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REFRIGERATION APPARATUS FOR CONTACT COOLING OF SMALL AREAS

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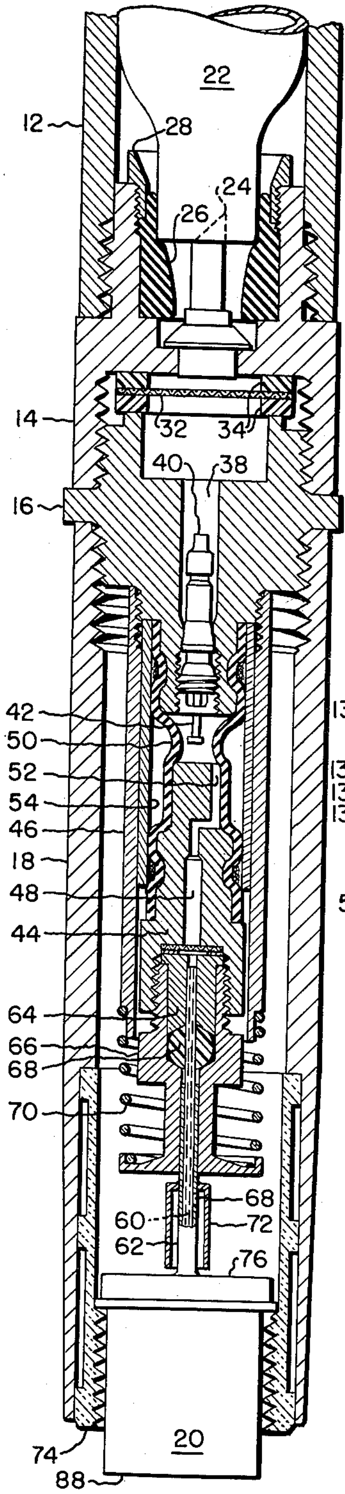


Fig. 1

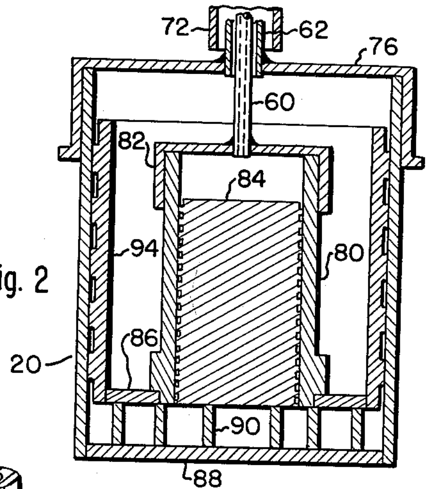
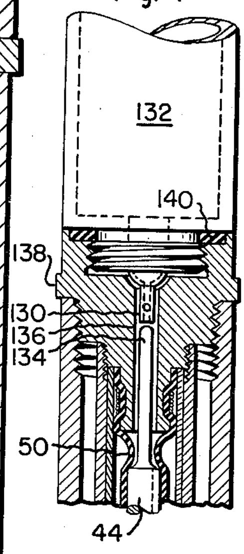


Fig. 2

Fig. 4



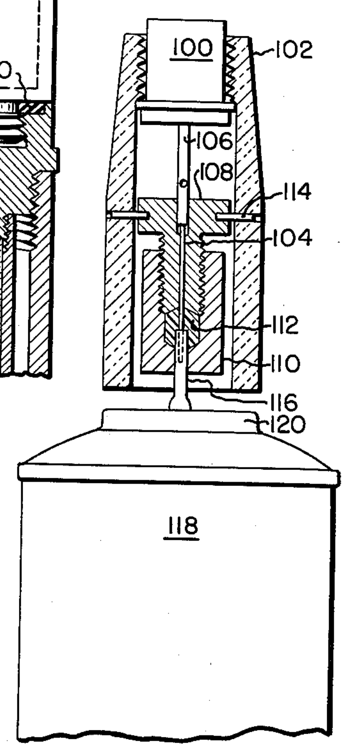


Fig. 3

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REFRIGERATION APPARATUS FOR CONTACT COOLING OF SMALL AREAS

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The present invention relates to a miniature refrigeration unit and more particularly to a manually-actuated refrigeration unit especially adapted for use in desensitizing skin regions in preparation for a hypodermic injection or the like.

