United States Patent [19]

Kollner et al.

[11] **3,794,039**

[45] **Feb. 26, 1974**

[54] **APPARATUS FOR CRYOSURGERY**

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[30] **Foreign Application Priority Data**

Oct. 25, 1969 Germany ..... P 19 53 835.3

[52] **U.S. Cl.** **128/303.1,** 128/240, 128/256, 128/400, 62/293

[51] **Int. Cl.** **A61f 7/00,** A61b 17/36, F25d 3/10

[58] **Field of Search** 128/303.1, 240, 276, 65, 66, 128/241, 256, 257, 400; 62/293

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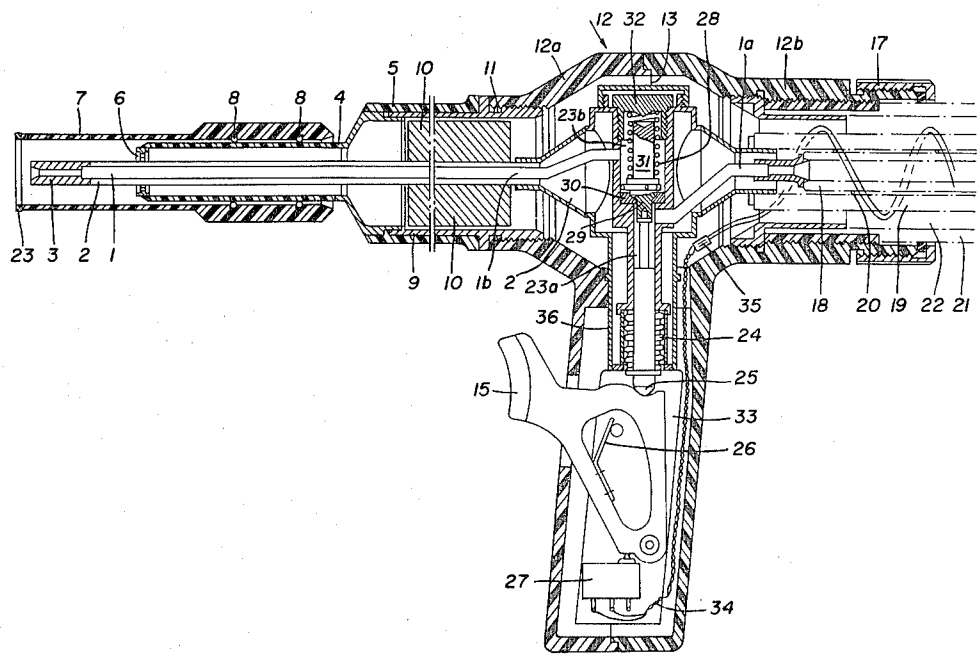
[57] **ABSTRACT**

An apparatus for cryosurgery wherein the probe includes a grip member having a hollow cryogenic coolant feed line supported by said grip member open at the tip thereof and connected at one end to the cryogenic coolant supply for transmitting coolant to impinge directly upon the tissue to be frozen. A return line open at the tip thereof and concentrically disposed around the feed line forms a space therebetween, with means communicating said space to suction means for returning vaporized coolant from the feed supply line. The open end of the feed supply line is recessed with respect to the corresponding open end of the return line, allowing a cryogenic coolant to impinge directly upon the tissue to be frozen, while vaporized coolant is returned through the return line.

