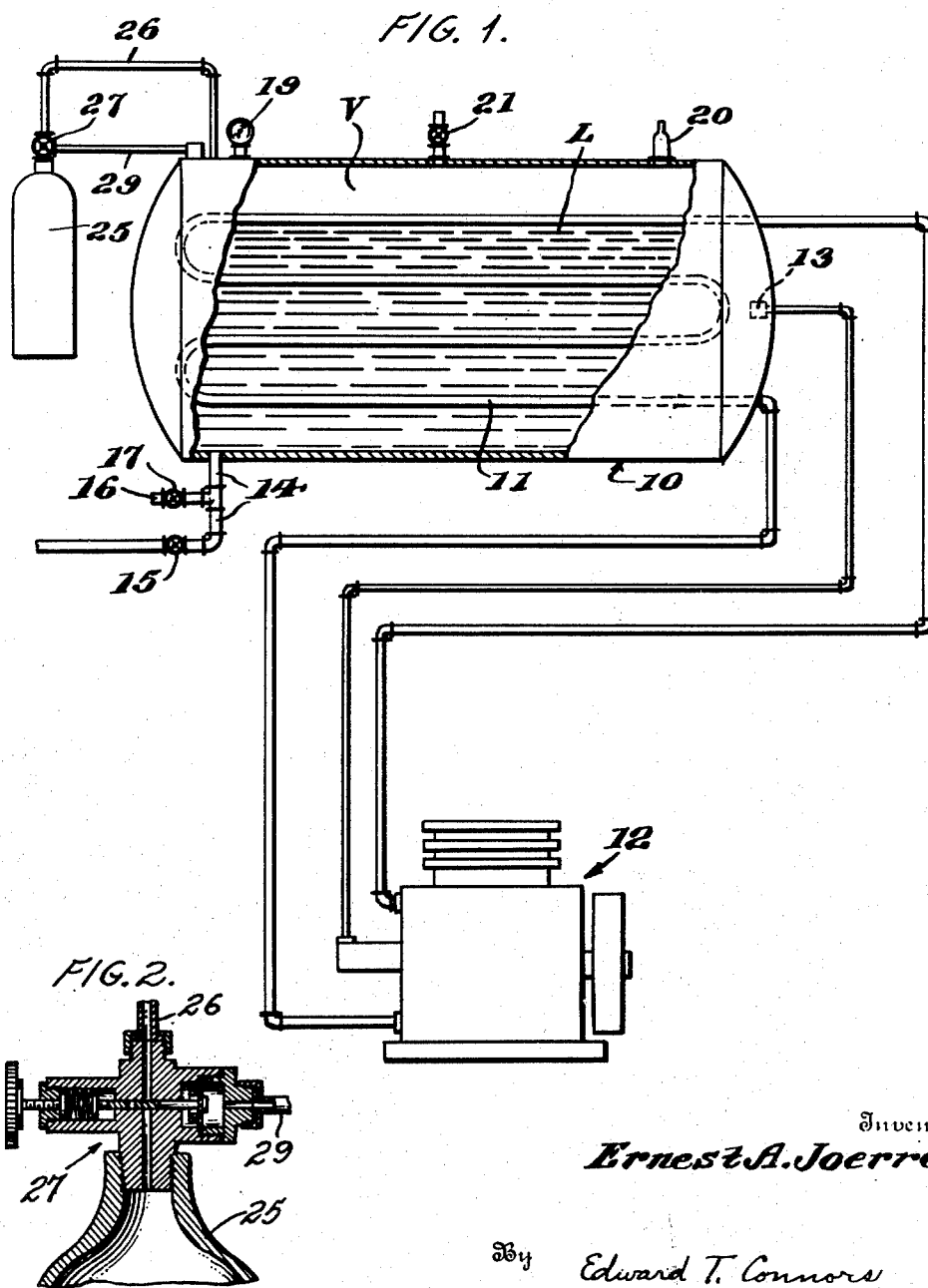
Oct. 17, 1950

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2,525,802

FIRE EXTINGUISHING SYSTEM AND METHOD

Filed March 1, 1944



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UNITED STATES PATENT OFFICE

2,525,802

FIRE EXTINGUISHING SYSTEM AND METHOD

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Application March 1, 1944, Serial No. 524,581

6 Claims. (Cl. 62—1)

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The present invention relates to liquid carbon dioxide fire extinguishing systems, and more particularly to a fire extinguishing system and method wherein the liquid carbon dioxide is stored at sub-atmospheric temperatures.

