Jan. 12, 1937. D. S. LEES 2,067,676

COOLING SYSTEM FOR UTILIZING SOLID CARBON DIOXIDE

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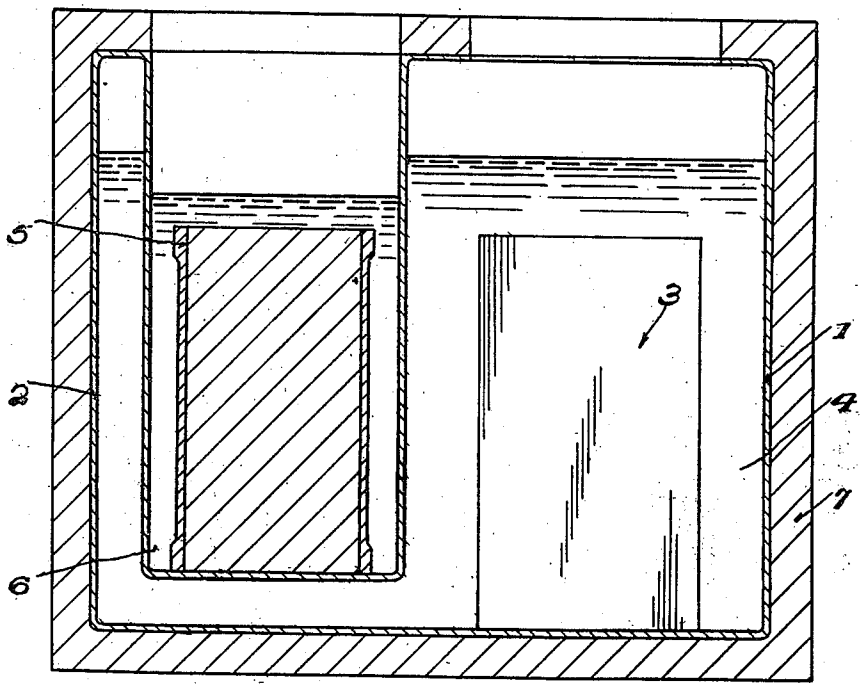


FIG. 1.

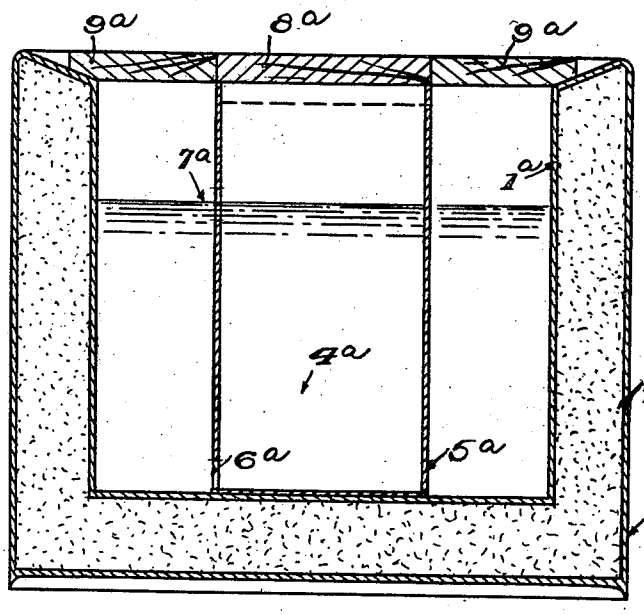


FIG. 2.

