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PROCESS AND APPARATUS FOR OBTAINING DENSE CARBON DIOXIDE SNOW DIRECTLY FROM LIQUID CARBON DIOXIDE

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Fig. 1.

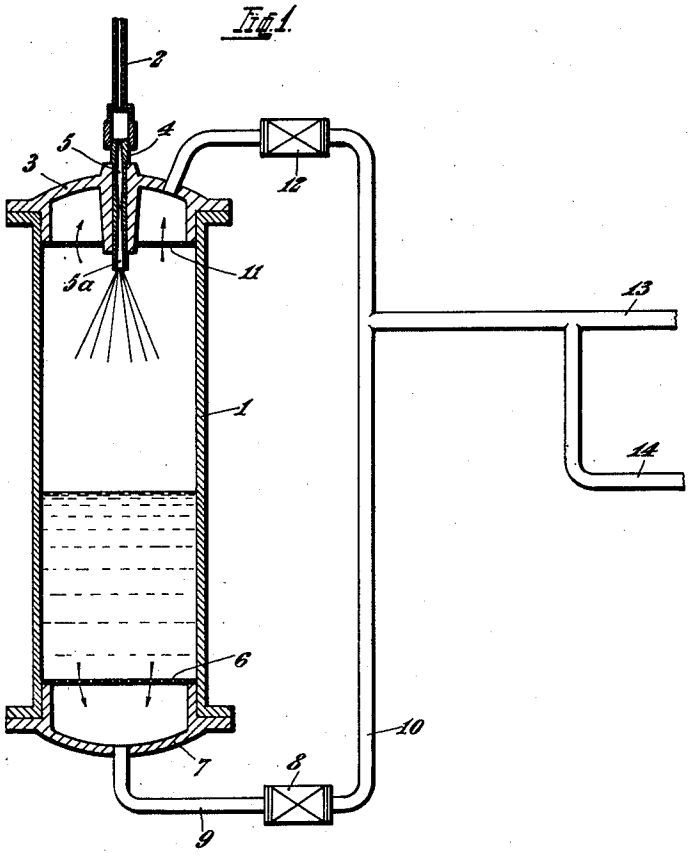
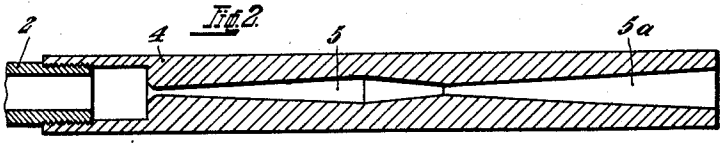


Fig. 2.



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PROCESS AND APPARATUS FOR OBTAINING DENSE CARBON DIOXIDE SNOW DIRECTLY FROM LIQUID CARBON DIOXIDE

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This invention relates to a process and apparatus for obtaining dense, specifically heavy carbon dioxide snow or ice directly from liquid carbon dioxide.

It is well known to make solid carbon dioxide, so-called carbon dioxide snow, by allowing liquid carbon dioxide to expand to atmospheric pressure, collecting the snow by filtration, and supplying the vapors that are formed to the low-pressure cylinder of the compresser to be liquefied again. Normally the escaping gases are simultaneously employed for pre-cooling the liquid to be expanded. The loose snow is then made by high pressure very dense, there being about 10% sublimated and reckoned as lost. In other words the dry and therefore looser snow which has previously been obtained from liquid carbon dioxide is condensed mechanically by compression, about 10% of the snow being converted into gas and lost to the yield.

In contradistinction to this known method the present invention enables exceedingly dense carbon dioxide snow or ice to be made in a simple physical manner in one single cycle of operations.

The process according to the present invention comprises the step of expanding the liquid carbon dioxide, for the purpose of forming moist snow, to a pressure which approximately corresponds to the tripple point of carbon dioxide.