It is well known that hypodermic injections may be made substantially painless by localized chilling of the skin in the region of injection and that such chilling may readily be accomplished by placing in contact with the skin for a brief interval, generally 45 to 60 seconds, a metal disk having a temperature between freezing and 40° F. A small area is chilled but not frozen, thus deadening the nerves temporarily in that region. This results in the elimination of all sensation both during and immediately after injection.

Apparatus of compact construction and arrangement for this purpose is disclosed in U.S. Letters Patent No. 2,746,264, issued May 24, 1956, to the present inventor. Such apparatus, while successfully utilized, has been found to be capable of improvement in respect to ease and cost of manufacture.

Accordingly, it is the object of this invention to provide an improved miniature refrigeration device which can be used rapidly and efficiently to desensitize localized areas of skin without freezing.

More specifically, it is an object of this invention to provide an improved heat exchanger for a miniature self-contained refrigeration unit for desensitizing localized areas of skin without freezing.

It is a further object to provide an improved system for delivering an accurately metered charge of refrigerant to the cooling surface of a miniature refrigeration unit for temporarily desensitizing localized areas of skin.

A still further object is to provide a miniature refrigeration device adapted for use in conjunction with a container of compressed refrigerant.

Other objects and features of the invention will appear in the following description. In the drawings illustrating the invention:

Fig. 1 is a longitudinal sectional view of a self-contained refrigeration unit embodying the novel features of the invention.

Fig. 2 is an enlarged longitudinal sectional view of the cooling head or heat exchanger forming a part of the invention.

Fig. 3 is a sectional elevation of a modified cooling device in accordance with this invention.

Fig. 4 is a sectional detail of an alternative construction of refrigerant container.

In Fig. 1 there is illustrated a preferred embodiment of a self-contained portable refrigeration unit. The unit is designed to be hand-held and provides an apparatus which is convenient, economical and effective as a means to desensitize a region of skin prior to injection with a hypodermic needle or the like.

In its general configuration and mode of utilization, the apparatus to be described resembles that shown in the

prior Keyes Patent No. 2,746,264. The apparatus, which is of a length and diameter to be held conveniently in the hand, comprises an upper or refrigerant-containing section **12**, short intermediate sections **14** and **16**, and a lower section **18** having an exposed tip **20** constituting the heat exchanger. It is this tip portion **20** which is placed in contact with the skin to provide, when the device is actuated, the chilled region of approximately five-eighths of an inch in diameter to receive the hypodermic needle.

The top section **12**, that which normally constitutes the handle portion of the unit, contains the refrigerant either in a capsule **22** as illustrated in Fig. 1 or directly within the walls of the body as in Fig. 4. The preferred refrigerant to use in this unit is dichlorodifluoromethane, commonly known as Freon 12. When the capsule is employed, the top section **12** is screwed onto the intermediate tapping section **14** with the capsule in place, thereby causing the hollow needle **24** to pierce the seal of the capsule. A resilient gasket **26** surrounds the neck portion of the capsule to provide an effective seal. A gland nut **28** serves to retain the gasket in place. The use of two intermediate body sections **14** and **16** permits assembly with a filter screen **32** between sealing rings **34**.

The body section **16** carries the novel metering structure of the invention, whereby upon pressing the tip of the device inwardly a predetermined charge of refrigerant is admitted to the heat exchanger to chill the tip. This metering structure extends from the section **16** into proximity to the exchanger **20**, with the lower body section **18** of the device forming a protective enclosure as well as the support for the heat exchanger.