35 Claims, 3 Drawing Figures



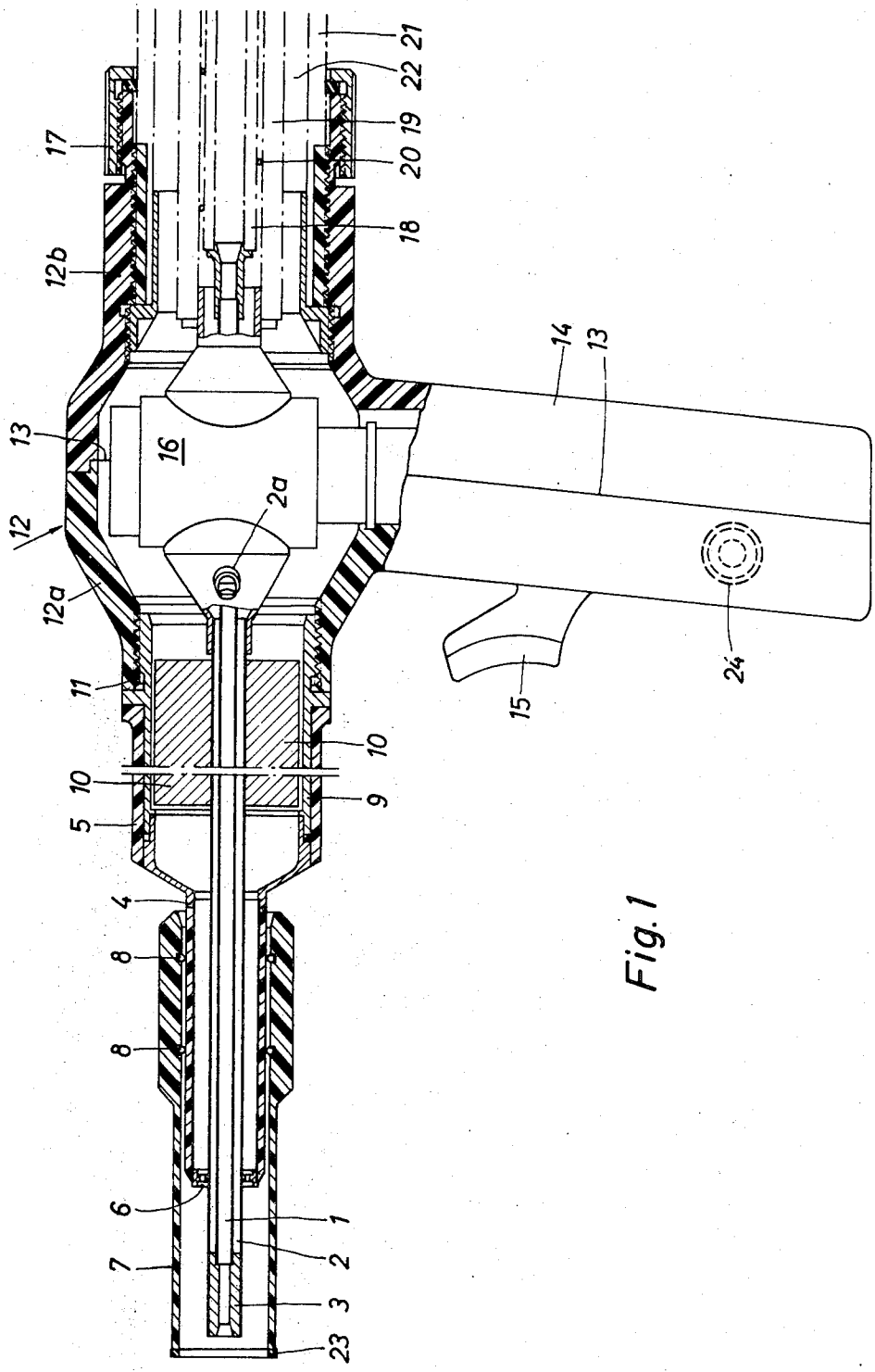


Fig. 1

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