

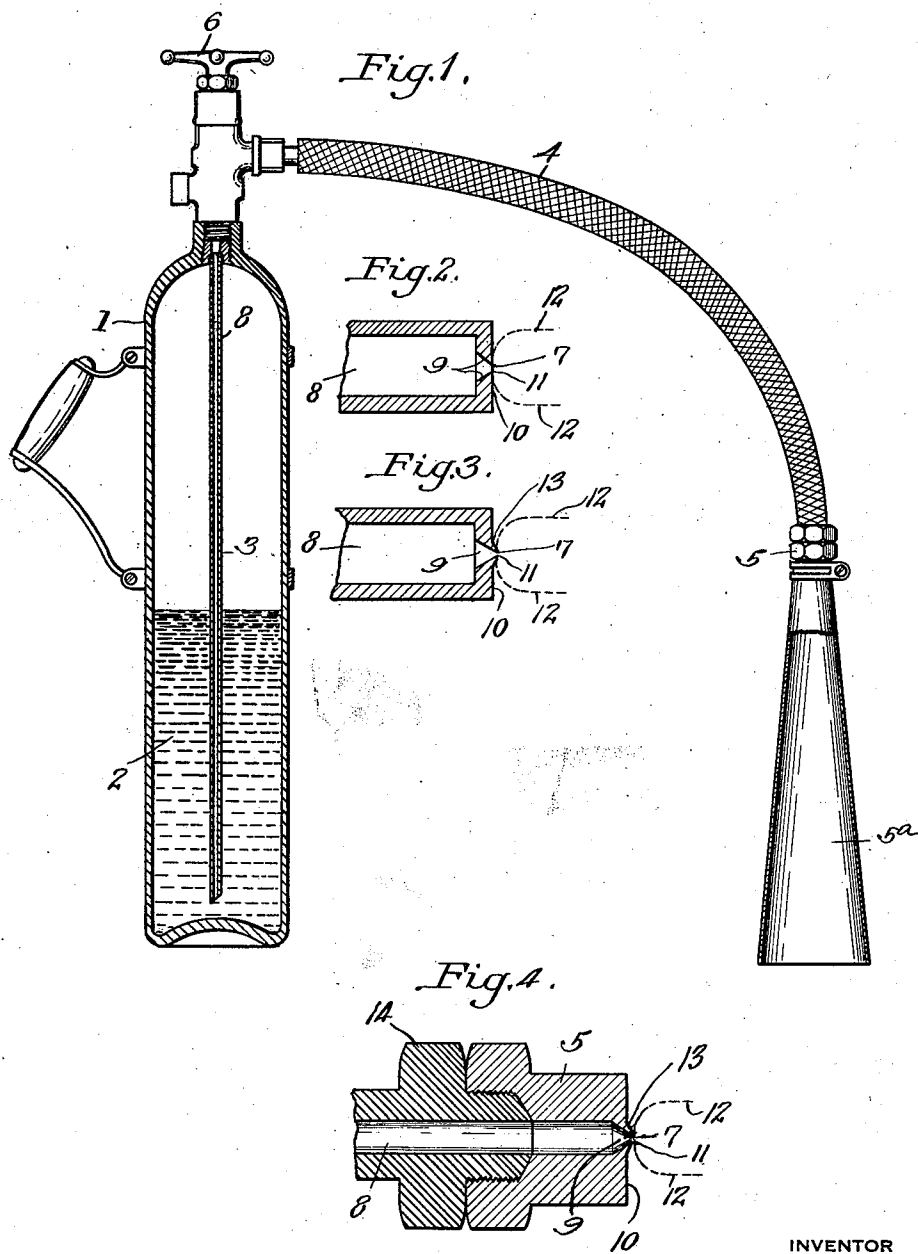
Oct. 4, 1927.

C. L. JONES

1,644,338

DISCHARGING CARBON DIOXIDE

Filed March 31, 1925



INVENTOR
Charles L. Jones,
by his atty.
Bygones, Stebbins & Parnell

Patented Oct. 4, 1927.

1,644,338

UNITED STATES PATENT OFFICE.

CHARLES L. JONES, OF PITTSBURGH, PENNSYLVANIA.

DISCHARGING CARBON DIOXIDE.

