

Aug. 27, 1968

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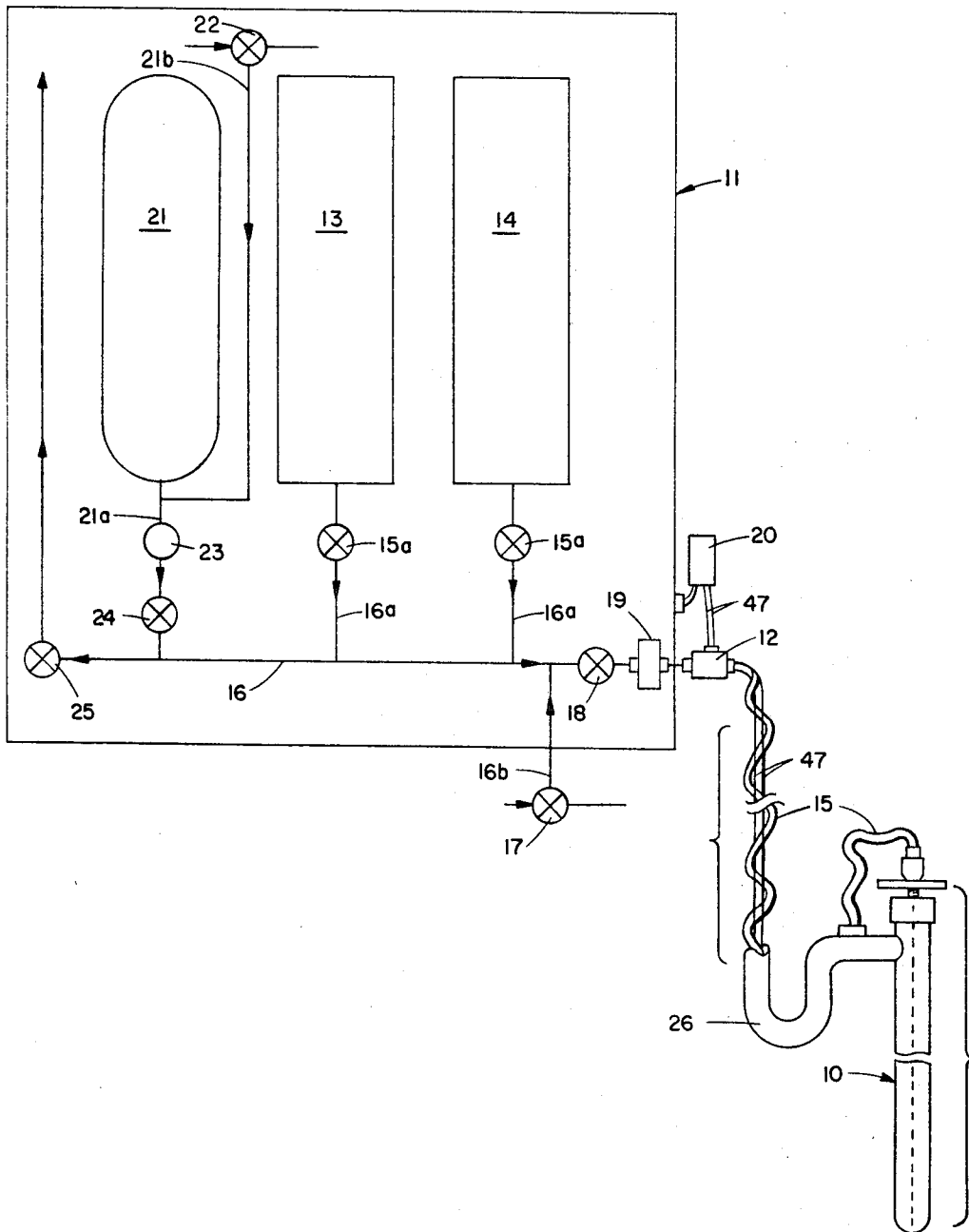
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REFRIGERATED SURGICAL PROBE