It has been proposed to store liquid carbon dioxide at temperatures not to exceed 32° F., and, for example, at 0° F. One of the benefits alleged to be derived from storing carbon dioxide at such temperatures is that the carbon dioxide, upon expansion, forms a greater amount of snow. For example, theoretically, at 32° F. about 39% by weight of carbon dioxide is converted to snow, and at 0° F. about 46% by weight of carbon dioxide is converted to snow.

One of the difficulties in connection with systems of the foregoing character is that, as the temperature of the carbon dioxide is lowered, its vapor pressure is correspondingly lowered, and, as a result, the pressure of the carbon dioxide is insufficient to rapidly direct the same to a point of use. In extinguishing fires, it is very important that a large amount of carbon dioxide be directed to the fire in a minimum amount of time.

The present invention aims to overcome the foregoing difficulties and disadvantages, and further aims to make feasible the storage of liquid carbon dioxide at even lower temperatures to form greater amounts of snow and to provide rapid and effective discharge thereof.

Accordingly, an object of the present invention is to store and maintain liquid carbon dioxide at sub-atmospheric temperatures for fire extinguishing purposes and to rapidly discharge and direct the carbon dioxide to its point of use.

Another object is to provide a fire extinguishing system and a method of operating the same, wherein liquid carbon dioxide may be maintained at temperatures lower than 20° F. to form relatively large amounts of snow and adapted to be discharged at a relatively high predetermined rate.

Another object is to provide a fire extinguishing system of the foregoing character and a method of operating the same, wherein the pressure in the carbon dioxide storage container is maintained at a predetermined value to control the discharge rate of the carbon dioxide.

A further object consists in the combination and arrangement of parts whereby the foregoing objects may be accomplished.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will

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be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

In accordance with the invention, it has been found that the foregoing objects and advantages may be accomplished by providing a container charged with liquid carbon dioxide which is refrigerated to maintain it at subatmospheric temperatures and its corresponding vapor pressure, and establishing and maintaining in the container a pressure substantially greater than the vapor pressure of the carbon dioxide which pressure is adapted to effect rapid discharge of the carbon dioxide. The increased pressure is provided by introducing into the storage container a gaseous pressure medium other than carbon dioxide, which has a substantial pressure at the temperatures at which the carbon dioxide is stored.

A preferred embodiment of the invention has been chosen for purposes of illustration and description and is shown in the accompanying drawing, forming a part of the specification, wherein

Figure 1 is a diagrammatic view, partly in section, illustrating a fire extinguishing system embodying the present invention.

Figure 2 is a fragmentary sectional view of a pressure responsive valve for controlling the introduction of the pressure medium into the storage container.

Referring to the drawing, there is shown a container 10, such as an efficiently heat insulated tank adapted for storing large quantities of liquid carbon dioxide. At the interior of the tank, suitable heat exchange coils 11 are provided which may be arranged to extend through the liquid L (the level of which is indicated by the broken lines) and through the vapor space V. A suitable cooling medium or refrigerant is circulated through the coils which is supplied by a standard low temperature refrigerating unit 12, illustrated diagrammatically. The unit 12 may be operated in response to the temperature within the container by thermostatic control means 13 of any suitable design. It will be understood that other suitable refrigerating means may be utilized.

The container 10 is provided with an outlet conduit 14, preferably at the bottom, through which the liquid carbon dioxide stored in the container may be discharged and conducted to its point of use. A suitable valve 15 is arranged in the conduit 14 for controlling the discharge of

the carbon dioxide. The valve may be manually operable or operable remotely by suitable well known manual or automatic control devices. It will be understood that the conduit 14 may divide into branches which extend to compartments or spaces to be protected and that such branches may be further provided with discharge devices, valves and control devices customarily employed in connection with carbon dioxide fire extinguishing systems.

The conduit 14 may also be provided with an extension 16 fitted with a valve 17 for introducing liquid carbon dioxide into the container in any well known manner.

The container 10 is further provided with a suitable gauge 19 for indicating the pressure within the container and a blow-off or safety valve 20 operable in the event the refrigerating system fails and unsafe pressures develop in the container. If desired, a bleed-off valve 21 is provided which is operable at a predetermined pressure to permit carbon dioxide gas in the vapor space V to expand and effect refrigeration of the stored carbon dioxide.

In order to provide a substantial pressure at relatively low temperatures, the vapor space V may be charged with a gaseous medium other than carbon dioxide, which is adapted to exist as a gas at temperatures approaching -70°F . Such gaseous medium may be air, argon, carbon monoxide, helium, hydrogen, krypton, neon, nitrogen or oxygen, or mixtures thereof. However, argon, helium, krypton, neon and nitrogen are preferred, because they are substantially inert, non-oxidizing, non-combustible and non-combustion supporting.

