United States Patent

Zacarian

[15] **3,702,114**

[45] **Nov. 7, 1972**

[54] **LIQUID REFRIGERANT SPRAY DEVICE**

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[22] Filed: **Aug. 26, 1970**

[21] Appl. No.: **67,046**

[52] **U.S. Cl.** ....**128/173 R,** 62/293, 128/303.1, 239/337

[51] **Int. Cl.** **A61b 17/36,** A61m 11/00

[58] **Field of Search** ....128/173 R, 303.1, 225, 184, 128/400, 2.1 R; 222/396, 397, 399; 62/293, 52, 514; 239/337, 573, 577, 579

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[57] **ABSTRACT**

There is disclosed medical apparatus for spraying a low boiling point liquid refrigerant directly onto a site to be treated. It comprises a container which is vented but has a valve for selectively closing the vent, normal boiling of the liquid thereby resulting in self pressurization. A discharge orifice at the bottom of the container leads through an evaporating coil to an applicator, to which may be connected interchangeable needles. The evaporating coil permits partial vaporization of the refrigerant so that the spray is a liquid-gas mixture with little propensity to drip or run from the point of contact.

6 Claims, 4 Drawing Figures

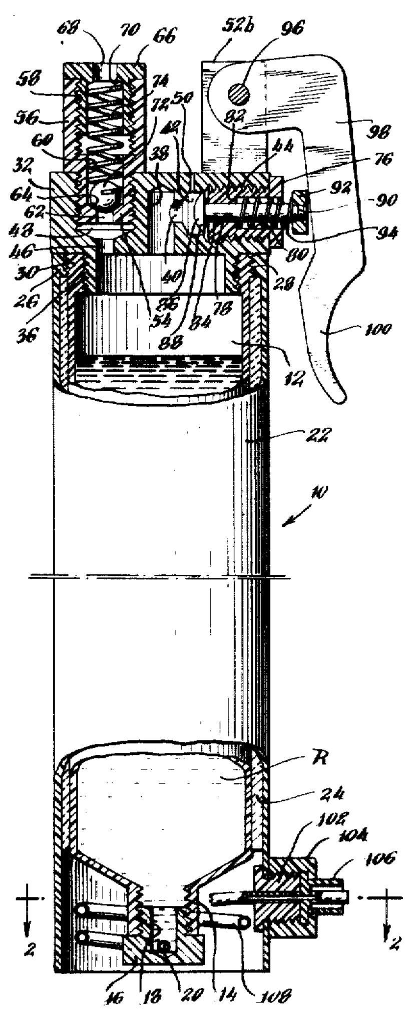

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Fig. 1

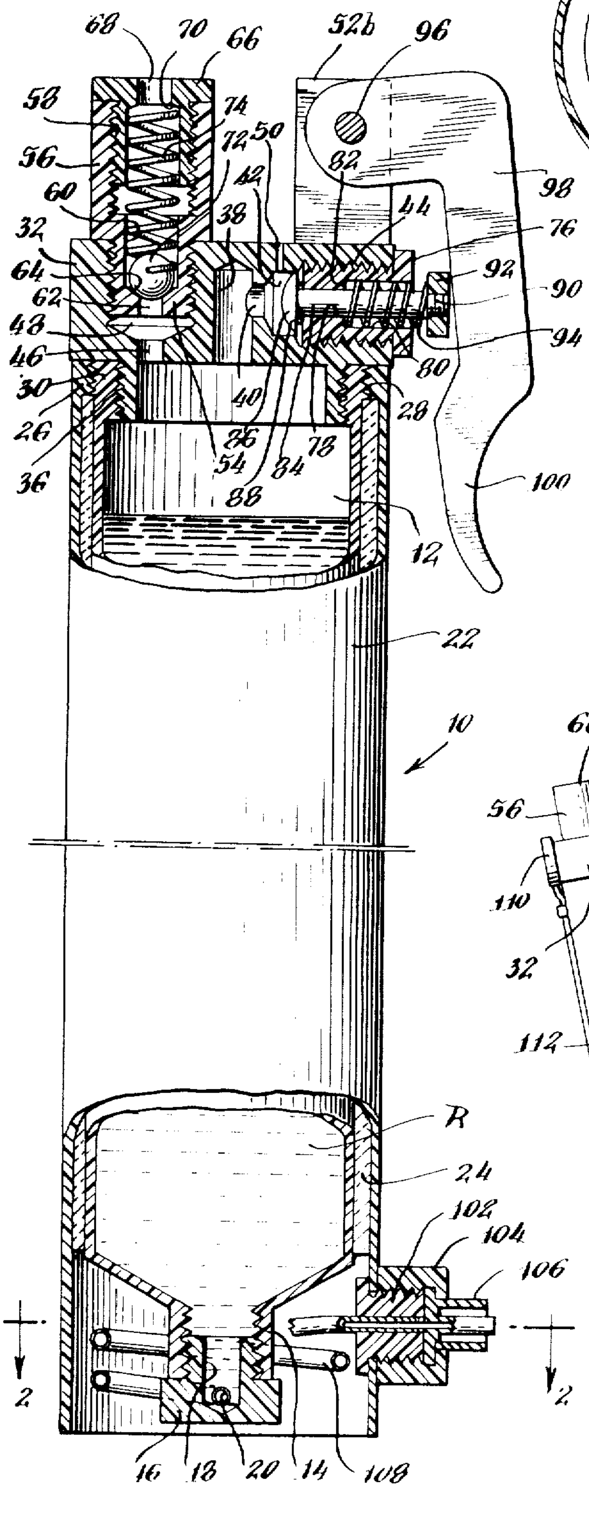


Fig. 2

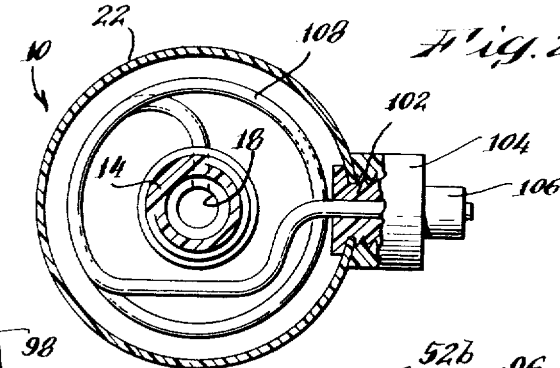


Fig. 3

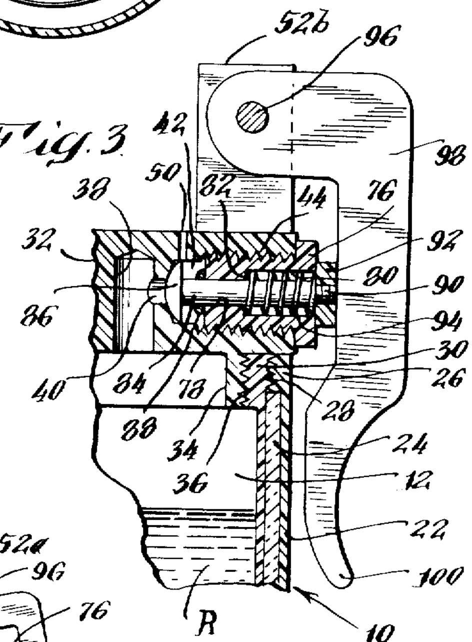
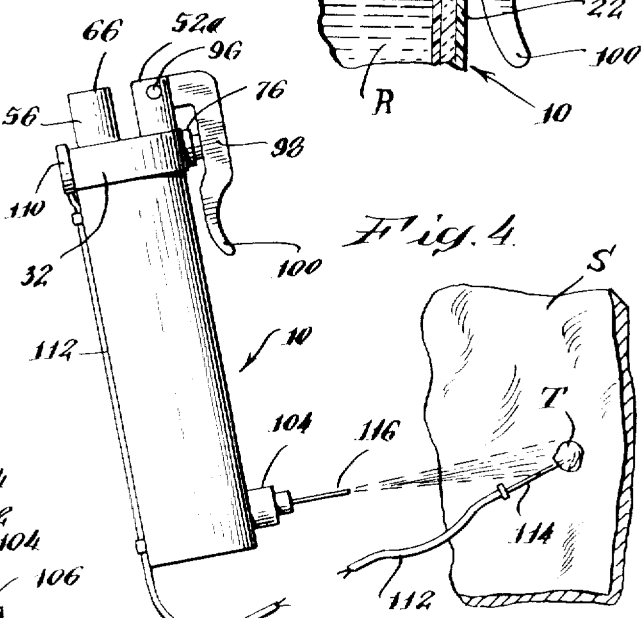