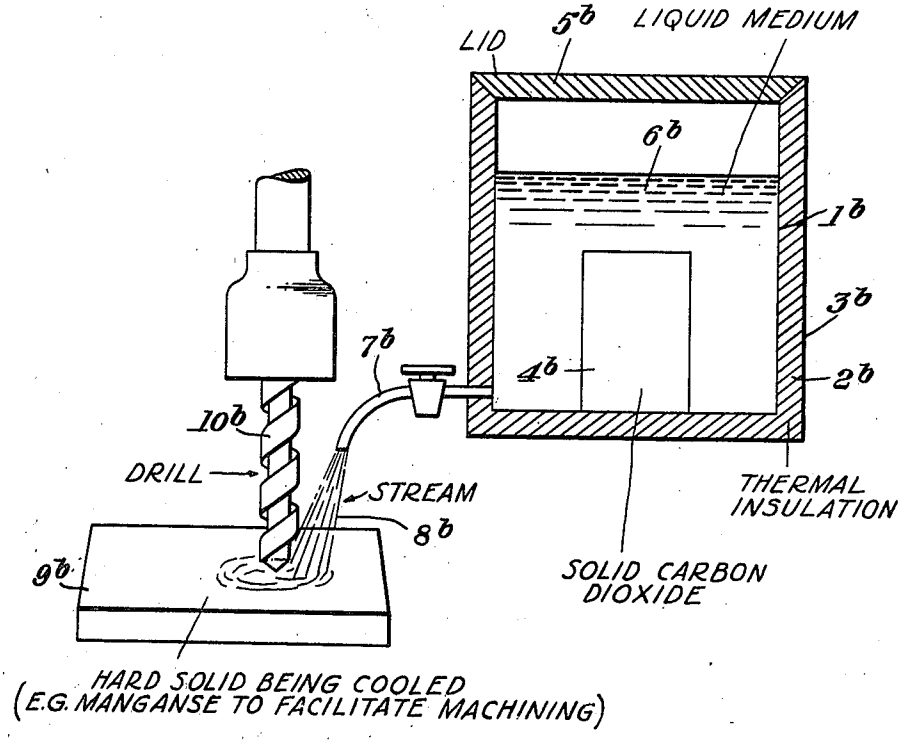
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Fig. 3



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COOLING SYSTEM FOR UTILIZING SOLID CARBON DIOXIDE

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4 Claims. (Cl. 62—1)

This invention relates to an improved cooling system for utilizing solid carbon dioxide and its principal object is to provide a cooling system which is adapted for the efficient and rapid cooling of solid bodies, especially metallic bodies, by means of solid carbon dioxide.

The rate and efficiency of the cooling action of solid carbon dioxide is limited by the low conductivity of the gaseous atmosphere immediately surrounding the solid, and even when a block of solid carbon dioxide rests upon a metal plate for example, there is a gas film between the block and the plate which causes a temperature gradient between the two.

I have now found that the efficiency of the cooling action of solid carbon dioxide, especially when in block form, may be greatly increased by introducing a liquid medium between the solid carbon dioxide and the solid body to be cooled. Thus the solid carbon dioxide and the solid body to be cooled may be immersed together in a suitable liquid, or the liquid may be divided into two compartments by means of a metal partition, the solid carbon dioxide being immersed in the one compartment and the solid body to be cooled in the other compartment. The latter arrangement has the advantage that the compartment into which the solid body is to be introduced contains liquid which is free from dissolved carbon dioxide and consequently no frothing occurs as a result of the temporary rise in temperature.

Suitable liquids for the purpose of the invention are those which have a sufficiently low freezing-point, which do not react with carbon dioxide and which do not have any deleterious effect upon the articles to be cooled. In this connection it may be explained that the invention is not dependent upon the vaporization of the liquid medium as in the case of the known freezing mixtures consisting of solid carbon dioxide snow and an organic liquid such as ether, alcohol, or acetone, which have been used for scientific purposes in obtaining very low temperatures substantially below the temperature of solid carbon dioxide. In fact, we prefer to employ liquid media which are not freely volatile at the ordinary temperature. Examples of such preferred liquids are the lower aliphatic alcohols, liquid paraffin hydrocarbons, toluene and chlorinated derivatives of aliphatic hydrocarbons having two carbon atoms in the molecule for example trichlorethylene. However, in certain cases we may use liquid media which are freely volatile at the ordinary temperature, in particular chlorinated derivatives of aliphatic hydrocarbons, e. g. ethyl chloride. It may be pointed out that chlorinated hydrocarbons such as trichlorethylene have special advantages for industrial use since they are non-inflammable, non-poisonous and non-corrosive; moreover, when using these liquids with a small amount of oil in solution the cooled metal parts retain an oily film after removal from the liquid, which film facilitates insertion into other metallic parts.

According to my invention, therefore, in the cooling of solid bodies by means of solid carbon dioxide, a liquid medium is introduced between the solid carbon dioxide and the solid body to be cooled. The liquid medium is preferably a liquid which is not freely volatile at the ordinary temperature, and may advantageously be a chlorinated hydrocarbon such as trichlorethylene. If desired the liquid medium may be applied to the solid body in the form of a stream.