Application filed March 31, 1925. Serial No. 19,562.

This invention relates to discharging carbon dioxide and is shown as being particularly applied to a fire extinguisher employing liquefied carbon dioxide. It will be understood, however, that the invention has many other applications.

Carbon dioxide as such has not heretofore been widely used for extinguishing fires on account of the difficulty of securing positive, and, at the same time, extremely rapid discharge of liquefied carbon dioxide from the steel cylinders in which it is commercially obtained. This is due to the fact that when the gas is discharged from its state of very high pressure in the tank the boiling of the liquefied gas and its great expansion produce low temperatures until some of the gas or liquid congeals to form carbon dioxide snow. The temperature of this snow is about -110° Fahrenheit. If any water is present the water will freeze at a much higher temperature. In either case the system becomes clogged with solid products of this freezing action and the flow of carbon dioxide is materially lessened or altogether stopped.

I provide for handling the liquefied gas through a piping system having a non-uniform passage dimension as contrasted with the system shown in the Rustige Patent, No. 1,335,394. This patent shows a liquid transporting system having a substantially uniform passage dimension so that the pressure drop is evenly distributed along a pipe leading from the bottom of a carbon dioxide cylinder to the point of application to the fire or other place where the gas is used. In the application of this system the piping becomes intensely cold and is thereby subject to stoppage if very large amounts of liquefied gas are discharged through it. I provide a system having a non-uniform passage dimension, the conduit being relatively large and terminating in an orifice which is small enough to localize most of the pressure drop and hence most of the expansion at the orifice.

The actual size of the orifice in every case depends on the resistance to flow in the passage leading thereto. Obviously, the smaller the orifice the greater the pressure immediately behind it, other conditions being equal, and I regard it as sound practice to proportion the system so that the pressure drop from the cylinder to the orifice will not exceed 100 lbs. per square inch under normal temperature conditions. For example,

the pressure in a cylinder of liquefied carbon dioxide at 60° Fahrenheit is approximately 750 lbs. per square inch, and I would use a piping system leading to the orifice or orifices so large that the pressure just behind the orifice would be 650 lbs. per square inch or more, the expansion from 650 lbs. to atmospheric pressure taking place across the nozzle. Excellent results have been secured in experiments on a piping system of moderate length with a minimum passage diameter of $\frac{1}{8}$ " in combination with a discharge orifice of $\frac{1}{16}$ " diameter and therefore having 25% of the minimum area of the passage leading to it.

In the present state of the art the viscosity and thermal properties of liquefied carbon dioxide are not known with sufficient accuracy to form a basis for a general formula by which the size of the orifice and the minimum passage size may be determined. It will be understood that the above figures are the result of experiment only and have been found to give good results. They are here given for purposes of illustration and the invention is, of course, not limited to the sizes given.

The preferred relationship of pressure drop in the piping of 100 lbs. or less with a pressure drop across the orifice of 650 lbs. or more may be greatly modified and considerably more pressure drop permitted in the piping, if it is absolutely certain that no moisture is present in the carbon dioxide. According to Faraday, carbon dioxide freezes to a solid at -56.50° C. and 5.3 atmospheres pressure (-70° F. at 78 lbs. per square inch). It is evident that if the piping system is so designed that the pressure can not at any point get below 78 lbs. per square inch until the carbon dioxide passes out the discharge orifice, the carbon dioxide can not possibly solidify in the piping and stoppage of the piping will therefore not occur. In practice, however, it is never certain that traces of moisture may not be present, and it is therefore preferable to have a relatively small pressure drop along the conduit leading to the nozzle and to localize the greater part of the pressure drop at the nozzle orifice, since a very small amount of water, if frozen, may clog the piping or orifice. The preferred pressure drop and proportioning of the orifice area to the cross sectional piping area are calculated to prevent a temperature drop below

the freezing point of water, and the dimensions stated have been shown by tests to result in no temperature below 32° F. behind the discharge nozzle when the storage container and assembly is initially at a temperature of 50° F. or above. Commercial systems embodying my invention may be and are being operated successfully in which the orifice area is somewhat larger than 25% of the minimum cross sectional area of the conduit leading from the container to the nozzle.

