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CRYOGENIC APPLICATOR WITH PROBE MEANS

Filed July 26, 1963

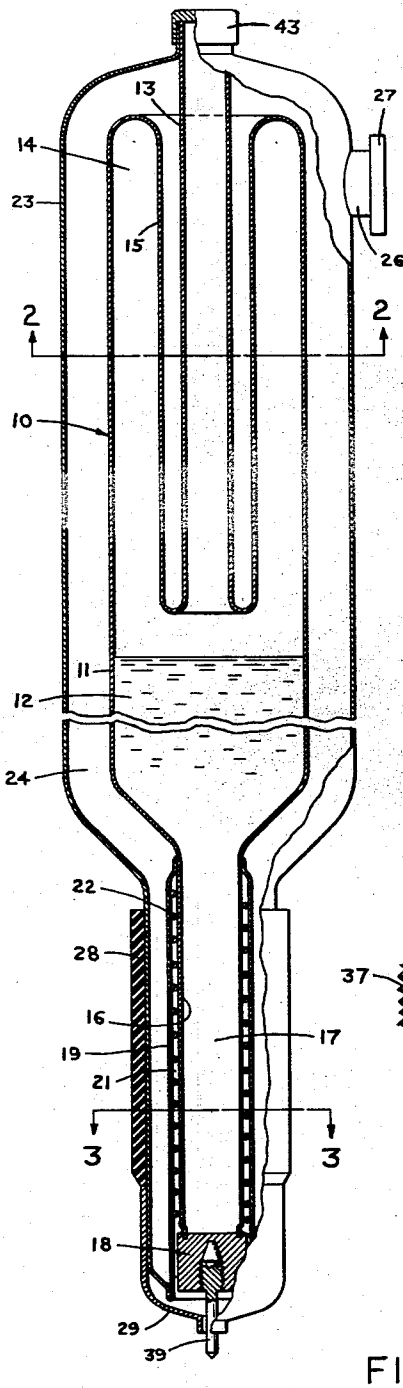


FIG. 1

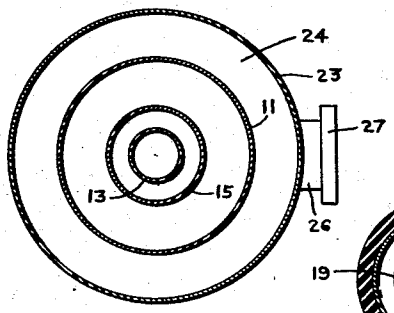


FIG. 2

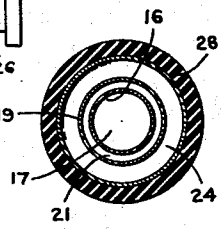


FIG. 3

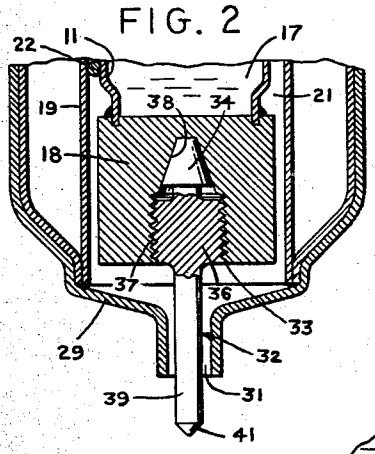


FIG. 4

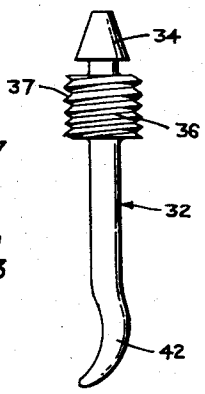


FIG. 5

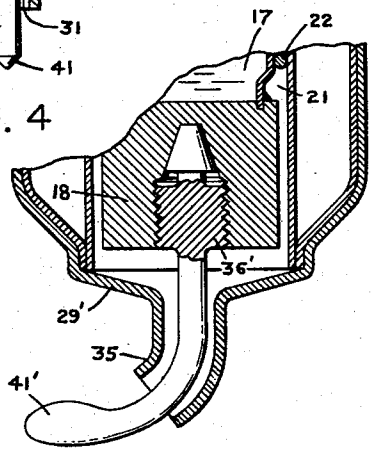


FIG. 6

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CRYOGENIC APPLICATOR WITH PROBE MEANS

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16 Claims. (Cl. 62—293)

This invention relates to a cryogenic apparatus, it relates in particular to a cryogenic device adapted to provide on contact, a low temperature at specific areas.