Further, according to the invention, apparatus for carrying into practice this improved process is characterized in that an expansion nozzle having a diffuser directly attached thereto serves for introducing the liquid carbon dioxide into the expansion vessel.

Other features of the invention will be described hereinafter and pointed out in the claims.

One form of apparatus for carrying the improved process into practice is diagrammatically illustrated by way of example in the accompanying drawings, wherein:—

Figure 1 is an elevation, partly in section, showing an expansion chamber and diffuser associated therewith, and

Figure 2 shows a detail thereof in the form of a nozzle in longitudinal section on an enlarged scale.

Referring to the drawings, the apparatus comprises a vertical expansion chamber 1 for liquid carbon dioxide which is supplied through a pipe 2 to an expansion nozzle 4 inserted into the cover 3 of the vessel. The expansion nozzle 4 runs directly into a diffuser 5*a*. In the expansion nozzle 5 the liquid carbon dioxide is first expanded to a pressure lying below the tripple point (about − 56.6°) of carbon dioxide, in order to obtain snow with certainty. The snow and gas are then compressed by the diffuser to over the tripple point. This pressure lies between 5–6 atmos. In this manner a moist snow it obtained. The wet snow ejected from the diffuser is caught by a screen 6, on which the snow gradually grows into a block. A pipe 9 having a valve or stop cock 8 is connected to the removable bottom 7 of the expansion vessel 1. A pipe 10 that is connected below to the stop cock 8 is connected above to the cover 3 at a situation above an upper screen 11, and can be closed at 12 by a stop cock or valve. Branch pipes 13 and 14 lead to the low-pressure and high-pressure cylinders, for example of a two-stage compressor (not shown), so that it is possible to regulate the pressure in the vessel 1 as desired by closing or opening one or other of the valves 8 and 12, or by corresponding alternate opening thereof, or by supplying more or less liquid from the pipe 2. According to the desired final pressure in the expansion vessel and according to the intended density of the carbon dioxide snow, the gases that are formed or only a part thereof are sucked away through the block of snow. Owing to these gases (so-called throttle vapors) diffusing through the moist plastic mass of snow, a solid coherent icy mass is produced having a high pecific weight up to 1.45. Besides the dense product, owing to working with a higher final pressure the additional advantage is obtained that a compressor of relatively small dimensions can be used, and in consequence of the high suction

pressure the requisite work of compression is less than when exhausting from one atmosphere.

When a snow block of the desired height is obtained the connection with the high-pressure cylinder is exchanged with that of the low-pressure compressor, the valve in the pipe 2 being closed. The pressure in the expansion vessel is thereby reduced to atmospheric pressure and in consequence of the fall in temperature to − 80° C., the moist mass of snow is caused to congeal. When the bottom 7 of the vessel 1 is removed with the filter 6 the icy snow block in the usual commercial form can be removed below from the vessel 1 that has a corresponding cross-section, and those losses due to radiation which are unavoidable with known processes do not occur. After closing the expansion vessel the described process can be repeated. The escaping gases can be used during the process for cooling the liquid carbon dioxide to be used, in order still more to increase the efficiency of the process.

By means of the described process dense carbon dioxide snow or ice is obtained in one single cycle of operations and without the aid of a press.

Various modifications may be made in the details of construction of the apparatus described above within the scope of the invention as defined by the claims.

We claim:—

1. A process of obtaining dense, specifically heavy carbon dioxide ice from liquid carbon dioxide, including the steps of expanding the liquid carbon dioxide to a pressure that corresponds approximately to the triple point of carbon dioxide, whereby snow and gases are produced, and in compelling gas to diffuse through the snow in order to compress the snow in a single operation simultaneously with a further reduction of pressure to form the snow into a mass of higher density.

2. Apparatus for obtaining dense, specifically heavy carbon dioxide ice from liquid carbon dioxide, comprising in combination, an expansion vessel, an expansion nozzle for admitting liquid carbon dioxide into said vessel, a screen in said vessel for receiving snow formed therein, and a pipe that opens into said vessel at the side of said screen remote from said nozzle for drawing off from the vessel gas formed therein through the snow on the screen and through the screen.