The use of an orifice as above described in connection with a passage of materially larger diameter than the orifice gives rise to a localizing of the cooling effect at the nozzle. The tendency of the nozzle itself to freeze up depends largely upon the shape of the nozzle passage and orifice and the material of which the nozzle is made.

When the carbon dioxide is discharged into the atmosphere from a nozzle having a constricted discharge orifice, it expands tremendously as it emerges from the orifice. If an attempt be made to use the ordinary nozzles heretofore suggested, in which the surface around the orifice is substantially flat or reentrant, as shown for example in Camus' British Patent No. 9123 of 1902, the suddenly divergent stream of carbon dioxide expanding from the nozzle will brush against the surface of the nozzle around the orifice and chill it. The issuing stream as it expands beyond the orifice consists of expanded gas together with carbon dioxide snow formed by the sudden expansion, and is very cold, being about -110° F. The nozzle surface around the orifice is therefore subjected to intense cold and by conduction through the metal of the nozzle, the walls of the passage in the nozzle leading to the discharge orifice become chilled sufficiently to freeze the carbon dioxide snow or moisture in the stream of carbon dioxide in the passage and cause it to become clogged. If even a small amount of water is entrained in the carbon dioxide, it will greatly facilitate the freezing and clogging of the discharge passage. I have found that such freezing in the discharge passage of the nozzle may be prevented by thermally insulating the discharge passage of the nozzle leading to the discharge orifice from the cooled issuing stream of carbon dioxide emerging from the orifice. This may be accomplished in different ways, as for example, by making the nozzle of a thermally poor conducting material or so forming the nozzle that the expanding stream of carbon dioxide emerging from the nozzle does not brush against the surface of the nozzle around the orifice, so that a heat-insulating layer of air lies over the surface of the nozzle around the orifice.

In the accompanying drawings:

Figure 1 is a side elevation partly broken away of a fire extinguisher embodying my invention;

Figure 2 is a cross section of a nozzle formed of heat-insulating material;

Figure 3 is a cross section of a nozzle which may be made of metal and so shaped as to prevent brushing of the emerging stream against the nozzle face around the orifice; and

Figure 4 is a sectional view of a nozzle of the type shown in Figure 3 as actually constructed.

Referring to the illustrated embodiment of the invention, reference numeral 1 indicates a storage container or tank shown as the usual carbon dioxide-containing cylinder and adapted to hold the charge of highly compressed carbon dioxide. The carbon dioxide will be in the form of a liquid, as indicated at 2, at ordinary room temperatures. The carbon dioxide is discharged through a conduit formed by a tube 3, extending to the bottom of the cylinder 2, and a flexible hose 4 leading to the discharge nozzle 5. A valve 6 is provided for releasing the carbon dioxide. A flaring horn 5^a is preferably fitted over the end of the nozzle to more effectively direct the issuing stream of carbon dioxide and prevent too great an entrainment of air. The nozzle 5 has a restricted discharge orifice 7. The area of the orifice 7 is small, preferably not over 25% of the cross sectional area of the passage 3 through the conduit leading to the nozzle. As shown in the drawings, the passage 8 terminates in a converging portion 9 leading to the constricted orifice 7. The inner surface of the converging passage 9 meets the outer or end surface 10 of the nozzle to form a sharp edge 11, which constitutes the periphery of the orifice 7. The bore 8 of the conduit leading from the carbon dioxide storage container or cylinder to the nozzle is of sufficient size so that the pressure drop along such conduit is nowhere sufficient to permit expansion to a pressure low enough to form carbon dioxide snow; but in order to safeguard the conduit from clogging, in case water is present in the carbon dioxide, I prefer to make the conduit of sufficient size so that there will be no pressure drop in it sufficient to freeze water, and therefore, the carbon dioxide preferably will be delivered to the nozzle 5 at a pressure approximating that of the initial pressure in the storage container. The stream of carbon dioxide delivered to the nozzle will, at temperatures below 88° F., consist of liquid carbon dioxide together with some gas produced by the bubbling of the stream as caused by the pressure drop along the conduit. Since the critical tem-

perature of transition between the liquid and solid phases of carbon dioxide is about 88° F., carbon dioxide can not exist as a liquid above such temperature, irrespective of the pressure; and if the room temperature exceeds 88° F., the carbon dioxide in the storage cylinder will be in the gaseous phase, occupying, however, the same volume as the liquid phase.