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4 Sheets-Sheet 1

Fig. 1



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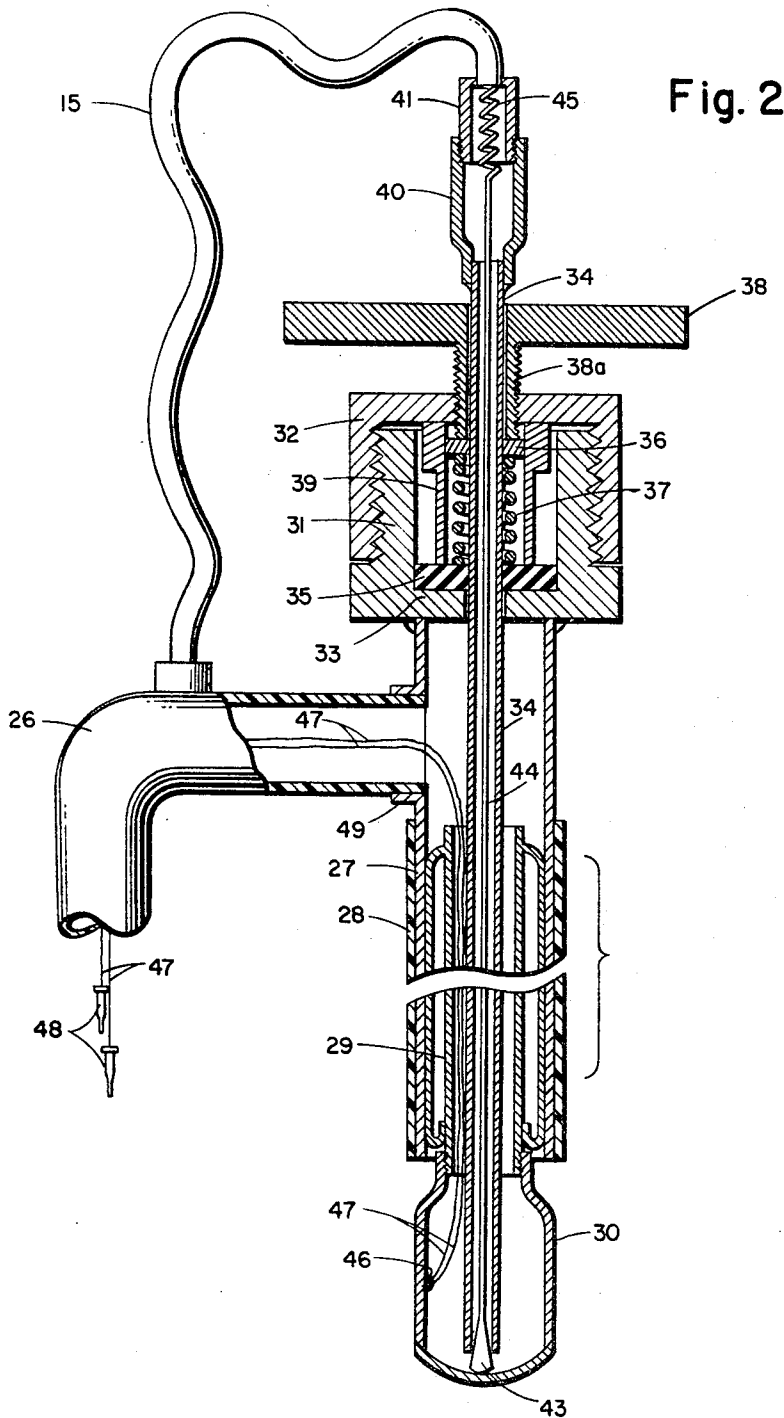
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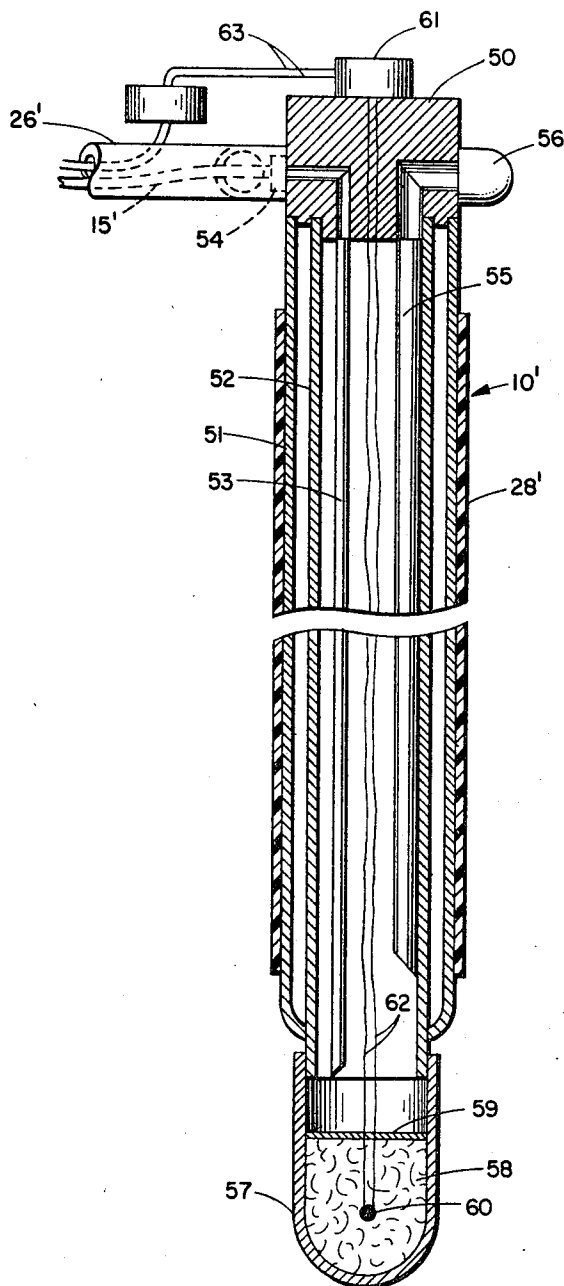
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Fig. 3



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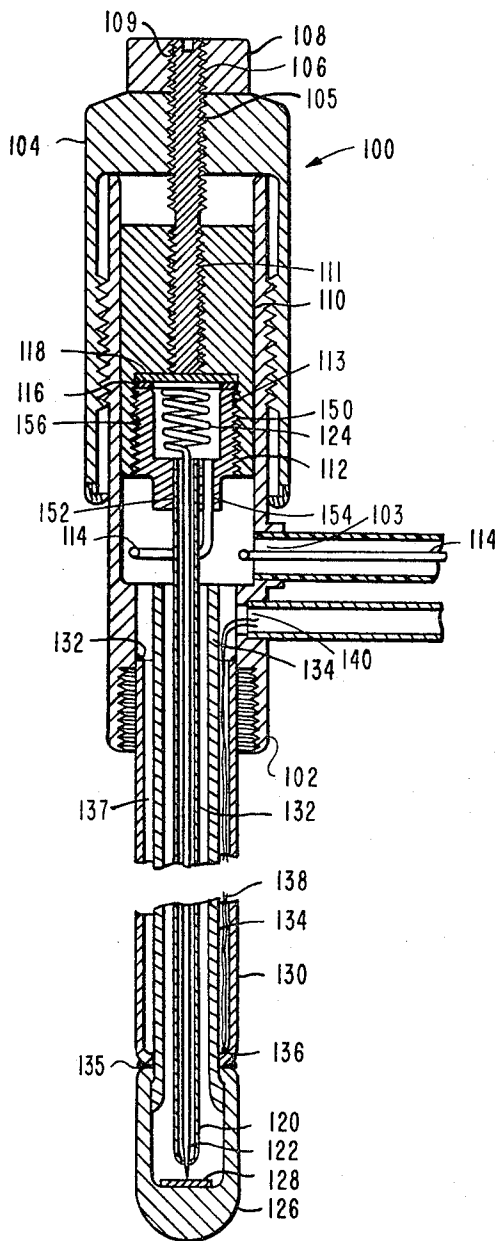
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REFRIGERATED SURGICAL PROBE

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tion, Azusa, Calif., a corporation of Ohio
Continuation-in-part of application Ser. No. 360,563,
Apr. 17, 1964. This application Sept. 24, 1964, Ser.
No. 398,802

11 Claims. (Cl. 128—303.1)

The present invention generally relates to apparatus in-
cluding a surgical instrument of the type suitable for de-
stroying diseased or degenerated cells in a living being by
freezing such cells, and more particularly to a surgical
probe for administering a freezing treatment to abnormal
cells in areas which may be embedded in or surrounded
by healthy body tissue without injury to the healthy body
tissue.

The application is a continuation-in-part of applicant's
copending application Ser. No. 360,563 filed Apr. 17, 1964,
now abandoned.

Heretofore, the attempted alleviation of such medical
disorders as Parkinson's disease, whose most prominent
symptoms are pronounced tremors, halting speech, and
rigidity of parts of the human body, has included treat-
ment of the human brain by alcohol injection to destroy
areas of abnormal cells in the brain. This form of treat-
ment is difficult to control because the alcohol may "mi-
grate" into healthy tissue with resulting injury thereto.
Such injury sometimes causes damage to the motor
nervous system of the body.

More recently, a refrigerated surgical probe technique
has been developed to destroy affected cells by freezing.
Such a treatment has been generally regarded as being
more satisfactory than the alcohol injection treatment be-
cause its effects are more local in nature, and there is less
possibility of destroying or injuring body tissues other
than those which are intended to be destroyed.