The body section **16** is provided with an axial passage **38** that is normally closed by a valve **40** which may be similar to the conventional automobile tire valve. The valve is provided with a stem **42** by which the valve may be opened against the pressure of the refrigerant above the valve, thereby allowing refrigerant to pass through the valve into the region below.

The valve is adapted to be opened upon upward movement of an actuator **44** which is guided for sliding movement in a cylindrical tube **46** secured to the body member **16**. Flow communication between the passage **38** and an axial passage **48** in the actuator is provided by a section of tubing **50** of resilient material. One end of the tube is secured to the neck portion of body **16**, while the other end of the tube is secured to a corresponding neck portion of the actuator **44**. An off-center passage **52** affords communication between the axial passage **48** and the interior of the tube, while permitting a central abutment at the end of the actuation for engagement with the valve stem **42**.

The resilient tubing **50** not only provides gas-tight flow communication to the movable actuator **44** but in addition it serves to meter the charge released from the valve **40**. Upon opening the valve following upward movement of the actuator **44**, the resilient tubing distends under the influx of the gas under pressure. Outward movement of the tube walls is limited to a predetermined amount by a confining jacket formed by a cylindrical sleeve **54**. For convenience the sleeve consists of two semicylindrical shells confined by and capable of limited sliding movement within the tube **46**. The sleeve **54** likewise serves as a stop to limit upward movement of the movable actuator and prevent possible damage to the valve. The resilient tubing **50**, formed of rubber or rubber-like material, may be secured at its ends by wrapping with suitable binding means, the neck portions of body **16** and actuator **44** preferably being formed with regions of reduced diameter.

At its lower end the actuator **44** is arranged to make suitable connection to the heat exchange **20**. The exchanger, hereinafter to be described in detail, is provided with small-diameter inlet and discharge tubes **60** and **62**, respectively, best illustrated in Fig. 2. The exhaust tube **62** surrounds the inlet tube with slight clearance, this telescoping arrangement being advantageous to provide appreciable pre-cooling of the entering refrigerant by the counter-flow exhaust from the exchanger.

The inlet tube **60** is received within a plug **64** which cooperates with packing nut **66** and resilient ball **68** to provide a gas-tight seal when the packing nut **66** is tightened into the threaded recess in actuator **44**. A filter screen is preferably included in the assembly above the plug **64**. The lower stem portion of packing nut **66** is adapted to receive the exhaust tube **62**, the latter having a vent **68** through the wall thereof closely adjacent the flanged end of the nut. This flange provides a seat for coil spring **70** by which the actuator **44** is normally positioned in spaced relation to the valve. A shroud **72** serves to direct the discharged gas downwardly onto the top of the exchanger for additional cooling.

The heat exchanger is guided for limited sliding movement within the lower end of body portion **18** by means of a liner **74** of non-metallic material. The inner portion of the liner which contacts the exchanger is preferably serrated to minimize the contact area between exchanger and liner and thereby reduce heat transfer to the exchanger.

Referring to the sectional showing of Fig. 2, the outer shell of the heat exchanger is closed by a cap **76** to which the exhaust tube **62** is sealed. The inlet tube **60** extends into the interior of the exchanger into communication with an expansion unit for the entering refrigerant. This comprises a tube **80** and cap **82**. Secured within the tube is a plug **84** provided with helical grooving around its periphery. Preferably the grooving consists of a multiple-start thread, for example a four-start thread, to provide independent multiple small passages for the refrigerant through the tube **80** from top to bottom. The plug may conveniently make a press fit within the tube.