When the carbon dioxide, either as liquid or liquid with entrained gas, or as a highly compressed gas, is discharged into an atmospheric pressure from a nozzle having a restricted discharge orifice, it expands tremendously as it emerges from the nozzle orifice; and with the ordinary type of nozzle having a flat or reentrant face around the orifice, the suddenly expanding divergent stream will brush against the surface of the nozzle around the orifice. A great expansion takes place just beyond the orifice where the carbon dioxide suddenly expands or flashes into the gas at low pressure, so that there is at this point a point of intense cold sufficient to convert part of the expanded gas into snow. The envelope of the expanding stream beyond the orifice is indicated approximately by the dotted lines 12 in the drawing. The face of the envelope immediately at the sides of the orifice is at substantially right angles to the axis of the discharge passage through the orifice or may even be inclined slightly backward along such axis, so that if the face of the nozzle around the orifice is flat, the stream of expanding gas with its entrained snow will brush against the face of the nozzle around the orifice.

Unless the walls of the passage leading to the orifice are insulated from the intense cold of the emerging stream of carbon dioxide, the walls in such passage will be chilled below the freezing point of carbon dioxide or the freezing point of water and will collect either frozen water or frozen carbon dioxide and the passage will clog. This insulation may be accomplished by making the nozzle or portion of the nozzle adjacent to the orifice 7 of a thermally poor conducting material, such as bakelite. A nozzle of this type is illustrated in Figure 2. Since the material of the nozzle itself acts as a heat insulator, the face of the nozzle may be flat, if desired, and the emerging stream may brush against its outer face.

However, for mechanical reasons, an orifice of some corrosion-resisting and mechanically strong metal, such as Monel metal, is to be usually preferred in practice. Since metal is a good heat conductor, other provision must be made in a metal nozzle to insulate the passage leading to the orifice from the intense cold produced by the emerging and expanding stream of carbon dioxide. This is preferably accomplished

as shown in Figures 3 and 4, in which a metal nozzle is illustrated. The face of the nozzle immediately surrounding the orifice 7 protrudes, as indicated at 13, so that the point or region of the expansion or divergence of the issuing stream of carbon dioxide is projected beyond and out of contact with the face 10 of the nozzle. As shown in the drawings, the portion 13 of the nozzle protrudes sufficiently so that the point of expansion of the stream of carbon dioxide emerging past the sharp edge of the nozzle orifice is sufficiently beyond the face 10 of the nozzle, so as not to brush against it. As shown in the drawings, there is left a small layer of air between the envelope 12 of the expanding stream and the face 10 of the nozzle, which serves as a heat insulator. The expanding stream will act somewhat as an aspirator to draw in this film of air between its envelope and the face of the nozzle.

In Figure 4 is illustrated a nozzle of the type shown in Figure 3 as actually constructed. This consists of a nozzle proper 5, which is threaded on to a coupling member 14, at the discharge end of the hose 4. The conduit passage 8 is continued into the nozzle and converges, as indicated by reference numeral 9, to the restricted outlet orifice 7. The inner walls of the converging portion 9 of the nozzle passage meet the protruding portion of the outer face 10 of the nozzle to form the protruding sharp edge or lip 11 which defines the circumference of the orifice. The outline of the discharged stream is shown in dotted lines in this figure. It will be seen that the expanded gas does not brush against the body of the nozzle in any way and the ordinary tendency of a nozzle to freeze is therefore eliminated. Preferred dimensions for this nozzle are as follows: The diameter of the conduit 6 is $\frac{1}{4}$ "; the diameter of the nozzle 9 is $\frac{1}{8}$ ", and the portion 8 protrudes $\frac{1}{16}$ " from the face of the nozzle body 4. It will be understood, of course, that these dimensions are for purposes of illustration only.

By thermally isolating or insulating the bore or passage of the nozzle within the orifice from the intense cold of the emerging stream of carbon dioxide beyond the orifice, I am enabled to do away with the application of heat to the nozzle, which has been one of the remedies proposed to prevent nozzle freezing. The application of heat would necessitate the complications of a heating system and would be impracticable, particularly with fire-extinguishing apparatus, which should be available for instant and unfailing discharge. It would be particularly impracticable to complicate a fire extinguisher of the portable type with any auxiliary nozzle-heating device.