The success of the freezing technique in a given in-
stance is, however, dependent upon certain factors which
are not yet predictable with definitive accuracy. In this
respect, the temperature at which specific tissues or
organs cease to function is not known with any degree of
assurance. Also, the temperature and rate of cooling re-
quired to destroy living cells and tissue is still undergoing
investigation.

In employing a refrigerated surgical probe, care must
be exercised in removing the probe from the body at the
conclusion of a freezing treatment administered by the
probe because healthy tissue may become frozen to the
operative portion of the probe during the treatment. Pre-
mature removal of the probe where this adherence of
healthy tissue to the probe has occurred is likely to dam-
age the healthy tissue to a considerable extent.

It is therefore an object of the present invention to
provide an improved surgical instrument of the refriger-
ated probe type, wherein the surgical probe is so con-
structed as to enable a temperature selection therefor
over a wide range, thereby affording requisite flexibility
as to temperature selection to enhance the probability of
success in the use of the freezing technique as a treat-
ment for medical disorders associated with various por-
tions of the body, such as the brain.

It is another object of this invention to provide an
improved surgical probe for administering a freezing
treatment to abnormal cells of a living body, wherein
the surgical probe includes a mechanism for rapidly
warming its operative portion to facilitate withdrawal of
the probe from the body without damage to healthy tissue
when the treatment is completed, while also freeing any
frozen refrigerant which may form in the probe.

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It is a further object of this invention to provide an
improved surgical probe for administering a freezing treat-
ment to abnormal cells of a living body, wherein the
operative area of the surgical probe is of limited extent
such that the area of cells refrigerated thereby is sharply
localized, this being accomplished by constructing the
probe as a slender elongated element effectively insulated
except at its tip which forms its operative portion. The
improved surgical probe is thereby enabled to administer
a freezing treatment to small areas of abnormal cells
in the human brain without injuring healthy tissue.

Some of the objects of the invention having been stated,
other objects and features will become apparent from
the following detailed description when read in connection
with the accompanying drawings in which—

FIG. 1 is a diagrammatic view of a system for ad-
ministering a freezing treatment in accordance with the
present invention, the surgical probe forming a com-
ponent thereof being greatly enlarged;

FIG. 2 is a longitudinal sectional view of one embod-
iment of the surgical probe;

FIG. 3 is a longitudinal sectional view of another em-
bodiment of the surgical probe; and

FIG. 4 is a longitudinal sectional view of another em-
bodiment of the surgical probe.

Referring more specifically to the drawings, FIG. 1
diagrammatically illustrates a system for administering a
freezing treatment to portions of a living body in which
a surgical probe broadly designated by reference numeral
10 is a component part in accordance with the present
invention. The probe 10 to be hereinafter described in
detail is supplied with fluid refrigerant or coolant mat-
erial from containers 13 and 14 which are mounted in a
case 11, the refrigerant being delivered from the case 11
through a quick-disconnect pipe coupling 12 to a tube
15 and directed therethrough to the probe 10.

Preferably the containers 13 and 14 are filled with
liquid refrigerants having distinctively different boiling
points. By way of example, the container 13 may be filled
with liquid Freon 114 which has a boiling point of 3.6°
C., while container 14 may be filled with liquid Freon 22
which has a boiling point of -40° C. The containers 13
and 14 are respectively connected to a manifold 16 by
branch conduits 16a, 16a, each of which has a manually
operable valve 15a interposed therein for controlling the
flow of refrigerant from the containers 13, 14 into the
manifold 16. The manifold 16 is connected to an external
supply conduit 16b which has a manually operable valve
17 therein and leads to a fitting (not shown) adapted to
connect any external tank of fluid refrigerant into the
manifold 16 through the external supply conduit 16b.
The valve 17 is closed when no external tank of fluid
refrigerant is being used with the system to prevent ex-
ternal leakage of refrigerant from the manifold 16.

A flow control valve or outlet valve 18 is installed in the
manifold 16 at one end portion thereof to regulate the
flow of liquid refrigerant from the manifold 16 to the
probe 10. The manifold 16 also includes a filter 19 therein
and is connected to the quick disconnect pipe coupling 12
mounted on the case 11. A temperature indicating mecha-
nism 20 for indicating the temperature of the operative
portion of the probe 10 is mounted on the exterior of
the case 11 for detachable connection to the probe 10
as will later appear.

The case 11 also contains a container 21 having a warm-
ing fluid therein maintained at ambient temperature for
reasons which will hereinafter appear. By way of a pre-
ferred example, the warming fluid in container 21 may be
dry nitrogen gas under pressure maintained at room tem-
perature. The container 21 is connected to the manifold 16
by a branch conduit 21a in which a pressure regulator
23 and a manually operable valve 24 are installed so that

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the introduction of the warming fluid from the container 21 into the manifold 16 at a predetermined pressure can be controlled. A supply conduit 21b is connected to the branch conduit 21a at a position between the container 21 and the pressure regulator 23, the supply conduit 21b having a manually operable valve 22 therein and leading to a fitting (not shown) adapted to connect a source of warming fluid to the supply conduit 21b. When it is desired to re-fill the container 21 with warming fluid, the valve 24 is closed, the source of warming fluid is connected to the supply conduit 21b through the fitting, and the valve 22 is opened so that the source of warming fluid is connected to the container 21 through the supply conduit 21b and the branch conduit 21a.

The manifold 16 is further provided with a manually operable valve 25 disposed on the opposite side of the branch conduits 16a, 16a, and 21a from the flow control valve 18, the manually operable valve 25 serving as a venting or exhausting means for the manifold 16 when opened to rapidly exhaust any liquid refrigerant from the manifold 16. The valve 25 is normally closed.

Referring now to the surgical probe 10, a preferred embodiment thereof is illustrated in FIG. 2. Liquid refrigerant from either or both of the containers 13, 14 is directed through the manifold 16 to the quick disconnect pipe coupling 12, from where the liquid refrigerant is delivered to the probe 10 through the tube 15. The tube 15 is constructed of suitable material, which may be stainless steel, for example. Preferably, the major length of the tube 15 is loosely received within a protective tubular jacket 26 which may be made of suitable plastic material. In this connection, the portion of the tube 15 extending from the pipe coupling 12 to a location adjacent to the probe 10 is enclosed within the protective tubular jacket 26. The remaining portion of the tube 15 extends through the wall of the tubular jacket 26 and is connected to a delivery tube at the top of the probe housing for delivering liquid refrigerant through the delivery tube in the probe housing to the lower tip thereof, as later described.