Suitable apparatus for carrying out the above method comprises a vessel having two adjacent compartments adapted to contain a body of liquid as well as the solid body to be cooled and a quantity of solid carbon dioxide respectively, the said compartments being separated by a heat conducting wall, which may have one or more openings to enable the liquid to pass freely from either compartment to the other. Thus the vessel may be a metal tank open at the top but otherwise surrounded by heat insulating material, an inner compartment of the tank being formed by one or more metal partitions, with separate lids for the said compartment and for the other part of the tank. The partition or partitions may advantageously be adapted to permit liquid to pass freely into or out of the inner compartment.

I have applied the invention to the cooling of metallic cylinder liners, and have obtained very satisfactory results. A tank, suitably insulated on the outside, was divided into two compartments, the one to take the solid carbon dioxide and the other of suitable dimensions to hold the cylinder liner. Both compartments were filled with trichlorethylene to a suitable depth to ensure complete immersion of both the solid carbon

dioxide and the cylinder liner. A block of solid carbon dioxide was lowered into the one compartment and the apparatus was allowed to stand for about 15 minutes. A steel liner was then introduced into the other compartment. A contraction of 0.004" on a diameter of 4.25" was obtained in one minute, in which time the temperature of the cylinder liner dropped to −60° C. On removal the liner did not expand again rapidly; after one minute only 0.001" of contraction had been lost.

Three forms of suitable apparatus are illustrated in the accompanying drawings, in which Figures 1, 2, and 3 are sectional elevations of the apparatus. Referring to Figure 1, the apparatus consists of two tanks 1 and 2, the latter being fitted into the former so as to be as far as possible surrounded by liquid 4. The tank 2 is filled with liquid 6, which is not necessarily the same as the liquid 4. A block of solid carbon dioxide 3 is immersed in the liquid 4, and a cylinder liner 5, for example, is immersed in the liquid 6 in the tank 2. The liquid in the tank 1 is initially at a higher level than that in the tank 2 to allow for loss of level due to gasification of the solid carbon dioxide. Insulation 7 is employed for covering the outer surface of the larger tank.

With a total quantity of 4 gallons of trichlorethylene in tanks 1 and 2, 15 lbs. of solid CO_2 were used up in cooling the apparatus down to −70° C., the time required for this purpose being 20 minutes. 8 lbs. of solid CO_2 per 24 hours were used up in maintaining the apparatus at this temperature, i. e. to compensate for leakage of heat from the surroundings. Each cylinder liner, weighing 4 lbs. 7.25 ozs., required 1 minute to cool from 20° C. to −60° C. and 5 ozs. of solid CO_2 were used thereby. After withdrawal from the bath the liners were rapidly inserted into the appropriate cylinders.

Referring to Figure 2, a sheet metal tank 1^a is surrounded by insulation 2^a and the whole is encased in sheet metal 3^a. An inner compartment 4^a is formed by a metal cylinder 5^a which is provided with holes 6^a and 7^a to allow liquid to pass freely into or out of the compartment, the tank being filled with liquid up to about the level of the upper hole 7^a. Insulating lids 8^a and 9^a cover the compartment 5^a and the surrounding tank respectively. A quantity of solid CO_2 is placed in the outer compartment of the tank and when the temperature of the liquid in the compartment 5^a has fallen to the required degree the lid 8^a is opened and the articles to be cooled are introduced. Thermometers (not shown) of any suitable type are preferably provided in the inner and outer compartments.

Referring to Fig. 3, 1^b indicates a metal tank or container surrounded by heat insulation 2^b, the whole being surrounded by a metal casing 3^b. The open top of the tank is covered by a lid 5^b. The tank is filled with liquid medium 6^b in which is immersed a block of solid carbon dioxide 4^b. After the liquid medium has been sufficiently cooled, it is discharged through a small valve-controlled orifice or conduit in the container 1^b and applied in the form of a small stream or jet 8^b to the metallic body or hard solid 9^b (e. g. manganese) to be cooled. This arrangement is particularly advantageous where, for example as illustrated in Fig. 3, it is desired to cool a body to facilitate machining, as by a drill 10^b, the cooling liquid being directed or applied while the machining operation is being carried on.