I thus provide a highly effective means for discharging carbon dioxide, by localizing the cooling effect at a point beyond the nozzle orifice and thermally isolating this point from the nozzle bore or passage leading to the orifice, thus eliminating the stoppages ordinarily met with due to solidification of the carbon dioxide itself or of the moisture contained therein. It will be understood, of course, that the invention is applicable to the discharge of carbon dioxide which is in gaseous form before it leaves the nozzle as well as to gas which reaches the nozzle in liquid form.

While I have shown a preferred embodiment of my invention and one commercial application thereof, it will be understood that the invention is not thus limited as it may be otherwise embodied within the scope of the following claims.

I claim:

1. The method of discharging carbon dioxide under high pressure, comprising localizing the greater part of the pressure drop at a constricted discharge orifice, and thermally insulating the passage leading to the orifice from the cooled expanded stream of carbon dioxide emerging from the orifice to prevent stoppage of flow therethrough.

2. The method of discharging carbon dioxide from a container holding the carbon dioxide under high pressure, comprising leading the carbon dioxide from the container to a discharge nozzle through a conduit along which the pressure drop is insufficient to form carbon dioxide snow in the conduit, and then passing the carbon dioxide through a restricted nozzle orifice and thereby converting part of the issuing stream of carbon dioxide into snow beyond the nozzle orifice and thermally insulating the nozzle passage leading to the orifice from the cold developed by the expansion of the carbon dioxide beyond the nozzle.

3. The method of discharging carbon dioxide from a container holding the carbon dioxide under high pressure, comprising leading the carbon dioxide from the container to a discharge nozzle through a conduit along which the pressure drop is insufficient to form carbon dioxide snow in the conduit, and then passing the carbon dioxide through a restricted nozzle orifice and thereby converting part of the issuing stream of carbon dioxide into snow beyond the nozzle orifice and preventing the expanding stream of carbon dioxide gas and snow from brushing the outer surface of the nozzle.

4. The method of discharging carbon dioxide under pressure, comprising conducting the carbon dioxide, while retaining the greater part of this initial pressure, to a discharge

orifice, and thermally insulating the passage leading to the orifice from the cold developed by the expansion of the carbon dioxide beyond the orifice.

5. The method of discharging carbon dioxide under high pressure, comprising passing the carbon dioxide through a discharge nozzle, and projecting the point of expansive divergence of the issuing stream of carbon dioxide beyond and out of contact with the nozzle.

6. Apparatus for discharging carbon dioxide under high pressure, comprising a container for holding compressed carbon dioxide, a conduit leading from the bottom of the container, and a nozzle at the discharge end of the conduit having its outer face around the nozzle orifice tapered backwardly sufficient to prevent the expanding issuing stream of carbon dioxide from brushing against the nozzle.

7. Apparatus for discharging carbon dioxide under high pressure, comprising a container for holding compressed carbon dioxide, a conduit leading from the bottom of the container, and a nozzle at the discharge end of the conduit having a nozzle passage converging to a restricted discharge orifice and having its outer face around the orifice tapered backwardly sufficient to prevent the expanding issuing stream of carbon dioxide from brushing against the nozzle.

8. Apparatus for discharging carbon dioxide under high pressure, comprising a container for holding compressed carbon dioxide, a conduit leading from the bottom of the container, and a nozzle at the discharge end of the conduit having a converging nozzle passage leading to a discharge orifice and having its outer face around the orifice tapered backwardly sufficient to prevent the expanding issuing stream of carbon dioxide from brushing against the nozzle, the surface of the discharge passage and the outer face of the nozzle meeting at the circumference of the orifice to form a sharp protruding edge.

9. Apparatus for discharging carbon dioxide under high pressure, comprising a container for holding compressed carbon dioxide, a conduit leading from the bottom of the container, and a nozzle at the discharge end of the conduit having a nozzle passage converging to a discharge orifice and having provision for thermally insulating the nozzle passage behind the orifice from the cold expanding stream of carbon dioxide emerging from the orifice.

In testimony whereof I have hereunto set my hand.

CHARLES L. JONES.