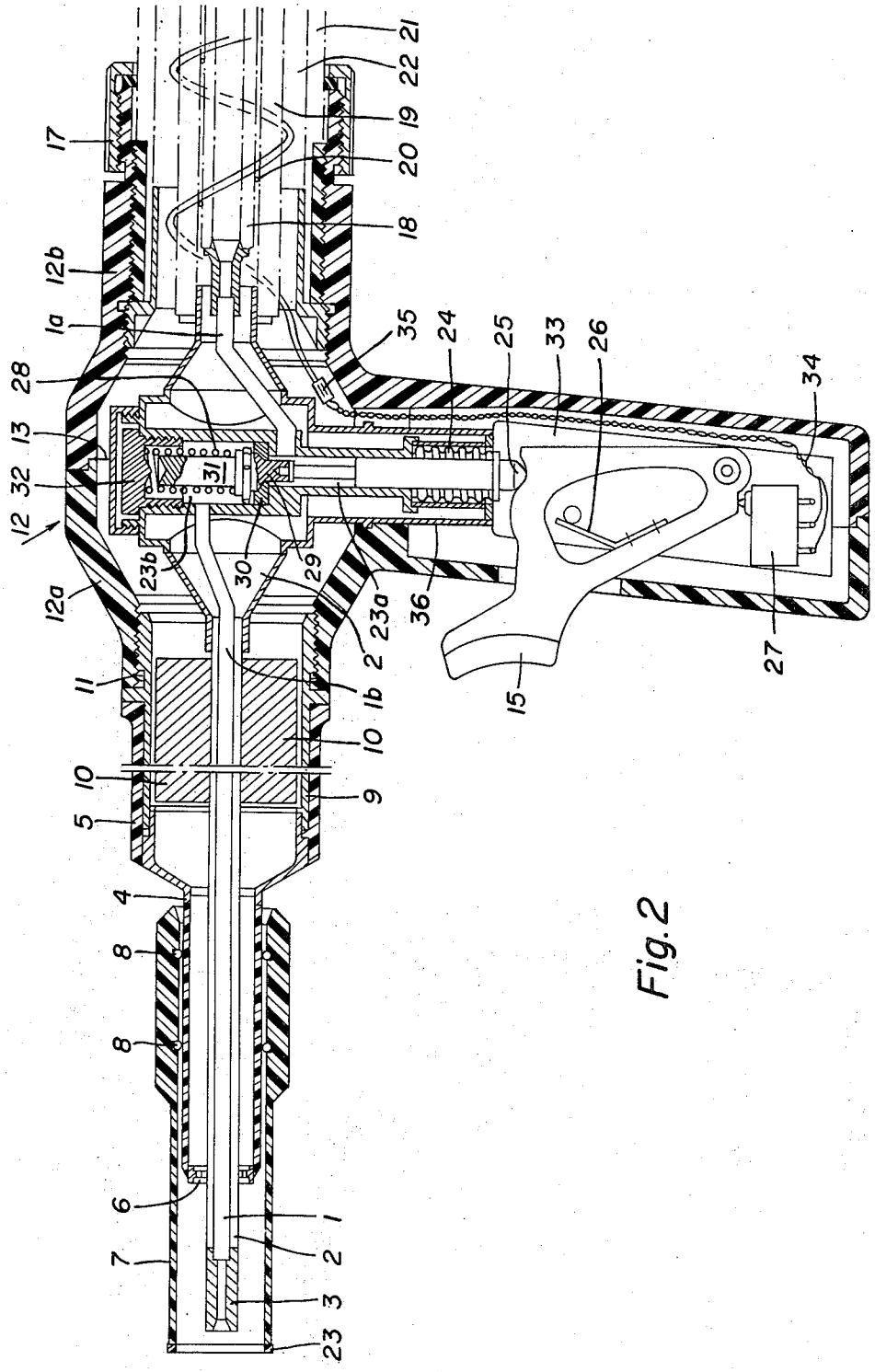
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Fig. 2