The housing of the probe 10 comprises a hollow body portion in the form of a cylindrical metallic tube 27 which may be stainless steel, for example. An exterior thermal insulation covering 28 is provided about the cylindrical tube 27 at its lower end portion. The thermal insulation covering 28 is preferably made of a plastic material such as polytetrafluoroethylene ("Teflon") which is self-lubricating to facilitate insertion of the probe 10 and which does not readily adhere to frozen body tissue. A double-walled internal insulating jacket 29 is frictionally received within the lower operative end portion of the tube 27, the insulating jacket 29 being pressed thereinto. The space defined between the walls of the internal insulating jacket 29 may be placed under a vacuum or may contain air for providing thermal insulation. The inner wall of the internal insulating jacket 29 extends beyond the outer wall thereof and the lower end of the tube 27, terminating in an externally threaded lower end portion for threadably receiving a hollow tip member or end can 30 to detachably secure the tip member 30 to the tube 27 forming the body portion of the probe housing through the internal insulating jacket 29 therefor. The tip member 30 is made of metal preferably stainless steel, and as shown is provided with a spherical end closure which is suitable for use in certain brain surgery operations. It will be understood, however, that the probe 10 may be provided with a plurality of interchangeable tip members of various types suitable for other operations in which the probe 10 is to be employed in administering a freezing treatment, since the tip member 30 is readily removable from the probe 10. The thermal insulation provided by the double-walled internal insulating jacket 29 of the probe 10 prevents undue heating of the operative end of the probe 10 from the heat of the body tissue into which the probe 10 is inserted.

The housing of the probe 10 further includes an upper externally threaded cup or receptacle 31 rigidly secured

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to the upper end of the tube 27. A cap member 32 is threadably received about the cup 31 and closes the open upper end thereof, the cap member 32 having a central aperture therein communicating with a chamber defined by the cup 31 and the cap member 32. The cup 31 has a centrally apertured bottom wall 33 adjacent the upper end of the tube 27. The central aperture in the bottom wall 33 of the cup 31 is axially aligned with the central aperture in the cap member 32 for receiving an elongated refrigerant delivery tube 34 therethrough. The delivery tube 34 extends through the length of the probe housing, the upper end of the delivery tube 34 projecting outwardly through the central aperture in the cap member 32 and the lower end of the delivery tube 34 projecting outwardly of the lower end of the tube 27 so as to terminate within the tip member 30 adjacent the end closure thereof.

Means are provided to seal off the upper portion of the probe housing from the tube 27 to prevent leakage of refrigerant material from the tube 27 upwardly through the central apertures in the bottom wall 33 of the cup 31 and the cap member 32. To this end, an annular sealing member 35 of suitable resilient material, such as rubber, is disposed within the cup 31 in sealing engagement with the delivery tube 34 which is slidably received therethrough. The annular sealing member is seated against the bottom wall 33 of the cup 31.

The delivery tube 34 is longitudinally or axially adjustable with respect to the probe housing comprising the lower body portion in the form of tube 27 and the upper portion including the cup 31 and the cap member 32 therefor. In this respect, an annular collar 36 is rigidly secured to the delivery tube 34, the collar 36 being disposed within the cup 31. A coil spring 37 encircles delivery tube 34 and is seated under compression at its opposite ends against the resilient sealing member 35 and the collar 36 within the cup 31. The collar 36 is axially movable within the cup 31 and carries the delivery tube 34 therewith, the position of the collar 36 within the cup 31 being adjusted by a manually rotatable thumb wheel 38 having an externally threaded stem 38a threadably received by the central aperture in the cap member 32. The delivery tube 34 is freely received through an axial bore provided in the thumb wheel 38 and its threaded stem 38a. The lower end of the threaded stem 38a abuts the collar 36. Upon rotating the thumb wheel 38 in either direction, the relative position of the threaded stem 38a changes to axially adjust the position of the collar 36 and the delivery tube 34 carried thereby, the collar 36 being held against the lower end of the threaded stem 38a by the spring 37. Centering means for maintaining the delivery tube 34 in properly centered relation within the probe housing are provided in a form of a guide sleeve 39 which is received within the cup 31. The opposite ends of the guide sleeve 39 are respectively seated against the cap member 32 and the resilient sealing member 35 to insure compression of the resilient sealing member 35 into sealing engagement with the delivery tube 34. The guide sleeve 39 is fixed with respect to the cup 31 and the cap member 32 of the probe housing and slidably receives the annular collar 36 therein to center the collar 36 and the delivery tube 34 carried thereby with respect to the probe housing.

The upper end of the delivery tube 34 extends through the thumb wheel 38. Suitable connector means are provided to couple the delivery tube 34 to the tube 15 providing the supply of liquid refrigerant to the probe 10. As shown, the connector means may comprise a socket member 40 rigidly secured to the upper end of the delivery tube 34 and a hollow plug 41 rigidly secured to the end of the tube 15 and threadably received by the socket member 40 to detachably connect the tube 15 and the delivery tube 34. Thus, liquid refrigerant is directed to the probe 10 through the tube 15 from where the liquid refrigerant flows through the delivery tube 34 into the tip member 30 at the lower operative end of the probe 10.

The discharge of liquid refrigerant into the tip member 30 is regulated by means of a valve assembly disposed in the delivery tube 34. The valve assembly comprises a stationary valve member 43 located at the lower end of the delivery tube 34 and an elongated valve stem 44 integral with the valve member 43. The valve member 43 is enlarged with respect to the valve stem 44 and is conically shaped with a generally spherical base surface bearing against the end closure of the tip member 30. The elongated valve stem 44 is preferably made of fine steel spring wire and extends longitudinally within the delivery tube 34, terminating at its upper end in a helically coiled spring portion 45 seated within the hollow plug 41 of the connector assembly joining the delivery tube 34 to the tube 15. The spring portion 45 of the valve stem 44 bears against the back wall of the hollow plug 41 to lightly press the valve member 43 against the end closure of the tip member 30. It will be understood that the lower open end of the delivery tube 34 may be variably restricted by the conical valve member 43 as desired to regulate the discharge of liquid refrigerant from the delivery tube 34 into the tip member 30. In this respect, the delivery tube 34 is axially movable with respect to the conical valve member 43, such axial movement of the delivery tube 34 being accomplished by rotating the thumb wheel 38 as earlier described. Thus, the degree to which the lower open end of the delivery tube 34 is restricted by the conical valve member 43 can be readily varied from a fully open position (where only the valve stem 44 restricts the area of the lower open end of the delivery tube 34) to a fully closed position (where the lower end of the delivery tube 34 is seated on the conical valve member 43 in sealing engagement therewith).