3. Apparatus for obtaining dense, specifically heavy carbon dioxide ice from liquid carbon dioxide, comprising in combination, an expansion vessel, an expansion nozzle in the upper part thereof for admitting liquid carbon dioxide into the vessel, a screen in the vessel below said nozzle for collecting snow formed in the vessel, a pipe that opens into said vessel at a location above said screen for withdrawing gas that is formed in the vessel and regulating the final pressure therein, means for opening and closing said pipe, and a pipe that opens into the vessel below the screen and serves to draw off gas from the vessel through the snow on the screen.

4. In a process of forming a dense specifically heavy carbon dioxide ice from liquid carbon dioxide, those steps which consist in, admitting liquid carbon dioxide into a chamber while maintaining the pressure in the chamber corresponding approximately to the triple point of carbon dioxide with resulting formation of a mass of carbon dioxide snow in the chamber, and finally reducing the pressure on and removing such mass of snow from the chamber.

5. In a process of forming a dense specifically heavy carbon dioxide ice from liquid carbon dioxide, those steps which consist in, admitting liquid carbon dioxide into a chamber while maintaining the pressure in the chamber approximately corresponding to the triple point of carbon dioxide with resulting formation of a mass of moist carbon dioxide snow therein, and then solidifying and hardening the moist snow mass.

6. In a process of forming a dense, specifically heavy carbon dioxide ice; expanding liquid carbon dioxide to a pressure approximately corresponding to the triple point of carbon dioxide with the resulting formation of a mass of moist carbon dioxide snow therefrom, maintaining the mass of snow during formation thereof at a pressure approximately corresponding to the triple point pressure, and solidifying the mass of moist snow into a block of carbon dioxide ice.

7. A process of forming a dense, specifically heavy carbon dioxide ice from liquid carbon dioxide, comprising the steps of; expanding liquid carbon dioxide to a pressure corresponding approximately to the triple point of carbon dioxide, with the resulting formation of a moist carbon dioxide snow, collecting the moist snow while maintaining the same under approximately the aforesaid pressure; and finally subjecting the collected mass of moist snow to a decrease in pressure down to approximately atmospheric pressure to congeal and solidify the same into a dense, specifically heavy mass of carbon dioxide ice.

8. A process of forming dense, specifically heavy carbon dioxide ice from liquid carbon dioxide, consisting in the steps of; expanding liquid carbon dioxide in a chamber to a pressure corresponding approximately to the triple point of carbon dioxide to form a wet carbon dioxide snow and carbon dioxide gas in the chamber, collecting the wet snow so formed in the chamber while

maintaining the chamber pressure at approximately the triple point of carbon dioxide, and then drawing off and diffusing carbon dioxide gas in the chamber through the collected wet snow while reducing the chamber pressure to congeal and solidify the wet snow into a block of carbon dioxide ice.

9. A process of forming a dense specifically heavy carbon dioxide ice, consisting in the steps of; expanding liquid carbon dioxide in a chamber to a pressure corresponding approximately to the triple point of carbon dioxide with the production of a wet carbon dioxide snow and gases, collecting the wet snow in the chamber while drawing off the gases from and maintaining the pressure in the chamber at approximately the triple point of carbon dioxide, and then reducing the pressure in the chamber to congeal and solidify the collected mass of wet snow therein into a block of dense, specifically heavy carbon dioxide ice.

10. A process of forming dense, specifically heavy carbon dioxide ice, including the steps of; expanding liquid carbon dioxide to a pressure at which a wet carbon dioxide snow is produced, collecting said wet snow while maintaining a wet snow preserving pressure thereon, and finally subjecting the wet snow to a further decrease in pressure with resulting lowering of the temperature to congeal and solidify the snow into a coherent block of dense, specifically heavy carbon dioxide ice.