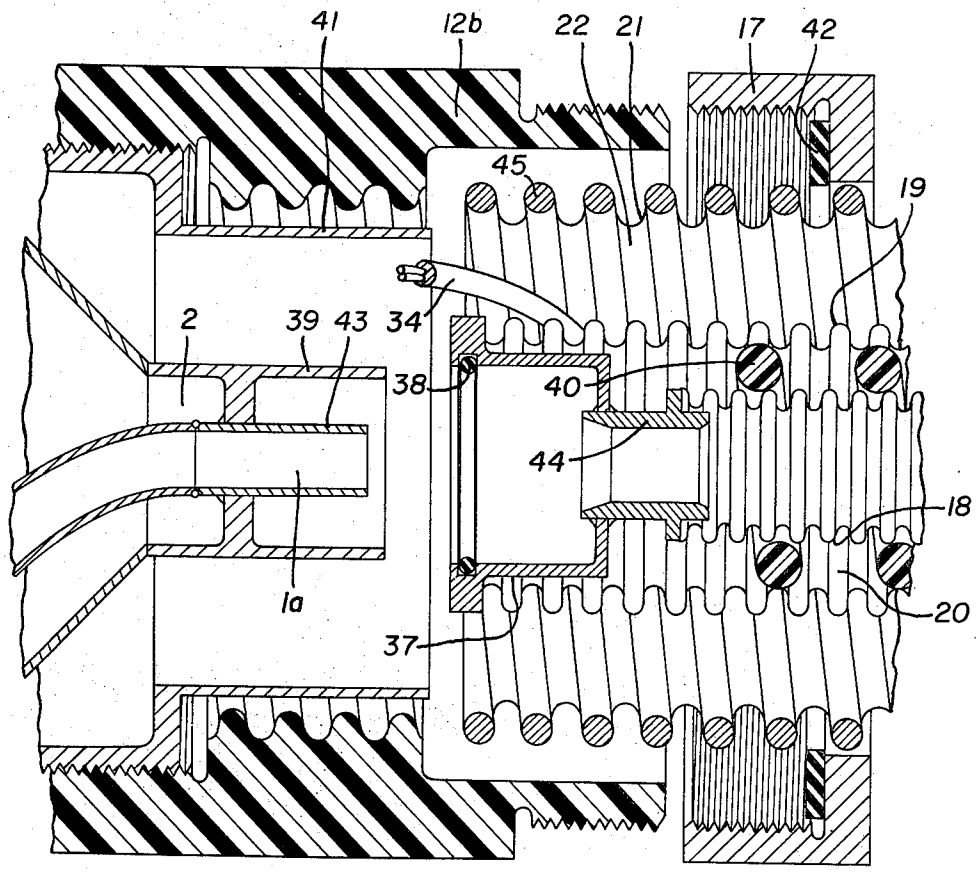

Fig. 3

APPARATUS FOR CRYOSURGERY

BACKGROUND OF THE INVENTION

Conventional cryosurgical devices of the type to which this invention pertains have probes which are sealed at the tip. In use, the ordinarily solid front end of the probe is brought into contact with the tissue to be subjected to low-temperature treatment. The coolant, normally liquid nitrogen, is introduced into the tip of the probe by means of a feed line, vaporized at that point, and returned to the central unit by means of a return line, or released into the atmosphere from the probe.

Such cryosurgical devices exhibit a disadvantage in that it is normally difficult to adapt the tip of the probe to the contour of the tissue to be treated, especially when projecting and strongly fissured proliferations are involved. One possibility of avoiding this disadvantage resides in maintaining probes of various sizes and shapes in readiness. However, this is very cumbersome and expensive and does not meet all situations occurring in practice.

SUMMARY OF THE INVENTION

Consequently, this invention provides a novel cryosurgical device, the probe of which does not have the above-mentioned disadvantages and which can furthermore be exchanged in a simple manner with probes of a different type of construction connected to a central supply unit.

This problem is solved by providing a feed supply line and return line which are open at the tip of the probe. This makes it possible for the coolant to impinge directly upon the tissue. In accordance with a special embodiment of the invention, the probe tip consists of two concentric tubes, wherein the front end of the inner tube is recessed with respect to the front end of the outer tube. Thereby, a chamber is produced within the outer tube which can be filled by the coolant fed by the inner tube. Accordingly, when such a probe is applied to the tissue to be treated, only the rim of the outer tube need be in contact with the tissue, and the surface of the tissue to be treated is completely under the effect of the coolant, independently of the shape of the tissue. In accordance with a further development of the invention, the inner tube exhibits a vacuum jacket at least in the rear section thereof. This prevents outside heat from contacting the coolant, which would result in an undesired cooling of the entire device and an unnecessary consumption of coolant.

The grip member can consist of a preferably sectioned housing and can be provided with a handle exhibiting a trigger. The grip member can be detachably connected by a connection line to a central unit. In this case, it is possible to attach different-type grip members with probes to a suitable connection line.

The connection lines between the grip member of the probe and the central unit are preferably concentrically arranged corrugated tubes detachably joined to the central unit by means of a coupling section.

An arrangement of this kind of connection lines for the supply of a probe with a coolant is disclosed for example in the U.S. Pat. No. 3,220,414.

BRIEF DESCRIPTION OF THE DRAWINGS

Additional details and advantages of the invention can be derived from the embodiment schematically illustrated in the drawings, illustrating the probe in a partially sectional view.