Fig. 4



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LIQUID REFRIGERANT SPRAY DEVICE

BACKGROUND OF THE INVENTION

In recent years there has been an upsurge of interest in the use of cryogenic techniques for medical and surgical applications. This has resulted in the development of a number of sophisticated instruments for producing localized cooling for various reasons, such as cryoadhesion and cell necrosis. However, the use of cryogenics for medical and surgical purposes is not new and may be traced, for example, as far back as Hippocrates who recommended the use of ice to check hemorrhage and to relieve pain and swelling. As more effective refrigerants became available, they were quickly utilized in the field of dermatology. A. Campbell White, for example, successfully treated moles and warts with cotton swabs dipped in liquid air in 1899.

Several liquid agents are now available for use by dermatologists. Some of the more effective are liquid oxygen, liquid air, and liquid nitrogen with respective boiling points of −182.5° C, −190.0° C, −195.6° C. Solid carbon dioxide may also be employed which has a sublimation temperature of −78.5° C. The ultimate object, of course, is to lower the temperature of the affected site. This may be effected in several ways. For example, a probe or block of heat conductive material, such as copper, may be pre-cooled in the refrigerant and applied to the skin. Hollow probes may be utilized in which the refrigerant is circulated within the probe, or solid carbon dioxide sticks may be applied directly to the site. However, direct application of refrigerant liquid to the site remains the favored technique under certain circumstances, and particularly in dermatology. The use of a dipped swab, for example, continues even though it is a relatively inefficient method, as several dippings and applications may be required.

A more recent innovation has been a commercial device constructed on the principle of the well known laboratory wash bottle. These bottles have a stopper through which a short tube extends into the free space above the liquid and through which a longer tube extends to the bottom of the bottle. If such a bottle is filled with a refrigerant such as liquid nitrogen, the liquid nitrogen will boil and its vapors will escape through the short tube. If, however, the end of the short tube is closed, vapor pressure will build and liquid nitrogen will be ejected forcibly from the end of the longer tube. A commercial instrument which operates on this principle employs a trigger valve for closing the vent.

Although the commercial instrument described above has certain advantages, it also has certain disadvantages which it would be desirable to overcome. One such disadvantage is the fact that the nitrogen which emerges is almost entirely liquid, thus it has a tendency to run or drip from the site of application. Another disadvantage is that the container is not insulated, requiring a separate handle which is positioned on the side of the container opposite the nozzle. This results in the surgeon's hand being spaced a considerable distance from the point of application with consequently less accurate control. Another disadvantage resides from the uninsulated feature of the container. This results in the vaporization rate of the contained liquid being relatively high, thereby reducing the amount of usable liquid refrigerant. A second problem resulting from the same feature is that condensation tends to gather on the insulated container and drop therefrom.

Accordingly, it is a primary object of the present invention to provide improved medical apparatus for spraying liquid refrigerant. Other objects are to provide such an apparatus wherein: the liquid refrigerant spray has a substantially reduced tendency to drop or run; the surgeon's hand may be positioned closer to the site to be treated; the container is insulated; control is simpler; and utilization of liquid refrigerant is more efficient.

The manner in which the foregoing objects are obtained will be more apparent from the following description and appended claims.

SUMMARY OF THE INVENTION

In accordance with this invention there is provided a medical apparatus for spraying liquid refrigerants comprising a thermally insulated, hand-held container for liquid refrigerant. The container, at its bottom, defines a discharge orifice and its top is closed by a removable cap which defines a vent to atmosphere. The apparatus includes a valve for selectively closing the vent, and an applicator for spraying the refrigerant on the site to be treated. A heat exchange conduit interconnects the discharge orifice and the applicator for simultaneously heating and transporting the refrigerant therebetween.