Many operations and treatments in the field of scientific research and surgery have advanced in technique to accomplish results heretofore impossible to obtain. A considerable number of such advances have been enhanced to a great extent by the use of various devices adapted to chill discrete parts of the body, particularly at locations where surgical incisions are to be made or where direct contact temperature reduction is desired.

While certain applications of the chilling technique require flooding or inundating an area in a cooling atmosphere such as an inert gas or the like, other more sophisticated operations necessitate treatment of only a limited area of the body so that excessive cooling would be a detriment.

For example, in the practice of surgery about the eyes such as in the removal of cataracts, the flooding technique is undesirable. Devices generally in use today embody the flooding principal by the use of carbon dioxide or liquids such as acetone. When these devices are employed it is not only difficult to control the area being treated but also to control the flow of the cooling medium to establish and maintain a desired chilled condition in the tissues of the area affected.

It is therefore an object of the invention to provide a device particularly adapted for withdrawing heat from a localized area of a body or an object to be treated.

It is a further object to provide a manually operable apparatus for use in surgical and similar operations which require rapid chilling of only discrete localized areas.

A still further object is to provide a manually operable device of the type described adapted to efficiently withdraw heat from a small portion of a body to be treated without affecting areas immediately adjacent to the treated portion.

Another object is to provide a portable surgical device of the type described for withdrawing heat from a localized area while maintaining adjacent areas free of low temperature fluids or gases.

Still another object is to provide a cryogenic apparatus employing a vaporizable liquid having means for avoiding excessive frosting of critical portions of the apparatus during normal usage.

These and other objectives of the invention not particularly mentioned are achieved by providing a manually operated lightweight cryogenic applicator for use in surgical and similar operations, said device holding a supply of low temperature vaporizable liquid as the chilling medium. A thermally conductive probe element depends from the device and includes a contact end adapted to engage a localized area of the surface to be treated. An enlarged portion of the probe is disposed in heat exchange relation with the supply of chilling medium to establish a sharp temperature gradient between the probe contact and the enlarged area to induce a rapid transfer of heat from surfaces contiguous with the contact end for a sustained period of time. Means associated with the applicator forms an envelope confining a layer of atmospheric air about cold surfaces to minimize the formation of frost along chilled surfaces.

In the drawings;

FIGURE 1 is an elevation view in cross-section of a preferred embodiment of the invention.

FIGURE 2 is a view in cross-section taken along line 2—2 of FIGURE 1.

FIGURE 3 is a view in cross-section taken along line 3—3 of FIGURE 1.

FIGURE 4 is a segmentary view of an enlarged scale of a portion of the embodiment shown in FIGURE 1.

FIGURE 5 is a view on an enlarged scale of an alternate embodiment of the probe element shown in FIGURES 1 and 2.

FIGURE 6 is a segmentary view on an enlarged scale and in cross-section of an alternate embodiment of the apparatus shown in FIGURE 1.

Referring to the figures, one embodiment of the apparatus contemplated is illustrated and includes in general an elongated inner jacketed container holding a pool of a vaporizable liquid. The exposed operating element of the device includes a highly thermally conductive probe having a contact end adapted to engage an area to be chilled for conducting heat to the liquid pool.

As seen in FIGURE 1, the inner container **10** formed of a low thermally conductive metal such as stainless steel, includes an elongated portion **11** preferably of cylindrical configuration defining a main reservoir **12** for holding a supply of low temperature vaporizable medium such as liquid nitrogen or liquid oxygen. The main reservoir **12** of the inner container is provided with an elongated inlet **13** disposed substantially axially of the cylindrical container and extending longitudinally thereof into the upper or inlet end of the reservoir **12**. Inlet **13** is associated with a convoluted section **15** of the inner container **13** to form therewith an annular storage area **14**. The function of the latter is to prevent liquid from escaping from main reservoir **12** when the apparatus is tilted or turned during normal usage. Thus, while the device is normally supported in an upright or vertical position as shown so that the cooling medium gravitates to the container sump, when the device reclines on its side the cooling medium flows into the upper annular storage area **14** without entering inlet passage **13**.