FIG. 1 is a schematic view, partially in cross-section, of a probe of this invention;

FIG. 2 is a cross-sectional view of a probe having a conventional trigger, valving member and control means incorporated therein; and

FIG. 3 is a cross-sectional view of a probe illustrating a corrugated connection line and electrical control lines.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A tube **1**, preferably consisting of stainless steel, serves as the feed line for the coolant which is preferably liquid nitrogen; this tube **1** is surrounded, in its rear portion, by a vacuum jacket **2**, by means of which cold losses and thus a premature warming and evaporation of the coolant are avoided. The vacuum jacket **2** can be evacuated by the disconnectable nipple **2***a*. The front end of the feed tube **1** consists of a solid metallic part **3** which is likewise normally made of stainless steel. A return tube **4** is arranged concentrically about the feed tube **1** with vacuum jacket **2**; this return tube is fixedly joined in the rear section with the probe shank **5**, which latter consists preferably of polytetrafluroethylene, and the front end of the return tube exhibits a mounting **6**, provided with openings, for the feed tube **1**. A return tube sleeve **7**, preferably consisting of transparent acrylic and sealed by "O" rings **8**, is displaceably arranged on the tube **4**, which latter is likewise made preferably of polytetrafluoroethylene.

By telescopic movement of the return tube sleeve **7** the free space present in the outer end can be reduced or enlarged, and the distance between the point of exit of the coolant from the tube **1** and the tissue to be treated can be varied. Due to the fact that the outer return tube sleeve **7** consists of a transparent material, it is possible for the operator to closely observe the processes in the probe, in particular to determine the amount of coolant which is still in the liquid phase and has not yet evaporated at the site of application.

An electric heating element **10** is disposed in the probe shank **5** within a metallic jacket **9**, which element serves for heating the recycled coolant to room temperature. This element is preferably thermostatically controlled. The thermostat for this device (not shown) can be arranged directly behind the heating device in the grip member **12**, or at some other place in the return line, for example within the central unit.

The tube **4**, according to a further embodiment of the invention, is mounted to a hollow-cylindrical shank of a larger diameter detachably joined to the grip member **12**, preferably, by means of a threaded section **11**, facilitating the exchangeability of the tip of the probe. This exchange possibility is of particular advantage, since, on the one hand, when the tip of the probe has been damaged, only the tip need be replaced, and, on the other hand, when probe tips of different lengths and different thicknesses are required for different purposes of application, only the probe need be interchanged.

The grip member **12** is composed of two parts **12***a* and **12***b* and can be disassembled along the parting line **13** after the release of fastening elements (not shown). This facilitates the servicing and repair of the elements

contained in the grip member. The grip member **12** is provided with a handle **14** in which a trigger **15** is installed. Furthermore valve **16** is disposed in the grip member, which valve is mechanically connected with the trigger **15** and can be operated by means of the latter. This valve can have a cone valving member of conventional design which serves as a metering valve when lifted mechanically. The valve member can furthermore be fashioned so that it can be lifted against the force of a spring by the excess pressure of the coolant. In this case, the valve has the effect of a safety valve in the feed line for the coolant.

By means of a screw cap **17**, the outer part of a connection line is detachably connected with the rear part **12*b*** of the grip member **12.** The feed line for the liquid coolant, for example, liquid nitrogen, consists of a corrugated pipe **18,** preferably made of stainless steel, surrounded by another corrugated pipe **19** of the same construction, but having a larger diameter. Between the two pipes there is an evacuated space **20.** Yet another corrugated pipe **21** is arranged concentrically and in spaced relationship to the corrugated pipe **19.** The pipe **21** consists of a soft resilient material such as plastic and is supported by a coil spring. Together with the corrugated pipe **19,** the pipe **21** forms an annular duct **22** of a relatively large cross-section for the gaseous coolant flowing back to a central unit (not shown) which coolant is warmed approximately to room temperature. This coolant is taken in by a suction fan (not shown) arranged in the central unit. The space **20** is evacuated in order to prevent the transfer of heat thereto, and electric lines (not shown) are installed in the duct **22** between the outer corrugated tubes wherein the warmed returned gas is flowing. The connection lines terminate in a coupling section detachably joined to the central unit.