Means are provided for continuously indicating the temperature of the tip member 30. To this end, a small thermocouple 46 is secured to the inner surface of the tip member 30 and is connected to the temperature indicating mechanism 20 by elongated electrical conductors or wires 47 which extend through the lower portion of the probe housing, and through the tubular jacket 26 and the quick disconnect coupling 12 to the temperature indicating mechanism 20. The wires 47 are respectively made in two segments in order to permit replacement of the tip member 30 on the probe 10. Accordingly, pin connectors 48 are shown at the terminals of corresponding segments of the wires 47, the pin connectors 48 being received within socket connectors (not shown) at the terminals of the other segments of the wires 47. The tubular jacket 26 is frictionally received within an annular fitting or socket 49 integral with the cylindrical tube 27 forming the body portion of the probe housing, such that a fluid-tight seal is provided between the tubular jacket 26 and the socket 49. To replace the tip member 30, the tubular jacket 26 is removed from the probe housing by withdrawing it from the socket 49, and the pin connectors 48 are disconnected from the socket connectors to separate the segments of the wires 47 so that the tip member 30 can be removed from the probe housing for replacement by another tip member.

Another embodiment of a surgical probe in accordance with the present invention is illustrated in FIG. 3, the modified surgical probe being broadly designated by the reference numeral 10'. It will be understood that the system for supplying liquid refrigerant and warming fluid to the surgical probe 10' is the same as shown in FIG. 1. The surgical probe 10' is not equipped with a valve assembly within the probe housing for regulating the flow of liquid refrigerant into the operative tip thereof, as is the surgical probe 10 of FIG. 2. In the probe 10', the rate of flow of the liquid refrigerant is regulated by manipulation of the flow control valve 18.

The probe 10' comprises a housing which includes a pair of concentric cylindrical tubes 51, 52 secured to a head 50 at their upper ends. The concentric tubes 51, 52 form the body portion of the probe 10' and may be made

of a suitable metal, such as stainless steel. The outer tube 51 has an inturned lower end which is rigidly secured to the inner tube 52 at a position above the lower end of the inner tube 52. The space defined between the concentric tubes 51, 52 may be evacuated or may contain air to provide thermal insulation for the probe 10'. Preferably, a thermal insulating covering 28' is provided about the outer tube 51, the thermal insulation covering 28' being made of a suitable plastic material such as polytetrafluoroethylene ("Teflon").

An elongated delivery tube 53 is secured at its upper end to the head 50 and extends longitudinally within the length of the probe housing. The head 50 is provided with a passage therein connecting the delivery tube 53 to a nipple 54 forming a terminal for the tube 15' through which the liquid refrigerant is directed to the delivery tube 53. An elongated exhaust tube 55 is also arranged within the probe housing, being secured at its upper end to the head 50 and communicating with the tubular jacket 26' protecting the tube 15' through another passage in the head 50 and a tubing connector 56 extending between the head 50 and the tubular jacket 26'.

A tip member or end can 57, preferably made of metal such as stainless steel, is removably attached to the lower end of the probe housing by suitable means. As shown, the tip member 57 is received over the lower projecting end portion of the inner tube 52, there being a press fit therebetween. The tip member 57 is provided with a heat sink 58 which may be made of any suitable material. By way of example, the heat sink 58 may comprise closely packed steel wool filling the lower portion of the tip member 57 and held in place in a compacted condition by a plate 59.

A thermocouple 60 is embedded in the heat sink 58 and is connected to a plug fitting 61 mounted on the head 50 of the probe 10' by elongated electrical conductors or wires 62 which extend through the heat sink 58, the tip member 57, the inner tube 52, and the head 50 to the plug fitting 61. The plug fitting 61 is connected to the temperature indicating mechanism 20 of FIG. 1 by a pair of elongated conductors or wires 63 which extend into the protective tubular jacket 26' and lead to the temperature indicating mechanism 20. The wires 63 may be disconnected from the plug fitting 61 should it be desired to disassemble the probe 10' from the liquid refrigerant supplying system.

In applying a freezing treatment to a body portion by using either of the probes 10 or 10', liquid refrigerant is supplied to the tip member of the probe through the delivery tube in the probe housing to cool the tip member to a selected temperature, the temperature of the tip member being visually indicated by the temperature indicating mechanism 20. By controlling the rates at which the two different liquid refrigerants from the containers 13, 14 are introduced into the probe, substantial flexibility as to the temperature of the tip member of the probe to be selected is permitted. Through the use of appropriate liquid refrigerants in the system of FIG. 1, it is possible to obtain a temperature range extending between approximately -80° C. and ambient temperature. The use of liquid Freon 114 in container 13 would provide cooling from ambient temperature to 3.6° C., and liquid Freon 22 in container 14 would provide lower temperatures to its boiling point of -40° C. Intermediate temperatures between ambient and 3.6° C. and between 3.6° to -40° C. would be obtained by varying the flow rate of each liquid refrigerant through the probe. Temperatures below -40° C. could be produced by using other liquid refrigerants, such as Freon 13 which boils at -81° C.

Initially, all of the valves in the liquid refrigerant supplying system for the probe are closed before the probe is inserted into the tissue to be cooled. Upon insertion of the probe into the tissue, the valve 15a for one or both of the containers 13, 14 is opened and the flow control valve 18 is adjusted to introduce liquid refrigerant into

the probe through the delivery tube for producing a selected temperature at the tip member of the probe. The probe 10 of FIG. 2 has a fine adjustment to regulate the flow of liquid refrigerant into the tip member 30 which is effected by manually rotating the thumb wheel 38 to axially adjust the lower end of the delivery tube 34 with respect to the conical valve member 43, thereby enabling the temperature to be more uniform at the tip member 30.

The temperature of the tip member of either probe 10 or 10' is monitored by the temperature indicating mechanism 20. As the liquid refrigerant evaporates in the tip member of the probe, the gas which is produced is exhausted from the probe housing. In the probe 10 of FIG. 2, the gas produced from the evaporation of the liquid refrigerant in the tip member 30 passes upwardly in the tube 27 and is exhausted from the probe housing through the tubular jacket 26 from where it may be vented to atmosphere or collected in a depository (not shown). In the probe 10', the gas is similarly exhausted from the probe housing by passing upwardly in the exhaust tube 55 and outwardly through the passage in the head 50 to the tubing connector 56 from where it is directed to the tubular jacket 26'.

At times it may be necessary to reposition the probe 10 or 10', and the probe must also be removed from the body tissue in which it is inserted following completion of a freezing treatment. The tip member of the probe may be frozen in place, however, to render repositioning or removal thereof difficult without causing injury to healthy body tissue. To facilitate such manipulation of the probe, the supply of liquid refrigerant to the tip member is shut off, and the warming fluid in container 21 is introduced into the probe by opening the valve 24. When the warming fluid has sufficiently raised the temperature of the tip member, the probe may be manipulated as desired without injury to the body tissue.