At its bottom end the tube **80** and plug **84** terminate at and are supported by an inner bottom plate **86** spaced from the outer end wall **88** of the exchanger by a spirally-wound strip **90** of metal of good thermal transfer properties. Thus the cold refrigerant discharging from the helical passages between plug **84** and tube **80** are directed into contact with the inner face of the tip **88**, flowing in a spiral path toward the outer side wall. Here the gas is directed upwardly in effective contact with the outer walls of the exchanger through the provision of a hollow plug **94** secured at its lower end to the inner bottom plate **86** and provided around its periphery with multiple helical passages of somewhat larger cross-section than those of the inlet expansion unit **80, 84**. Thus the still-cold gas is utilized to chill the body of the heat exchanger after serving the primary function of cooling the outer tip surface **88**. Still further useful cooling is derived from the flow of the gas upwardly through the exhaust conduit **62** surrounding the inlet passage, with the gas discharging through vent **68** and being guided by shroud **72** onto the top of the exchanger, finally escaping to the exterior of the apparatus between exchanger **20** and the insulating liner **74**.

In describing the operation of the device to chill a selected skin area, it will be assumed that the device has been loaded with a capsule charged with the refrigerant and that the hollow needle **24** has penetrated the end of the capsule so that the valve is retaining the charge under pressure. The operator now places the tip of the heat exchanger against a firm object, or against his hand, and applies sufficient pressure to move the exchanger inwardly against the force of spring **70**. Motion of the exchanger serves also to move the actuator up against the valve stem. Upon opening the valve, refrigerant is discharged into the resilient tube **50** which thereupon expands until confined by the jacket **54**. The pressure of the expanding refrigerant urges the actuator downwardly, away from the valve, to limit the discharge to that adequate for a cooling application.

The refrigerant is admitted to the inlet expansion section **80, 84** where it flows through the multiple extended passages of the helical grooves into the end chamber. The controlled expansion of the metered charge of refrigerant is such as to chill the exchanger tip surface **88** to a temperature just above the freezing point. The cooling action takes place in a matter of seconds, so that the device is now ready to be used. By placing the cold surface **88** of the tip against the skin of the patient in the region where the injection is to be made, the skin is temporarily and effectively desensitized.

It is thus apparent that the operation of the device is entirely automatic, with the metering of the refrigerant charge and its supply to the heat exchanger taking place when the tip of the device is pressed, preparatory to placing the apparatus in contact with the skin. The device is capable of repeated operation as long as the supply of refrigerant in the capsule is adequate. If the apparatus is to be used after an interval of non-use, so that the exchanger has warmed up to the temperature of the environment, then it may be desirable to actuate the device more than once, with a pause between actuations, to chill the exchanger to the desired low temperature before using the apparatus on a patient.

While the device has been illustrated and described as applicable to a self-contained unit employing charged capsules as the source of refrigerant, other modes of refrigerant supply may be utilized. Thus, in Fig. 3 is shown the use of the improved heat exchanger of the apparatus with a dispensing container of refrigerant. Such embodiment permits a relatively simple assembly which does not require the metering features heretofore described.

In this embodiment the exchanger **100** is received within the end portion of a body shell **102** of non-metallic material. The inlet and exhaust conduits **104**, **106** for the exchanger are received within a supporting and sealing assembly composed of plug **108**, nut **110**, and packing ball **112**, the plug being supported within shell **102** by pins **114** to minimize thermal conduction.

The nut **110** is adapted to receive the tip **116** of a can **118** charged with refrigerant, the can and tip being of conventional construction wherein the sealing valve for the container is releasable upon bending or otherwise displacing the tip **116** from normal position in the cap **120**. Such displacement of the tip in the illustrative embodiment permits refrigerant to flow into the heat exchanger as in the first-described embodiment and with similar effective cooling of the exposed tip. The metering of the charge is dependent on the judgment of the user.

A further alternative in respect to the mode of storing and supplying of the refrigerant is to fill the hollow handle portion **12** of the embodiment of Fig. 1, without using the capsule **22**. While this does not permit as simple a refill procedure as with the capsules, a somewhat greater amount of refrigerant may be stored.