In accordance with a particularly advantageous embodiment of the invention, provision is made for simultaneous operation by the trigger **15** of a check valve for the coolant and the suction fan disposed in the central unit, as well as for regulation of the metering valve **16** in the grip member. By means of providing the trigger **15** with several functions, it is possible, by an initial, slight depression of the trigger, first to open the check valve in the central unit and to actuate the suction fan. Next, by further depression of the trigger **15,** opening of the metering valve is effected corresponding to the extent of such depression.

In FIG. **2** an inlet portion **1*a*** and an outlet portion **1*b*** of feed tube **1** can be seen which are in communication with one another via inlet chamber **23*a*** and outlet chamber **23*b***. The inlet chamber **23*a*** is sealed against the inner part of handle **14,** while using a corrugated pipe **24** welded to valve body **36** and to valve stem **25.** When trigger **15** is pressed into the inner part of the handle **14** against the force of a spring **26,** one or more microswitches **27** are first activated and valve stem **25** is then lifted against the force of spring **28.** The microswitches **27** can operate relays, valves, or the suction fan in the central supply unit as desired. When valve stem **25** is lifted, a valve cone **29** is simultaneously lifted from a valve spring seating **30,** and liquid nitrogen passes from inlet portion **1*a*** through inlet chamber **23*a*** to outlet chamber **23*b*** and thence through outlet part **1*b***. Centering means **31** allows a centered lifting of valve cone **29** against spring **28** which is held in a turnable valve cup **32,** with which the force of spring **28** can be regulated. Valve **16** is surrounded by an evacuated chamber **2.** Trigger **15** and microswitches **27** are mounted on a mounting plate **33** which can be welded to valve body **36.** Electric lines **34** coming from the microswitches **27** and going to the central supply unit can have a plug connection **35** at each side of the connection line and are spirally wound around a corrugated pipe **19.**

FIG. **3** shows one coupling system between grip member **12** and the connecting line, which may also be used as a coupling system between the connecting line and the central supply unit. Conventional corrugated pipes **18** and **19** form an evacuated space **20,** in which there is a spirally wound spacer **40,** conveniently of plastic material, to maintain the distance between the corrugated pipes **18** and **19.** At the end of corrugated pipe **18** is welded a part **44,** while at the end of the corrugated pipe **19** is welded a part **37;** both parts **44** and **37** are welded together to sealingly enclose one end of evacuated space **20.** In the open end of part **37** there may be fitted an O-ring seal **38.** Corrugated pipe **21** is formed of a plastic tube fitted with a spring coil **45.** An annular duct **22** is formed between corrugated pipe **19** and corrugated pipe **21,** the latter being surrounded by a fitted screw cap **17** with a sealing device **42.** Within the annular duct **22** electric lines **34** are spirally wound around the corrugated pipe **19.** These electric lines **34** can be connected to an electric system in either the grip member **12** or the central supply unit by means of plug connections **35** such as shown in FIG. **2.** In fitting the connecting line to the grip member **12,** parts **44, 37, 38** are slid onto parts **43** and **39** of valve **16.** The corrugated pipe **21** is turned into the space between grip member **12*b*** and part **41,** fixed by means of screw cap **17,** and sealed by sealing device **42.**

Since the tissue to be treated can freeze to the front rim of the outer tube during the cold treatment, an annular heating device **23** is provided which is firmly connected to the front rim of the return tube sleeve **7** or can be placed thereon; this heating device is operable by means of a push button **24** likewise disposed in the handle **14.** In this manner, it is possible to remove the tip of the probe, frozen fast to the tissue to be treated, in a rapid and easy fashion. The feed lines for this heating device can also be laid within the flow path for the returning gas.

The mode of operation of the device of this invention is as follows:

First of all, the probe is firmly placed on the tissue to be treated with the front rim of the outer return tube sleeve **7.** Then, by actuation of the trigger **15,** an electric circuit is initially closed, which circuit opens a magnetic valve (not shown) in the central unit, whereby pressurized liquid nitrogen is conducted through the corrugated pipe **18** to the valve **16** in the grip member **12.** At the same time, the suction fan provided in the central unit is started, whereby the tissue to be treated is drawn against the rim of the outer return tube sleeve **7** and somewhat into this tube. Upon a further depression of the trigger **15,** the cone valve member of the valve **16** is lifted, by means of a suitable mechanical transmission (not shown) in dependence on the extent to which the trigger **15** is depressed. Thereby, the liquid coolant can pass through the feed tube **1** and can exit through the front end **3** thereof, and impinge on the tissue to be treated. The return tube sleeve **7** can be telescopically moved on the tube **4** at any time to adjust the