Another embodiment of a surgical probe in accordance with the present invention is illustrated in FIG. 4, the modified surgical probe being broadly designated by the reference numeral 100. It will be understood that the system for supplying liquid refrigerant and warming fluid to the surgical probe 100 is the same as shown in FIG. 1.

The housing of probe 100 includes a hollow body portion in the form of a cylindrical metallic tube 102 which may be of stainless steel, for example. This tube 102 is joined at its lower portion by a second cylindrical tube which carries the freezing tip 126, as will later be described. A barrel portion in the form of a cylindrical metallic end cap 104 is threadably attached to the upper portion of the body 102. Drive screw 106 is threadably received within the upper portion of barrel 104, in a threaded central aperture 105 provided therein.

A lock nut in the form of a solid metallic cylinder 108, having a threaded central aperture 109, therein is threadably attached to the upper portion of screw 106.

The housing of probe 100 further includes a gland member in the form of a solid cylindrical metallic element 110 with a central threaded aperture 111 in the upper portion thereof which joins on central threaded aperture of larger diameter defining a downwardly opening cavity in the lower portion thereof. The central threaded aperture 111 of gland member 110 is threadably attached to screw 106 at said screw's lower portion, and said gland member 110 is slidably received within body portion 102 but restrained against rotation relative thereto. Rotation of barrel portion 104 in either direction changes the relative position of gland member 110 axially in relation to body 102 by movement of gland member 110 on central drive screw 106.

There is provided a hollow plug 112, having a threaded outer circumference 150 on the upper portion thereof, a central axial aperture 152 in the lower portion thereof, and an off-center axial aperture 154 in said lower portion, both said apertures communicating with a cylindrical chamber 156 in the upper portion of said hollow plug.

The plug 112 is threadably received in the larger diameter central threaded aperture 113 in the lower portion of gland member 110, forming a chamber defined by the cylindrical chamber 156 of the plug 112 inserted in the gland member 110, and seal 116 and disc 118 as later described.

Refrigerated liquid enters the housing of probe 100 through an inlet tube 114 which passes through a radially positioned aperture 103 in body 102. The inlet tube 114 travels in the form of a spiral within the body 102 and enters the off-center aperture 154 in plug 112. The refrigerated liquid then passes into the defined chamber 156 in the plug 112. In order to seal off the upper portion of the gland member 110 from the chamber 156 to prevent leakage of refrigerant material upwardly from the chamber 156, an annular sealing member 116 of suitable resilient material, such as rubber, is seated against plug 112, and is in sealing engagement with disc 118. Disc 118 is in the form of a solid metallic cylindrical disc, made of a suitable material, which may be stainless steel, for example, and is seated against seal 116 and screw 106.

The refrigerated fluid then passes from the chamber 156 into an elongated delivery tube 120 in the form of a hollow cylindrical metallic tube which may be stainless steel, for example. Delivery tube 120 is fixedly attached at its upper end to plug 112 to prevent relative axial movement therebetween and projects through the central axial aperture 152 in the plug 112. The bottom of delivery tube 120 is shaped to engage valve member 122.

The discharge of liquid refrigerant is regulated by means of valve member 122 which comprises an elongated needle valve preferably made of fine steel spring wire extending longitudinally within delivery tube 120. Valve member 122 terminates at its upper end in a helically coiled spring portion 124 seated within the chamber of plug 112. The spring portion 124 of the needle valve 122 bears against the disc 118 to lightly press the needle valve 122 against a disc 128 in the end closure of tip member 126, as later described. It will be understood that the lower open end of the delivery tube 120 may be variably restricted by needle valve 122 to regulate the discharge of liquid refrigerant from delivery tube 120 into the tip member 126. In this respect the delivery tube 120 is axially movable with respect to the needle valve 122, such axial movement of the delivery tube 120 being accomplished by rotation of the barrel 104 or lock nut 108, the former being for fine adjustment, and the latter for coarse adjustment. Thus, the degree to which the lower open end of the delivery tube 120 is restricted by needle valve 122 can readily be varied from a fully open position (where only the point of the needle valve 122 restricts the area of the lower open end of the delivery tube 120), to a fully closed position (where the internal annular surface at the lower end of the delivery tube 120 is seated against the needle valve 122 in complete sealing engagement therewith).

The refrigerated fluid passes from delivery tube 120 into tip member 126. The tip member 126 is made of metal, preferably stainless steel, and, as shown, is provided with a spherical end closure which is suitable for use in certain brain surgery operations. It will be understood, however, that the probe 100 may be provided with a plurality of interchangeable tip members of various types suitable for other operations in which the probe 100 is to be employed in administering a freezing treatment.

The tip member 126 contains a disc 128 fixedly attached, such as by soldering, to its lower end on which needle valve 122 rests. The upper end of tip member 126 is fixedly attached, such as by soldering, to an outer jacket in the form of the previously mentioned second cylindrical tube 130. The operative portion of the probe, therefore, takes the form of a tube 130 closed at one end (by the tip 126). Outer jacket 130 terminates at its upper end by fixed attachment, such as by soldering, inside a central aperture 132 in the lower portion of body 102.

Spaced inwardly from tube 130 is an inner jacket in the form of a cylindrical tube 134 which is fixedly attached to the outer jacket 130 and the tip 126, such as by soldering at lower common junction 135. The upper end of inner jacket 134 terminates at the upper end of the central apertures 132 of body 102. Inner jacket 134 and outer jacket 130 define a space 137 between them which may be under a vacuum or may contain air for providing thermal insulation.

Means are provided for continuously indicating the temperature of the tip member 126. To this end, a small thermocouple 136 is secured to the inner surface of the outer jacket 130 at a point near the joint 135 where the inner and outer jackets are attached. The thermocouple 136 is connected to temperature indicating mechanism, such as 20 shown in FIG. 1, by elongated electrical conductors or wires 138 which extend through the space between the inner jacket 134 and outer jacket 130 said wires passing out of the probe 100 through radially positioned aperture 140 in body 102.

It will be understood that where careful control of the temperature of the tip is not required, such as where the boiling point of Freon 114, 3.6° C., is the temperature employed, a control valve mechanism is not required to control the flow of refrigerated liquid and a probe utilizing side-by-side internal tubes for the inlet and outlet of the refrigerated material might be used.

While the refrigerated surgical probe in the embodiments herein disclosed has been described with particular reference to its use in administering a freezing treatment for alleviating Parkinson's disease, it will be understood that the probe is capable of rendering freezing treatments prescribed for general medical disorders where it is desired to destroy areas of diseased or degenerate tissue.

Although preferred embodiments of the invention have been described and illustrated by way of example, various modifications of the described embodiments may be made by those skilled in the art without departing from the scope of the invention as defined by the appended claims.