11. A process of producing a dense, specifically heavy carbon dioxide ice, consisting in discharging and expanding liquid carbon dioxide into a chamber in which the pressure corresponds approximately to the triple point of carbon dioxide with resulting expansion of the liquid and formation thereof into a wet carbon doxide snow and gases, withdrawing the gases from the chamber while maintaining a wet snow preserving pressure therein and permitting the wet snow to collect in the chamber, then stopping discharge of liquid into the chamber, and finally reducing the chamber pressure to congeal and solidify the wet snow into a mass of carbon dioxide ice of higher density and specific weight.

12. A process of obtaining a dense, specifically heavy carbon dioxide ice from liquid carbon dioxide, including the steps of; discharging and expanding liquid carbon dioxide into a chamber to a pressure corresponding approximately to the triple point of carbon dioxide with resulting formation of wet carbon dioxide snow and vapors therefrom, withdrawing the vapors from the chamber during snow forming discharge and expansion of liquid therein while regulating the pressure in the chamber to maintain wet snow preserving conditions therein, stopping withdrawal of vapors and cutting off discharge of liquid into the chamber, and then diffusing vapors through the collected snow and withdrawing such vapors from the chamber while simultaneously reducing the pressure in the chamber to congeal and solidify the snow into a mass of carbon dioxide ice of higher density and specific weight.

13. A process of producing dense, specifically heavy carbon dioxide ice from liquid carbon dioxide, including the steps of; expanding liquid carbon dioxide into a chamber to a pressure corresponding approximately to the triple point of carbon dioxide with resulting formation of a wet carbon dioxide snow and vapors in the chamber, withdrawing vapors from the chamber during expansion of liquid thereinto to regulate and maintain a wet snow preserving pressure in the chamber while forming and collecting a mass of wet snow therein, stopping withdrawal of vapors from the chamber to regulate the final pressure on the wet snow mass therein, then cutting off discharge of liquid to the chamber, and finally reducing the chamber pressure to congeal and solidify the snow into a mass of carbon dioxide ice of higher density and specific weight.

14. A process of producing a cake or block of dense, specifically heavy carbon dioxide ice, comprising the steps of; forming and collecting a mass of wet carbon dioxide snow in a chamber while maintaining the chamber pressure corresponding approximately to the triple point of carbon dioxide, and finally reducing the chamber pressure to approximately atmospheric pressure with corresponding drop in temperature and congelation and solidification of the snow mass into a block or cake of dense, specifically heavy carbon dioxide ice for removal from the chamber for use.

15. A process of producing dense, specifically heavy carbon dioxide ice from liquid carbon dioxide, consisting in the steps of; expanding liquid carbon dioxide into a chamber to a pressure at which a wet carbon dioxide snow and vapors are formed, collecting the wet snow in the chamber while withdrawing vapors from the chamber above the collected snow and maintaining a wet snow preserving pressure in the chamber, stopping withdrawal of vapors to regulate the final pressure desired in the chamber, then cutting off discharge and expansion of the liquid into the chamber, and finally withdrawing vapors from the chamber at a point therein below the upper end of the wet snow mass to diffuse vapors through the mass while reducing the chamber pressure with resulting solidification of the snow mass into a block of dense, specifically heavy carbon dioxide ice.

16. Apparatus for obtaining dense, specifically heavy carbon dioxide ice from liquid

carbon dioxide, comprising in combination, an expansion vessel, an expansion nozzle for admitting liquid carbon dioxide into said vessel to form carbon dioxide snow and vapors therein, a member in said vessel below said nozzle providing a surface for receiving and on which the snow collects, and said vessel provided with a vapor outlet below said nozzle, and below the level of snow to be collected on said member, for drawing off vapor from the chamber and diffusing the vapor through the collected snow.

In testimony whereof we affix our signatures.

HANS RUFENER.
THEOPHIL EICHMANN.