It may be shown that the arrangement just described with reference to Figure 2 is much more efficient than one in which the articles to be cooled are simply introduced into a single bath of liquid containing solid CO_2. The following comparative tests are given in illustration of this fact, the test in each case being to cool down the liquid and then to cool 12 metal flanges weighing about 6 lbs. each.

Single bath	*Double bath*
Total quantity of trichlorethylene in bath =8.8 gallons.	Total quantity of trichlorethylene in bath =8.8 gallons.
Weight of solid CO_2 to reduce bath temperature =14 lbs. 5 ozs.	Weight of solid CO_2 to reduce bath temperature =14 lbs. 7 ozs.
Initial temperature of bath =−31° C.	Initial temperature of bath =−16° C.
Final temperature of bath =−72° C.	Final temperature of bath =−70° C.
Time taken to reduce bath temperature =42½ mins.	Time taken to reduce bath temperature =15½ mins.
Time taken to cool down 12 flanges (average weight 6 lbs.) total weight =71 lbs. 13 ozs. =99 minutes. (Note: Each flange was immersed separately.)	Time taken to cool down 12 flanges (average weight 6 lbs.) total weight =71 lbs. 13 ozs. =34 minutes. (Note: Each flange was immersed separately.)
Weight of solid CO_2 used for cooling of flanges=6 lbs. 6 ozs. (Equal quantities on each test.)	Weight of solid CO_2 used for cooling of flanges =6 lbs. 5 ozs. (Equal quantities on each test.)

It will be evident from the above that the double bath takes only about one-third of the time that the single bath takes to cool down and to cool the articles themselves.

My experiments have also shown that the above method and apparatus are much more efficient than the known method of cooling articles by placing them in refrigerators utilizing solid CO_2, both as regards the time required to attain the desired low temperature and the corresponding consumption of solid CO_2.

My invention may be applied to the cooling of any solid bodies and particularly metals. With the exception of tin, no appreciable permanent alteration in the crystalline structure or physical properties of the common metals and alloys appears to be brought about by cooling them for short periods to −44° C. Certain materials are known to be more readily machinable at low temperatures than at normal temperatures, and our invention includes the treatment of such materials for such purpose. Thus the materials may be submerged in the cold liquid during the actual machining, or in the case of certain machining operations such as drilling, a continuous jet of cold liquid may be applied to the part of the material being machined.

As many apparently widely different embodiments of this invention may be made without departing from the spirit thereof, it is to be understood that I do not limit myself to the foregoing examples or descriptions except as indicated in the following claims.

I claim:

1. In the inter-fitting of close-fitting machine parts, the method of shrinking one of said parts by cooling with solid carbon dioxide comprising immersing solid carbon dioxide in a bath of a liquid medium which does not solidify above about −70° C., and immersing the machine part to be cooled in an adjoining bath of similar liquid medium arranged in heat-conducting relation to the first bath, and cooling said machine part to a temperature approximating that of the solid carbon dioxide.

2. In the inter-fitting of close fitting parts, the method of shrinking one of the said parts by cooling with solid carbon dioxide through a liquid chlorinated hydrocarbon such as trichlorethylene which does not solidify above about −70° C, and which is introduced directly between the

solid carbon dioxide and the machine part to be cooled, so that the said machine part is cooled to a temperature approximating that of the solid carbon dioxide.

3. In the inter-fitting of close fitting machine parts, the method of shrinking one of the said parts by cooling with solid carbon dioxide through a liquid medium which does not solidify above about −70° C. and which is introduced directly between the solid carbon dioxide and the machine part to be cooled, so that the said machine part is cooled to a temperature approximating that of the solid carbon dioxide, said liquid medium being applied to the solid body in the form of a stream.

4. In the interfitting of close-fitting machine parts, the method of shrinking one of said parts by cooling with solid carbon dioxide comprising immersing solid carbon dioxide and the machine part to be cooled in a bath of a liquid medium which does not solidify above about −70° C. and cooling said machine part to a temperature approximating that of the solid carbon dioxide, said bath of liquid medium including a small amount of oil in solution whereby the cooled metal part retains an oily film after removal from the liquid medium.

DAVID S. LEES.