We claim:

1. A device for administering a treatment to living body tissue, said device comprising

- (a) a probe having an elongated hollow housing,
- (b) a hollow tip member having a closed lower end, said tip member being secured to the lower end of said housing,
- (c) a delivery tube carried by said probe said delivery tube extending at least partially within said housing and communicating with the interior of said tip member for delivering fluid refrigerant therethrough into said tip member,
- (d) an elongated valve stem extending within said delivery tube and being of substantially smaller diameter than the inner diameter of said delivery tube,
- (e) a valve member carried by the lower end of said valve stem and receivable by the lower open end of said delivery tube, said valve member being enlarged with respect to said valve stem and being of variable cross-sectional diameter, and
- (f) means for inducing relative axial movement between said delivery tube and said valve member carried by said valve stem to vary the restriction of the lower open end of said delivery tube by said valve member for regulating the rate of delivery of fluid refrigerant through said delivery tube into said tip member.

2. A device for administering a treatment to living body tissue, said device comprising

- (a) a probe having an elongated hollow housing provided with an operative tip portion adapted to be positioned in proximity to the body tissue to be treated,
- (b) a delivery tube carried by said probe, said de-

livery tube extending at least partially within said housing and communicating with said operative tip portion for delivering fluid refrigerant therethrough into said operative tip portion,

- (c) an elongated valve stem extending within said delivery tube and being of substantially smaller diameter than the inner diameter of said delivery tube,
- (d) an enlarged valve member of variable cross-sectional diameter carried by the lower end of said valve stem and engaging said operative tip portion, said valve member being receivable by the lower open end of said delivery tube, and
- (e) means for imparting axial movement to said delivery tube to vary the restriction of the lower open end of said delivery tube by said valve member for regulating the rate of delivery of fluid refrigerant through said delivery tube into said operative tip portion.

3. A device for administering a treatment to living body tissue, said device comprising

- (a) a probe having an elongated hollow housing,
- (b) a hollow tip member having a closed lower end, said tip member being secured to the lower end of said housing,
- (c) a delivery tube carried by said probe, said delivery tube extending at least partially within said housing and communicating with the interior of said tip member for delivering fluid refrigerant therethrough into said tip member,
- (d) an elongated valve stem extending within said delivery tube and being of substantially smaller diameter than the inner diameter of said delivery tube,
- (e) an enlarged valve member of variable cross-sectional diameter carried by the lower end of said valve stem and engaging the closed lower end of said tip member, said valve member being receivable by the lower open end of said delivery tube, and
- (f) means for imparting axial movement to said delivery tube to vary the restriction of the lower open end of said delivery tube by said valve member for regulating the rate of delivery of fluid refrigerant through said delivery tube into said tip member.

4. A device for administering a treatment to living body tissue, said device comprising:

- (a) a probe having an elongated hollow housing provided with an operative tip portion adapted to be positioned in proximity to the body tissue to be treated, said housing including
 - (1) an elongated tubular body portion,
 - (2) a receptacle secured to the upper end of said tubular body portion, and
 - (3) a cap member received by said receptacle and closing the upper end thereof to define a chamber therewith;
- (b) an elongated delivery tube carried by said probe, said delivery tube extending through said housing and communicating with said operative tip portion for delivering fluid refrigerant therethrough into said operative tip portion,
- (c) an elongated valve stem extending within said delivery tube and having a diameter substantially smaller than the inner diameter of said delivery tube,
- (d) an enlarged valve member of variable cross-sectional diameter carried by said valve stem at the lower end thereof and engaging said operative tip portion, said valve member being receivable by the lower open end of said delivery tube,
- (e) an annular collar rigidly secured to said delivery tube, said collar being disposed in said chamber,
- (f) resilient means within said chamber and engaging the lower surface of said collar to axially bias said collar in an upward direction,
- (g) a rotatable adjustment member threadably re-

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- ceived through said cap member and having an axial bore through which said delivery tube extends, said adjustment member engaging the upper surface of said collar,
- (h) the position of said collar within said chamber being adjusted in response to the rotation of said adjustment member with respect to said cap member for axially moving said delivery tube with respect to said valve stem and said valve member carried thereby, and
- (i) the restriction of the open lower end of said delivery tube by said valve member being changed upon axial movement of said delivery tube to vary the rate at which fluid refrigerant is admitted into said operative tip portion from said delivery tube.
5. A device for administering a treatment to living body tissue, said device comprising:
- (a) a probe having an elongated hollow housing, said housing including
- (1) an elongated tubular cylindrical body portion,
 - (2) a thermal insulating cylindrical jacket fixedly received within the lower portion of said tubular body portion and having radially spaced inner and outer cylindrical walls defining an annular space therebetween,
 - (3) a receptacle secured to the upper end of said tubular body portion, and
 - (4) a cap member received by said receptacle and closing the upper end thereof to define a chamber therewith;
- (b) said outer wall of said thermal insulating jacket engaging the inner surface of said tubular body portion,
- (c) said inner wall of said thermal insulating jacket having a lower end portion extending below said outer wall,
- (d) a hollow tip member threadably secured to the lower end portion of said inner wall, said tip member having a closed lower end,
- (e) an elongated delivery tube carried by said probe, said delivery tube extending loosely through said housing within said inner cylindrical wall of said thermal insulating jacket and having its lower end disposed within said tip member adjacent the closed end thereof,
- (f) an elongated valve stem extending within said delivery tube and having a diameter substantially smaller than the inner diameter of said delivery tube,
- (g) an enlarged valve member of variable cross-sectional diameter carried by said valve stem at the lower end thereof and engaging the closed lower end of said tip member, said valve member being receivable by the lower open end of said delivery tube,
- (h) an annular collar rigidly secured to said delivery tube, said collar being disposed in said chamber,
- (i) resilient means within said chamber and engaging the lower surface of said collar to axially bias said collar in an upward direction,
- (j) a rotatable adjustment member threadably received through said cap member and having an axial bore through which said delivery tube extends, said adjustment member engaging the upper surface of said collar,
- (k) the position of said collar within said chamber being adjusted in response to the rotation of said adjustment member with respect to said cap member for axially moving said delivery tube with respect to said valve stem and said valve member carried thereby, and
- (l) the restriction of the open lower end of said delivery tube by said valve member being changed upon axial movement of said delivery tube to vary the