Such form of construction is illustrated in Fig. 4, wherein valve **130** is mounted in body portion **132** to retain the refrigerant fill in the hollow handle. The valve, of conventional construction, is opened by axial pressure on the tip as in the embodiment of Fig. 1.

To operate the valve, the actuator **44** is provided with an extension **134** which is aligned with the valve tip within passage **136** in body portion **138**. Thus, in the same fashion as in the Fig. 1 embodiment, pressure on the heat exchanger tip is transmitted via the actuator to open the valve and release a charge of refrigerant to the resilient metering tube **50**.

When the handle portion is to be refilled, the device is separated at the screw-threaded connection between portions **132** and **138** having a gasket **140**. The handle portion may then be coupled to the refrigerant source, the latter preferably having provision for accurately metering the amount of refrigerant in the fill.

It is apparent that the miniature cooling unit of the present invention, while operating in the same general manner as the device of the prior patent, presents new and useful features of construction and effectiveness of operation. It will further be understood that such features as the metering mechanism and the heat exchanger are not limited to use in the particular forms and embodiments shown, but may be utilized in other apparatus and for other purposes.

Having thus described my invention, I claim:

1. In a hand-type refrigerating unit for contact cooling, having a case and adapted to have a supply of refrigerant under pressure associated therewith, a refrigerating head having a cylindrical side wall portion and a flat end wall, the outer face of the end wall providing an exposed surface for contact cooling, a refrigerant supply passage coaxially disposed at the opposite end of the head from the end wall and having connections to receive refrigerant from the supply, means within the head to conduct refrigerant from the supply passage through the interior of the head out of contact with the cylindrical wall portion thereof into contact with the inside of the end wall at its central region, and means within the head in contacting concentric relation with the cylindrical wall portion thereof, said means and the cylindrical wall portion forming inner and outer members, and an extended refrigerant discharge passage between the said members from the end wall region of the head, said passage being a spiral groove in the surface of one of said members.

2. Apparatus according to claim 1 wherein the refrigerant discharge passage is relatively shallow in proportion to its width.

3. Apparatus according to claim 1 wherein the means in contacting concentric relation within the cylindrical wall portion of the head is spirally grooved around its periphery and wherein the portions of the inner member between the grooves and in contact with the cylindrical wall portion of the head have a width approximating the groove width.

4. Apparatus according to claim 1 wherein the means for conducting refrigerant from the supply passage through the head to the end wall includes a spiral passage independent of and inwardly spaced from the spiral discharge passage around the cylindrical wall portion of the head.

5. In a hand-type refrigerating unit for contact cooling, having a case and adapted to have a supply of refrigerant under pressure associated therewith, a refrigerating head having a cylindrical side wall portion and a flat end wall, the outer face of the end wall providing an exposed surface for contact cooling, a refrigerant supply passage coaxially disposed at the opposite end of the head from the end wall and having connections to receive refrigerant from the supply, means within the head to conduct refrigerant from the supply passage through the interior of the head out of contact with the cylindrical wall portion thereof into contact with the inside of the end wall at its central region, said means having a refrigerant passage terminating adjacent the inner surface of said end wall in the central region thereof, means defining a spiral passage outwardly along the inner surface of the end wall from the central region toward the cylindrical wall portion of the head, an inner cylindrical member in contacting concentric relation to the cylindrical wall portion of the head, and an extended refrigerant discharge passage around the head between the cylindrical wall portion thereof and the inner member, said passage comprising a shallow groove in the surface of one of said contacting members.

6. Apparatus according to claim 5 wherein the means for conducting refrigerant from the supply passage through the head to the end wall includes a spiral passage independent of and inwardly spaced from the spiral discharge passage around the cylindrical wall portion of the head.

7. Apparatus according to claim 5, having a refrigerant discharge passage from the head for refrigerant from the extended refrigerant passage around the cylindrical wall portion, said discharge passage from the head being disposed in coaxial relation to the refrigerant supply passage at the end opposite the contact-cooling end wall.

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