The lower or neck end **16** forming a continuation of inner container **11** is substantially smaller than the cylindrical upper portion and defines a sump **17** communicating with the main reservoir **12** in which a pool of the cooling medium will collect. A cold block **18** to be hereinafter dsecribed more completely is affixed to the neck end **16** of the inner container at the bottom of the sump **17** and forms a wall which is normally in direct contact with cooling medium held in the sump.

A cylindrical baffle member **19** disposed about the neck **16** of inner container **10** but spaced slightly therefrom defines an annular channel **21**. The upper end of the baffle **19** sealably engages the inner container wall adjacent the upper end of the neck **16** while the lower end of the baffle extends slightly forward of the cold block **18**.

The annular channel **21** is open at the lower side to the atmoshpere. Channel **21** includes a separating or spacing means **22** providing an interwall separation of from about .020 to .060 inches. The separating element may be made of fiberglass thread or a similar material having the approximate thickness of the channel **21** which is wrapped and held in place about the container neck portion **16**.

The primary function of baffle **19** is to minimize or avoid accumulation of frost on chilled members. Such frost accumulation results when atmospheric air containing an amount of moisture enters the apparatus particularly at the probe end thus contacting block **18** and other members. Since a frost layer tends to decrease thermal conductivity of the block and probe elements, the forma-

tion of an envelope to maintain a static air mass about affected surfaces at least minimizes frosting.

A vacuum jacket **23** having a configuration approximating that that the container is spaced outwardly of the inner container **11** wall to define an evacuated insulating space **24**. Inner container **11** is supportably maintained within the evacuated space **24** at the upper end by elongated inlet **13** which is welded or soldered to an opening at the jacket **23** upper end to form an annular vacuum tight seal. Similarly, the lower end of jacket **23** is fastened at an annular vacuum tight seal to the peripheral edge of baffle **19** disposed forward of cold block **18**.

To supplement the insulating function of space **24**, a thin layer of gold or other radiant reflective metal is applied to the jacket inside wall. Further, space **24** may be provided if desired, with a suitable granulated or wrapped insulation embodying both thermal and radiant reflective characteristics.

Following standard procedure for evacuating sealed double wall containers, an opening **26** is provided in jacket **23** communicating with inner space **24** and adapted to attach to a vacuum pump or other evacuating means. Opening **26** may be provided with a threaded portion and an attaching cap **27** or may alternatively be permanently sealed after the vacuum has been established.

The lower end of jacket **23** adjacent the container neck **16** is provided with a hand grip or collar **28** made of plastic material. As suggested by the name, the collar affords means for manipulating and guiding the applicator into place during an operation. While plastic material is suggested for collar **28**, cork or rubber or other cellular structured materials having low thermal conductivity properties may be used to prevent heat flow from the operator's hand gripping the applicator and conversely, to prevent undue chilling of the operator's hand.

The lower end of jacket **23** is provided with a thin walled cup-like plastic member **29** forming an air cover. This member is preferably made of a fluorocarbon resin type material and is slidably retained on the jacket outer wall although it may be threadedly held in place or positioned by other similar means.

Air cover **29** includes a constricted opening **31** extending axially through the lower wall thereof and shaped to closely fit about the protruding portion of probe **32**. This joint between air cover **29** and the probe, is not airtight. However, the construction of the annular channel **21** and the clearance between the wall of the air cover **29** and the adjacent surface of the probe **32** represented by the opening **32** is such that only limited communication and change of air will occur with the surrounding atmosphere. Cover **29** is readily disengaged from the lower end of the jacket to permit release of the probe from the cold block **18** when the probe is to be adjusted or changed.

Referring to enlarged FIGURE 4, cold block **18** comprises a plug-like relatively massive member formed of a highly conductive metal such as copper or silver. One face of said member is adapted to sealably engage the lower opening in sump **17**, the block may be removable but preferably soldered in place so as to form a liquid and airtight seal.

The lower face of the cold block **18** includes a bore **33** adapted to threadedly receive a probe element **32**. The bore **33** includes a portion threadedly formed to closely fit about mating threads on the probe element. An inner portion of the bore **33** is formed in a frusto-conical seat **34** accurately machined to provide a close fit with the similarly formed end of the probe element. When cold block **18** and probe **32** are threadedly engaged, the latter is inserted into the bore **33** and rotated to firmly seat against the frusto-conical seat portion of the latter. Thus, there will be a maximum area of heat transfer surface between the cold block and the probe element regardless of the limited heat transfer surface at the threaded portion.