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- rate at which fluid refrigerant is admitted into said tip member from said delivery tube.
6. A device for administering a treatment to living body tissue, said device comprising:
- (a) a probe having an elongated hollow housing, said housing including
- (1) an elongated tubular body portion,
 - (2) a receptacle secured to the upper end of said tubular body portion, and
 - (3) a cap member received by said receptacle and closing the upper end thereof to define a chamber therewith;
- (b) a hollow tip member removably secured to said tubular body portion, said tip member having a closed lower end,
- (c) an elongated delivery tube carried by said probe, said delivery tube extending loosely through said housing and having its lower end disposed within said tip member adjacent the closed end thereof,
- (d) an elongated valve stem extending within said delivery tube and having a diameter substantially smaller than the inner diameter of said delivery tube,
- (e) an enlarged valve member of variable cross-sectional diameter carried by said valve stem at the lower end thereof and engaging the closed lower end of said tip member, said valve member being receivable by the lower open end of said delivery tube,
- (f) the upper end of said valve stem terminating in a coiled spring portion,
- (g) means carried by said delivery tube and providing an apertured back wall against which said coiled spring portion of said valve stem is seated,
- (h) an annular collar rigidly secured to said delivery tube, said collar being disposed in said chamber,
- (i) resilient means within said chamber and engaging the lower surface of said collar to axially bias said collar in an upward direction,
- (j) a rotatable adjustment member threadably received through said cap member and having an axial bore through which said delivery tube extends, said adjustment member engaging the upper surface of said collar,
- (k) the position of said collar within said chamber being adjusted in response to the rotation of said adjustment member with respect to said cap member for axially moving said delivery tube while the compression of said coiled spring portion of said valve stem changes to compensate for the axial movement of said delivery tube, and
- (l) the restriction of the open lower end of said delivery tube by said valve member being changed upon axial movement of said delivery tube to vary the rate at which fluid refrigerant is admitted into said tip member from said delivery tube.
7. Apparatus for administering a treatment to living body tissue, said apparatus comprising
- (a) a probe having an elongated hollow housing provided with an operative tip portion adapted to be positioned in proximity to the body tissue to be treated,
- (b) a delivery tube communicating with the interior of said housing,
- (c) a plurality of sources of liquid refrigerants, each of said liquid refrigerants having different boiling points,
- (d) a source of warming fluid,
- (e) conduit means connecting said sources of liquid refrigerants and said source of warming fluid to said delivery tube, and
- (f) valve means in said conduit means for selectively controlling the rate and the nature of the substance admitted into the operative tip portion through said delivery tube from said respective sources of liquid

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refrigerants and warming fluid so that the temperature of said operative tip portion may be varied over a wide range by regulating the respective percentages of liquid refrigerants from said plurality of sources to be admitted into the operative tip portion.

8. A device for administering a treatment to living body tissue, said device comprising

- (a) a probe having an elongated hollow housing,
- (b) a hollow tip member having a closed lower end, and tip member being secured to the lower end of said housing,
- (c) a delivery tube carried by said probe, said delivery tube extending at least partially within said housing and communicating with the interior of said tip member for delivering fluid refrigerant therethrough into said tip member,
- (d) an elongated valve stem extending within said delivery tube and being of substantially smaller diameter than the inner diameter of said delivery tube,
- (e) a valve member carried by the lower end of said valve stem and receivable by the lower open end of said delivery tube, said valve member being of variable cross-sectional diameter, and
- (f) means for inducing relative axial movement between said delivery tube and said valve member carried by said valve stem to vary the restriction of the lower open end of said delivery tube by said valve member for regulating the rate of delivery of fluid refrigerant through said delivery tube into said tip member.

9. A device for administering a treatment to living body tissue, said device comprising

- (a) a probe having an elongated hollow housing provided with an operative tip portion adapted to be positioned in proximity to the body tissue to be treated,
- (b) a delivery tube carried by said probe, said delivery tube extending at least partially within said housing and communicating with said operative tip portion for delivering fluid refrigerant therethrough into said operative tip portion,
- (c) an elongated valve stem extending within said delivery tube and being of substantially smaller diameter than the inner diameter of said delivery tube,
- (d) a valve member of variable cross-sectional diameter carried by the lower end of said valve stem and engaging said operative tip portion, said valve member being receivable by the lower open end of said delivery tube, and
- (e) means for imparting axial movement to said delivery tube to vary the restriction of the lower open end of said delivery tube by said valve member for regulating the rate of delivery of fluid refrigerant through said delivery tube into said operative tip portion.

10. A device for administering a treatment to living body tissue, said device comprising

- (a) a probe having an elongated hollow housing,
- (b) a hollow tip member having a closed lower end, said tip member being secured to the lower end of said housing,
- (c) a delivery tube carried by said probe, said delivery tube extending at least partially within said housing and communicating with the interior of said tip member for delivering fluid refrigerant therethrough into said tip member,
- (d) an elongated valve stem extending within said delivery tube and being of substantially smaller diameter than the inner diameter of said delivery tube,
- (e) a valve member of variable cross-sectional diameter carried by the lower end of said valve stem and engaging the closed lower end of said tip member,

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said valve member being receivable by the lower open end of said delivery tube, and

- (f) means for imparting axial movement to said delivery tube to vary the restriction of the lower open end of said delivery tube by said valve member for regulating the rate of delivery of fluid refrigerant through said delivery tube into said tip member.

11. A device for administering a treatment to living body tissue, said device comprising:

- (a) a probe having an elongated hollow housing provided with an operative tip portion adapted to be positioned in proximity to the body tissue to be treated, said housing including
 - (1) an elongated tubular body portion, and
 - (2) an end cap secured to the upper end of said tubular body portion;
- (b) a gland member slidably received within said tubular body portion and having a downwardly opening cavity formed therein,
- (c) a hollow plug received in said cavity and secured to said gland member,
- (d) said gland member and said plug cooperating to define a chamber,
- (e) an elongated delivery tube extending through said housing and communicating with said operative tip portion for delivering fluid refrigerant therethrough into said operative tip portion, the upper end of said delivery tube being rigidly secured to said plug and communicating with said chamber,
- (f) an elongated valve stem extending within said delivery tube and having a diameter substantially smaller than the inner diameter of said delivery tube,
- (g) a valve member of variable cross-sectional diameter carried by said valve stem at the lower end thereof and engaging said operative tip portion, said valve member being receivable by the lower open end of said delivery tube,
- (h) fluid inlet means for said probe communicating with said chamber,
- (i) resilient means within said chamber and engaging said valve stem to axially bias said valve stem toward said operative tip portion,
- (j) an elongated screw member secured to said end cap and threadably received by said gland member, and
- (k) said end cap being rotatable to impart rotation to said elongated screw member for inducing axial movement of said gland member along said elongated screw member,
- (l) whereby the position of said plug is axially adjusted for axially moving said delivery tube with respect to said valve stem and said valve member carried thereby so as to change the restriction of the open lower end of said delivery tube by said valve member to vary the rate at which fluid refrigerant is admitted into said operative tip portion from said delivery tube.

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