proximity of the tip of the tube 1 to the tissue as desired. The largest portion of the thus-supplied liquid nitrogen is vaporized during this process. The gaseous nitrogen is returned in return tube sleeve 7 and passes through the openings in the mounting 6 and through the tube 4 to the heating device 10 wherein it is warmed to room temperature or about 20° C. The gaseous nitrogen then flows on through the grip member 12 into the space 22 formed between the corrugated pipes 19 and 21 and passes in this hallow space to the exhauster of the central unit and from there to the outside.

Upon releasing the trigger 15, the valve in the central unit and the valve 16 in the grip member are closed and the suction fan is cut off. The conduit 18 is, however, still filled with liquid coolant. If the probe is not operated for an additional period of time and a portion of the liquid gas remaining in line 18 evaporates, the pressure in this line will rise. In order to avoid any damage to the apparatus thereby, the valve 16 is fashioned as a safety valve in such a manner that the valve cone is lifted against the force of a spring by the pressure of the medium present in line 18, and the medium can then exit through the tip 3 of the feed line 1. In case the probe tip is still resting on a counter surface and the exiting coolant thus cannot freely be released, the gaseous medium can readily flow off through the return line, even if the suction fan is not on.

The suction fan in the central unit need not be actuated only upon opening of the magnetic valve in the control device and of the valve 16 in the probe; rather, it can if so desired, be run continuously, On the other hand, it can also be advantageous to provide means to cut off the blower even when both valves are opened.

It should furthermore be noted that the probe of the device of the present invention can also be provided with a conventional endoscope, if it is necessary to employ the tip of the probe at places which are not readily accessible optically.

From the foregoing description, one skilled in the art can easily ascertain the essential characteristics of this invention, and without departing from the spirit and scope thereof can make various changes and modifications of the invention to adapt it to various usages and conditions.

What is claimed is:

1. In an apparatus for cryosurgery having a central unit containing a supply of liquid cryogenic coolant, control and regulating means, and subatmospheric suction means connected to a probe for feezing tissue, the improvement comprising:

a. a cryogenic probe including a grip member having a hollow cryogenic coolant feed line supported by said grip member, said line being open at the tip thereof and connected at one end to said cryogenic coolant supply for transmitting liquid coolant to impinge directly upon tissue to be frozen;

b. a hollow cryogenic coolant return line open at a transparent end thereof concentrically disposed around said feed line to form a space therebetween; and

c. means communicating said space to said subatmospheric suction means for returning vaporized coolant from said feed line, the open end of said feed line being recessed with respect to the corresponding open end of said return line.

2. Apparatus according to claim 1, wherein said return line is provided with a vacuum jacket therearound at least in the portion thereof most proximate said one end of said feed line.

3. Apparatus according to claim 1, wherein said second line comprises two portions telescopically mounted with respect to one another.

4. Apparatus according to claim 3 wherein the portion of said return line most proximate the free end of said first line is transparent acrylic.

5. Apparatus according to claim 4, wherein the portions of said return line are sealed with respect to one another by "O" ring seals.

6. Apparatus according to claim 1, wherein said return line is connected to a detachable portion of said grip member.

7. Apparatus according to claim 1, wherein heating means are disposed to raise the temperature of returning vaporized coolant.

8. Apparatus according to claim 7, further comprising thermostatic control means for said heating means.

9. Apparatus according to claim 1, wherein a fluid supply communicates said feed line with said supply of cryogenic coolant and wherein a valve is disposed in said fluid supply to control flow of coolant therethrough.

10. Apparatus according to claim 9, wherein said valve has a valving member formed to meter flow thereby as a function of the displacement thereof.

11. Apparatus according to claim 10, wherein said valving member is spring loaded to normally block flow therepast and which can be lifted by excess pressure to serve as a pressure release.

12. Apparatus according to claim 1, wherein said grip member comprises a sectionalized housing which can be readily disassembled.

13. Apparatus according to claim 12, wherein said grip member is provided with a handle having a trigger thereon.

14. Apparatus according to claim 13, wherein a connection line detachably connects said grip member to said central supply unit.