Referring to FIGURE 4, the probe element in general includes a body **36** having the previously mentioned threaded portion **37** with a frusto-conical or tapered seat **38** disposed adjacent to the threaded section for mating with the corresponding seat **34** in the cold block. An elongated shank **39** protrudes axially from the body and terminates in a tapered or pointed contact end **41**.

The probe element **32** is fabricated preferably of a highly thermally conductive material such as silver or copper. The shank portion **39** is relatively narrow in diameter as contrasted with the diameter of the cold block **18** to assure that when the tip **41** is brought into contact with a warm or heated surface, there will be a positive flow of heat along the tip, into the cold block **18** and thence to chilling medium held in sump **17** where it is absorbed.

While the tip end **41** of probe element **32** is presently shown as being a pointed section, it is understood that for a particular condition or application, the actual disposition or configuration of the tip may be adapted to conform to a given surface or to be received in a particular area. For example, when the probe element is to be brought into contact with a portion of the eye, the contact end **41** is preferably provided with an oval shape having a concave surface adapted to mate with the corresponding surface on a lens capsule.

It may be readily seen that when the contact end or tip **41** is applied to a surface there will be a rapid withdrawal of heat from the surface through the shank **39** of the probe element due to the sharp temperature gradient normally maintained between the back end of the cold block **18** and the element contact end **41**.

While not presently illustrated, the probe element may be provided with means to aid in assembling the same with the cold block **18**. It should be noted however that because of the use to which the instant device is applied, the probe element may be subject to frequent removal and replacement for sterilizing purposes and for application to varied surfaces.

Under normal operating conditions, main reservoir **12** of the apparatus is provided with a supply of vaporizable liquid gas such as liquid nitrogen or liquid oxygen introduced through inlet **13** at the container upper end. This opening is optionally provided with a suitable cover **43** including vent means for relieving pressure developed within the container reservoir due to the constant vaporization of the chilling liquefied gas.

Since the applicator is normally maintained in a vertical attitude, the chilling medium will gravitate to the sump **17** and be supported on the upper surface of the cold block **18**. Because the capacity of the reservoir and sump are substantially limited, it will be necessary to frequently replace the supply of continuously vaporizing liquid gas whether or not the applicator is being put to use or is standing idle.

Since the air cover or cap **29** carried on the lower end of jacket **23** and contacting the probe shank **39** does not form an airtight closure, there will be as mentioned, a limited exchange of atmospheric air along the shank **39** and into annular channel **21**. The enveloping effect achieved by the baffle **19** and the outer wall of the container neck **16** assured that the amount of frost formed on the chilled forward parts such as the cold block and inner part of shank **39**, will be minimized. Further, air trapped within the enclosure defined by the annular chamber and the cap **29** will be maintained in a relatively static condition so that there will be little or no actual circulation from the inside of the cap to the atmosphere and vice versa.

From the foregoing it is readily seen that the use of the present invention provides a valuable flexible tool which may be readily applied to a large variety of scientific experimental and surgical operations and particularly with reference to the latter, the removal of cataracts from the eye and similar operations where only localized cooling is required. By simply replacing the probe with an element that is peculiarly suited to a particular job, the area from which heat is to be withdrawn may be varied within cer-

tain limitations governed by the practical size of the probe contact end.

It should be understood that while the foregoing description provides a preferred embodiment of the apparatus certain modifications and changes may be made in the structural arrangement and relationships of the parts without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. An applicator for withdrawing heat from a localized area on a surface comprising:
(a) a thermally insulated reservoir having an inlet means for charging a supply of vaporizable fluid therein, and means on said reservoir to vent vapors therefrom,
(b) an insulated neck section connected at one end with the reservoir,
(c) said neck section including walls forming a chamber in fluid communication with the reservoir to receive a portion of the vaporizable fluid present in said reservoir,
(d) a thermally conductive support means connected to and forming at least a portion of said walls in said neck section to permit heat exchange relation with the vaporizable fluid in the chamber,
(e) probe means for engaging the local area of the surface from which heat is to be removed,
(f) and said probe means secured to said support means to maintain a temperature gradient and to cause heat to flow from the local area of the surface being cooled to the vaporizable fluid.