In practice, nitrogen may be preferred because of its comparative low cost, its general availability, and its inert properties. The critical temperature of nitrogen, that is, the temperature at which nitrogen will exist as a gas regardless of the pressure to which it is subjected, is about -231°F . This temperature is well below the temperatures at which the carbon dioxide will be maintained, thus assuring the nitrogen will remain in its gaseous state.

Compressed air may be used advantageously because it can be readily produced by means of any suitable compressor. While air contains about 20% oxygen, by volume, it is rendered substantially inert upon being mixed with carbon dioxide vapors.

The gaseous medium may be introduced into the container from a suitable source, such as a cylinder 25 containing the same, having its outlet connected by a conduit 26 to the container 10. A suitable valve 27 may be provided in the conduit 26 which may be manually operable or operable automatically in response to the pressure in the container.

In the event such automatic operation is desirable, the valve 27 may be of the diaphragm operated type having a pressure communicating conduit 29 connected to the container 10. Such a valve is shown by way of example in Figure 2.

Alternately, the source of pressure medium indicated as a cylinder 25, may be the pressure tank of a standard air compressor unit adapted to be operated from time to time, as additional pressure medium may be required.

In practicing the present invention, the container may be charged with liquid carbon dioxide to a desired level and refrigerated to a desired temperature. In the following table there are shown, the theoretical percentage of snow by

weight of carbon dioxide adapted to be formed and the approximate corresponding vapor pressure at various sub-atmospheric temperatures:

Temperature, Degrees F	Vapor Pressure, Lbs./sq. in. (gauge)	Per cent Snow By weight of CO_2
20	407	42
0	290	46
-20	200	50
-40	131	54
-60	80	58
-68	64	59

A sufficient quantity of pressure medium may then be introduced into the container to establish a desired pressure in the vapor space at a given temperature. For example, the established pressure may vary between about 450 and about 1000 pounds per square inch in cases where the carbon dioxide is maintained at a temperature of between about -20°F . and the established pressure may vary between about 300 and about 700 pounds per square inch in cases where the carbon dioxide is maintained at a temperature of between about -20°F . and the triple point temperature (-69.88°F).

Preferably, a pressure not in excess of about 500 pounds per square inch is maintained at temperatures of between about -68°F . and 20°F . These combinations produce goods yields of snow (between about 42 and about 59%) and provide for rapid discharge of the carbon dioxide. By not exceeding 500 pounds per square inch, the carbon dioxide can be safely stored in large capacity containers which are lighter in weight and cheaper in construction, as compared with standard gas cylinders.

As a specific example of the present invention, a container may be charged with carbon dioxide and maintained at a temperature of about -40°F . Sufficient nitrogen may be introduced to establish a pressure of about 450 pounds per square inch in the vapor space of the container. The carbon dioxide so stored will form about 54% snow upon being discharged through a snow producing discharge device, and it will be discharged at substantially twice the rate at which liquid carbon dioxide stored at -40°F . will be discharged under its own vapor pressure.

In the foregoing example, the safety valve 20 may be set to relieve pressure in the container when the same exceeds about 500 pounds per square inch. The valve 21, if utilized, may be adjusted to bleed-off gases in the vapor space to permit expansion of the gaseous carbon dioxide and provide a refrigerating effect in the event the pressure in the container exceeds about 460 pounds per square inch. The automatic valve 27 may be adjusted to introduce additional pressure medium to compensate for the reduction in pressure when the pressure drops below about 450 pounds per square inch. The thermostatic control means 13 in this case is adjusted to cause the carbon dioxide to be refrigerated and maintained at about -40°F .

From the foregoing description, it will be seen that the present invention provides a system and method for storing and discharging liquid carbon dioxide at low temperatures to produce a large quantity of snow while at the same time attaining a relatively high discharge rate. When the liquid carbon dioxide at low temperatures

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is discharged rapidly, it is prevented from solidifying in the container, whereby substantially the entire supply may be conducted to a fire. By adjusting the pressure to which the carbon dioxide is subjected when stored, uniform or predetermined discharge rates may be obtained at various predetermined sub-atmospheric temperatures.

By the term "sub-atmospheric temperatures," as used herein and in the appended claims, is meant temperatures between about 20° F. and the temperature at which carbon dioxide solidifies, namely at about its triple point.

As various changes may be made in the form, construction and arrangement of the parts herein, without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in any limiting sense.