15. Apparatus according to claim 13, wherein means are provided to simultaneously operate a valve controlling the coolant supply and said suction means in said central supply unit and to regulate flow through said valve in said feed line by actuation of said trigger.

16. Apparatus according to claim 14, wherein said connection line comprises plural concentrically arranged corrugated pipes detachably coupled to said central supply unit.

17. Apparatus according to claim 16, wherein the space between the innermost of said pipes is evacuated, and wherein electric control lines are disposed through the space between the outermost of said pipes.

18. Apparatus according to claim 1, wherein heating means are disposed on the end of said return line corresponding to the free end of said first line.

19. In a process for freezing tissue with a cryogenic probe by passing a liquid cryogenic coolant through a hollow feed line open at an end thereof and recessed with respect to a corresponding open end of a hollow return line concentrically surrounding said feed line to vaporize said coolant directly upon tissue to be frozen, the improvement which comprises:

returning vaporized coolant by subatmospheric suction from said feed line through said return line.

20. A process according to claim 17, further characterized by:
a. placing a front rim of said return line on the tissue to be frozen; and
b. drawing the tissue to be frozen against the rim of said return line by suction prior to passing said coolant onto said tissue to be frozen.

21. A process according to claim 19 wherein said return line is transparent, further comprising observing the amount of coolant which is in the liquid phase at the site of application.

22. A process according to claim 21 further comprising regulating said coolant feed responsive to said observation.

23. An apparatus according to claim 1 further comprising a pressure relief safety valve responsive to excess coolant pressure.

24. An apparatus according to claim 18 wherein said heating means includes an annular heating device around the open end of said return line.

25. An apparatus according to claim 1 further comprising
d. a pressure relief safety valve responsive to excess coolant pressure; and
e. an annular heating device around the open end of said return line.

26. A cryosurgical instrument adapted for use in the freezing of tissue comprising:
means for providing a confined volume including and surrounding at least a portion of the tissue to be frozen;
means for filling said confined volume with liquified gas coolant in liquid form to a level above the level of tissue to be frozen;
means for drawing the tissue to be frozen against said means for providing a confined volume; and
means for venting vapors of said coolant from said confined volume above said level of liquid.

27. An instrument according to claim 26 wherein said means for venting coolant vapors is a subatmospheric suction means.

28. The instrument according to claim 26 wherein said walled structure comprises a generally cylindrical wall having an axis extending in at least one direction.

29. The instrument according to claim 26 wherein said means for providing a confined volume is transparent.

30. A cryosurgical instrument for freezing of tissue comprising:
an open walled chamber for providing a confined volume including and surrounding at least a portion of the tissue to be frozen;
means including a vent tube having a coolant delivery tube disposed coaxially therewith for directing a flow of liquified gas coolant toward tissue to be frozen within said confined volume and for venting vapors of said coolant from said confined volume, said open walled chamber being fastened to the outer one of said tubes; and
subatmospheric suction means capable of drawing the tissue to be frozen against a rim of said open walled chamber.

31. The instrument according to claim 30 wherein said means for venting coolant vapors is a subatmospheric suction means.

32. The instrument according to claim 30 wherein said open walled chamber is transparent.

33. The cryosurgical instrument according to claim 30 wherein said outer tube and said chamber are adapted to releasably engage one another, whereby said chamber may be removed from the end of said tube.

34. A cryosurgical method which comprises
positioning one open end of an annular containment shield against the tissue to be frozen with sufficient subatmospheric suction force to form a hermetic seal thereat;
directing a flow of cryogenic liquid through the shield toward said one end into contact with the tissue to be frozen and vaporizing liquid thereat;
venting the vaporized liquid upstream of said one end;
and maintaining the hermetic seal until the tissue has been frozen and the liquid has been vaporized.

35. A method according to claim 34 wherein said vaporized liquid is vented by subatmospheric suction.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,794,039 Dated February 26, 1974

Inventor(s) Paul Kollner, et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

IN THE CLAIMS:

CLAIM 3, COLUMN 6: "second" should read -- return --.

CLAIM 4, COLUMN 6: "first" should read -- feed --.

CLAIM 20, COLUMN 7: The dependency of the claim should read -- 19 --.

Signed and sealed this 4th day of June 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.