BRIEF DESCRIPTION OF THE DRAWING

The invention may be best understood by reference to the attached drawing wherein:

FIG. 1 is an elevational view of apparatus constructed in accordance with this invention, the upper and lower portions thereof being in cross section to illustrate its internal construction;

FIG. 2 is a cross section taken substantially along the line 2—2 of FIG. 1;

FIG. 3 is a partial view similar to the upper portion of FIG. 1, illustrating the operation of the control valve; and

FIG. 4 illustrates the operation of a modified version of the apparatus in the treatment of a dermatological condition.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With particular reference to FIG. 1, there is illustrated a cylindrical container 10 comprising an inner tank 12 formed of a relatively rigid plastic tapering at its bottom to an internally threaded neck 14. Closing neck 14 is a threaded plug 16 which defines a bore 18 communicating with the interior of tank 12 and a lateral discharge orifice 20. Container 10 further comprises a cylindrical outer shell 22, the space between it and tank 12 being filled with foamed plastic thermal insulation 24. The top of shell 22 defines an inwardly extending annular rim 26 secured to the upper edge of tank 12 by means of cooperating threads 28. An inwardly extending annular flange 30 also extends around the top of tank 12.

The top of the assembly is closed by a substantially disc-shaped cap 32. Extending downwardly from cap 32 is a flange 34. Flange 34 and flange 30 are interconnected by means of cooperating threads 36. Extending upwardly into cap 32 from its lower surface is a central bore 38, which communicates with a lateral passage 40, which is enlarged to form a recess 42 which extends outwardly from the side of cap 32, the outer portion being internally threaded as at 44. A second bore 46 also extends upwardly from the bottom of cap 32 and an enlarged portion 48 thereof extends upwardly through the top of the cap, this enlarged portion being internally threaded. A vent 50 extends from atmosphere at the top of cap 32 downwardly into recess 42. The cap 32 further includes a pair of spaced, parallel, upwardly extending projections 52*a*, *b*.

Threadedly mounted in the enlarged portion 48 of bore 46 is the threaded end 54 of a cylindrical safety valve body 56. Body 56 defines an upper recess 58 which is internally threaded and of relatively large diameter. It communicates with a central bore 60, which in turn communicates with a reduced diameter passage 62 at a tapered valve seat 64. The top of safety valve body 56 is closed by a threaded plug 66 which defines an exhaust outlet 68 communicating with bore 60 and forming an annular shoulder 70 therewith. A ball 72 is retained against the valve seat 64 by means of a coil spring 74 having its upper end against the shoulder 70.

The control valve of the illustrated apparatus comprises a threaded plug 76 mounted in threaded recess 42. The plug defines an inner bore 78 and an outer bore 80, which join at an annular shoulder 82. Slidably mounted in inner bore 78 is a bolt 84 having a round head 86 positioned in the enlarged recess 42. Mounted directly behind the head is an O-ring 88. The threaded shank 90 of bolt 84 carries a nut 92. Positioned within the outer bore 80 and between shoulder 82 and nut 92 is a coil compression spring 94. The spring 94 tends to retain the bolt in its illustrated retracted position. Mounted on a hinge pin 96 extending between the projections 52*a*, 52*b* is an L-shaped lever 98 positioned to selectively engage nut 92 and terminating in a trigger portion 100.

At the bottom of the shell 22 there is mounted a nipple 102 and a bushing 104 engaging and retaining a standard hypodermic needle luer connector 106. Communicating between needle connector 106 and orifice 20 is a copper evaporating coil 108. The illustrated apparatus is constructed almost entirely of plastic, with the exception of a few obviously metallic parts such as the springs and the evaporating coil 108.

The cap 32 is unscrewed and the tank filled with a suitable refrigerant R such as liquid nitrogen. The cap is then replaced. The insulating qualities of the plastic construction allows the device to be hand-held, substantially eliminates surface water condensation, and greatly reduces the evaporation of the liquid refrigerant. Boiling, however, will occur and serves a useful purpose, both for self-pressurizing and for controlling the character of the spray, as will be later described. However, in the inoperative position of the control valve illustrated in FIG. 1, it will be noted that the retracted position of bolt head 86 provides an open passageway from tank 12 to atmosphere via bore 38, passage 40, recess 42, and vent 50. Thus, the pressure on the surface of refrigerant R will be substantially atmospheric.

It will be noted that the bottom of tank 12 is open to atmosphere through the evaporating coil 108. Although it might appear that the refrigerant R would escape, this does not, in fact, occur. The evaporating coil 108 is positioned away from tank 12 and is exposed to ambient air. The evaporating coil in one embodiment is a 10 ½ inch length of copper tubing having an outside diameter of one-eight inch and an internal diameter of 0.068 inch. The liquid refrigerant which enters this coil evaporates and passes out the connector 106 as a gas. It is believed that gas pressure resulting from such evaporation also assists in retaining the liquid within the container.