It is also to be understood that the following claims are intended to cover all the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

I claim:

1. A method of storing liquid carbon dioxide for fire extinguishing purposes which comprises maintaining a supply of liquid carbon dioxide in a container, supplying refrigeration to the carbon dioxide while in the container from an external source to maintain the carbon dioxide at a relatively low temperature and corresponding pressure, and introducing into the container in response to the pressure therein a gaseous pressure medium other than carbon dioxide which has a substantially higher vapor pressure than carbon dioxide at a given temperature, to thereby establish and maintain a substantial pressure in the container adapted to effect more rapid discharge of the carbon dioxide therefrom.

2. A method of storing liquid carbon dioxide for fire extinguishing purposes which comprises maintaining a supply of liquid carbon dioxide in a container, supplying refrigeration to the carbon dioxide while in the container from an external source to maintain its temperature between about -68° and about 20° F., and introducing into the container in response to the pressure therein a gaseous pressure medium other than carbon dioxide to establish and maintain a substantial pressure in the container at said temperatures which is adapted to effect discharge of carbon dioxide at a rate greater than about twice the rate of discharge of carbon dioxide under its vapor pressure at -40° F.

3. A method of employing liquid carbon dioxide for fire extinguishing purposes which comprises maintaining a supply of liquid carbon dioxide in a container, intermittently supplying refrigeration to the carbon dioxide while in the container from an external source in response to the temperature of the carbon dioxide to maintain its temperature between about -68° and about 20° F. whereby, when the carbon dioxide is expanded, between about 42 per cent and about 59 per cent by weight carbon dioxide snow will be produced, and introducing into container in response to the pressure therein a gaseous pressure medium other than carbon dioxide to establish and maintain a substantial pressure in the container at said temperatures which is adapted to effect discharge of carbon dioxide at a rate greater than about twice the rate of discharge

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of carbon dioxide under its vapor pressure at -40° F., and discharging the carbon dioxide and conducting it to its point of use.

4. A method of storing liquid carbon dioxide for fire extinguishing purposes which comprises maintaining a supply of liquid carbon dioxide in a container, supply refrigeration to the carbon dioxide while in the container from an external source in response to the temperature thereof to maintain its temperature at about -40° F., introducing into the container a gaseous pressure medium other than carbon dioxide to establish and maintain in the container a pressure of about 450 pounds per square inch at -40° F. which is adapted to effect discharge of carbon dioxide at a rate greater than about twice the rate of discharge of carbon dioxide under its vapor pressure at -40° F., and regulating the pressure in the container to maintain the same substantially constant by controlling the introduction of the gaseous pressure medium in response to the pressure in the container, whereby the carbon dioxide is adapted to be discharged at a predetermined rate.

5. A fire extinguishing system comprising an insulated container for storing liquid carbon dioxide having an outlet, conduit means connected to said outlet for conducting the carbon dioxide to its point of use, a refrigerating unit including a coil positioned in said container for heat exchange relation with liquid carbon dioxide stored in said container to maintain the carbon dioxide at a relatively low temperature and corresponding pressure and including means for controlling the refrigeration supplied responsive to the temperature of the liquid carbon dioxide, a second container for storing compressed gaseous medium having a substantially higher vapor pressure than carbon dioxide at a given temperature, a conduit connecting said containers for introducing the gaseous medium into said first container to establish a pressure in said first container substantially higher than the pressure at which the carbon dioxide is stored therein, a valve in said conduit for controlling the introduction of the gaseous medium into said first container, means responsive to the pressure in said first container to maintain a predetermined pressure in said first container.

6. A fire extinguishing system comprising in combination an insulated container for storing liquid carbon dioxide having an outlet, conduit means connected to said outlet for conducting the carbon dioxide to its point of use, a refrigerating unit including a coil positioned in said container for heat exchange relation with liquid carbon dioxide stored in said container to maintain the carbon dioxide at a relatively low temperature and corresponding pressure and including means for controlling the refrigeration supplied responsive to the temperature of the liquid carbon dioxide, a second container for storing a compressed gaseous medium having a substantially higher pressure than carbon dioxide at a given temperature, a conduit connecting said containers for introducing the gaseous medium into said first container to establish a pressure in said first container substantially higher than the pressure at which the carbon dioxide is stored therein, a valve in said conduit operable to control the introduction of the gaseous medium into said first container, means responsive to the pressure in said first container for controlling the operation of said valve to maintain a predetermined uniform pres-

sure in said first container, and a relief valve operable in response to excessive pressure in said first container.

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