The functioning of the safety valve is relatively conventional. The ball 72 will normally remain seated in the valve seat 64, as illustrated in FIG. 1. If, for any reason, the vapor pressure within tank 12 should build to an undesirable level, it will lift the ball 72 from its seat and permit the escape of vapor through exhaust outlet 68.

In order to employ the apparatus of FIG. 1, the surgeon attaches a conventional hypodermic needle in the usual manner to connector 106. The needle is selected to provide the desired spray size. The unit is then held by the surgeon with the needle pointed at, and in close proximity to, the site to be treated and trigger 100 is pressed. This presses bolt 84 inwardly against the pressure of spring 94 as illustrated in FIG. 3. The head 86 seats as illustrated to close passage 40 and thereby prevent vapor from escaping through vent 50. Pressure within the tank 12 immediately builds, forcing the liquid refrigerant out of orifice 20 through evaporating coil 108 and through the attached needle. As the liquid flows through the evaporating coil, a portion of it vaporizes so that there is ejected from the tip of the needle a fine spray, rather than a liquid stream. This prevents the liquid from running or dripping from the treated site. To stop the spray, it is necessary for the surgeon merely to release the trigger 100, whereupon the control valve returns to the position illustrated in FIG. 1.

It is important for the surgeon to monitor the depth of tissue freezing. This is best accomplished by the insertion beneath the treated site of a needle having in its point a small thermocouple. Leads from the needle pass to a temperature gauge which may be monitored by the surgeon. Accordingly, there is illustrated in FIG. 4 a modification of this invention wherein there is secured to the instrument a temperature gauge 110 connected by means of leads 112 to a thermocouple needle 114. In the illustration, the needle 114 is shown inserted beneath a tumor T on a section of human skin S. The spray is ejected from hypodermic needle 116, secured to connector 106. The illustrated combination thus provides a useful apparatus for controlled manipulation by the surgeon.

In one actual embodiment of the apparatus, the overall length of the unit is approximately 7 inches and has a diameter of 1 ½ inches. Such a device holds approximately 100 cc of liquid nitrogen and, with a number 20 gauge needle attached, is capable of delivering liquid nitrogen for several minutes. The average operating time may vary from 30 to 120 seconds. If multiple tumors are to be frozen, the instrument is simply directed to each and every tumor in succession. The unit is sufficiently well insulated to permit the operator to grasp the vessel within his hand and comfortably operate the control trigger. The efficiency of the described apparatus is approximately 5 times as great as that of existing devices. For example, 100 cc of liquid nitrogen will deliver a spray of approximately 6 minutes duration, whereas a 6 minute spray in conventional instruments requires a liquid nitrogen volume of approximately 500 cc.

It will be apparent to those skilled in the art that many variations and modifications may be made in this invention without departing from its spirit and scope. For example, the refrigerant discharge connector **106**, which is shown near the bottom of the container may, in fact, be positioned at any desired location, such as midway or at the top. Also, the hypodermic needle nozzle may be replaced with a hollow probe. The refrigerant would enter the probe, cooling it, and be ejected from the rear end of the probe. Such a construction would be particularly valuable in treating oral or internal lesions where spraying of the liquid would not be applicable. Accordingly, the foregoing description is to be construed as illustrative only, rather than limiting. This invention is limited only by the scope of the following claims.

I claim:

1. Medical apparatus for spraying liquid refrigerant which comprises: a thermally insulated container for a refrigerant adapted to be held by one hand of a user, said container having a top and a bottom and defining at its bottom a discharge orifice; a partially coiled heat exchange conduit attached to said discharge orifice; an applicator means fixed to and in flow communication with said heat exchange conduit; a removable cap closing the top of said container and defining a vent to atmosphere; normally-open valve means controlling the flow of gas through said vent; and valve actuation means attached to said cap whereby the user can direct and control the flow of refrigerant spray from said applicator means.

2. The apparatus of claim **1** wherein said container is plastic.

3. The apparatus of claim **1** wherein said valve means comprises a spring loaded valve and said valve actuation means comprises manually operated trigger means for closing said valve.

4. The apparatus of claim **1** wherein said heat exchange conduit comprises a metallic evaporating coil substantially exposed to ambient temperature.

5. The apparatus of claim **1** wherein said cap includes a safety exhaust valve.

6. The apparatus of claim **1** wherein said applicator means comprises: a luer connector and a hollow needle connectable thereto.

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