2. In an applicator as claimed in claim 1 wherein the probe means is removably connected to the support means and forms a highly conductive thermal joint therewith.

3. In an applicator as claimed in claim 1 wherein
(a) the thermally conductive support means on said neck section has a bore in one side thereof,
(b) means in said bore defining a seating surface,
(c) and said probe means having one end formed to mate with said seating surface when the probe means and the support means are in assembled position.

4. In an applicator as claimed in claim 1 wherein
(a) the thermally conductive support means on said neck section has a bore on one side thereof,
(b) said bore having a frusto-conical seat formed therein and means to connect the probe means,
(c) said probe means adapted to engage the connecting means in said bore and having one end adapted to mate with the frusto-conical seat to form a highly conductive thermal joint.

5. An applicator for withdrawing heat from a localized area on a surface comprising:
(a) a thermally insulated reservoir having an inlet means for charging a supply of vaporizable fluid therein, and means on said reservoir to vent vapors therefrom,
(b) an insulated neck section connected at one end with the reservoir,
(c) said neck section including walls forming a chamber in fluid communication with the reservoir to receive a portion of the vaporizable fluid present in said reservoir,
(d) a thermally conductive support means connected to and forming at least a portion of said walls in said neck section to permit heat exchange relation with the vaporizable fluid in the chamber,
(e) probe means for engaging the local area of the surface from which heat is to be removed,
(f) said support means having a substantially larger cross-sectional area than the cross-sectional area of the probe means,
(g) and said probe means secured to said support means to maintain a temperature gradient and to cause heat to flow from the local area of the surface being cooled to the vaporizable fluid.

6. An applicator for withdrawing heat from a localized area on a surface comprising:
(a) a thermally insulated reservoir having an inlet means for changing a supply of vaporizable fluid therein, and means on said reservoir to vent vapors therefrom,
(b) an insulated neck section connected at one end with the reservoir,
(c) said neck section including walls forming a chamber in fluid communication with the reservoir to receive a portion of the vaporizable fluid present in said reservoir,
(d) a thermally conductive support means connected to and forming at least a portion of said walls in said neck section to permit heat exchange relation with the vaporizable fluid in the chamber,
(e) probe means for engaging the local area of the surface from which heat is to be removed,
(f) said probe means secured to said support means to maintain a temperature gradient and to cause heat to flow from the local area of the surface being cooled to the vaporizable fluid,
(g) and means disposed in the neck section about the walls thereof and the thermally conductive support means to define an air envelope for minimizing formation of frost on the portion of the neck section exposed to the atmosphere.

7. In an applicator as claimed in claim 6 wherein said means for minimizing formation of frost comprises, a cylindrical baffle having a length approximately that of said neck section, said cylindrical baffle connected at one end to the reservoir and disposed to extend about and in spaced relation to the walls of the neck section to form said air envelope in the space therebetween.

8. In an applicator as claimed in claim 6 wherein said means for minimizing formation of frost comprises:
(a) a cylindrical sleevelike member disposed about and in spaced relation to said neck section,
(b) said sleevelike member connected to the thermally insulated reservoir about the end of said neck section connected with the reservoir and disposed to extend about the end of the neck section remote from the connected end to a point beyond the thermally conductive support means,
(c) and means holding said sleevelike member in predetermined spaced relation to said elongated section and to limit the flow of air from the atmosphere about said elongated section.

9. An applicator for withdrawing heat from a localized area on a surface comprising:
(a) a thermally insulated reservoir,
(b) an elongated tubelike inlet means connected substantially coaxially in said reservoir for charging a supply of vaporizable fluid into said reservoir, and means to vent vapors from said reservoir,
(c) said inlet means to form an annular storage chamber in the reservoir for vaporizable fluid when the applicator is not in vertical position,
(d) an insulated neck section connected at one end with the reservoir,
(e) said neck section including walls forming a chamber in fluid communication with the reservoir to receive a portion of the vaporizable fluid present in said reservoir,
(f) a thermally conductive support means connected to and forming at least a portion of said walls in said neck section to permit heat exchange relation with the vaporizable fluid in the chamber,
(g) probe means for engaging the local area of the surface from which heat is to be removed,
(h) and said probe means secured to said support means to maintain a temperature gradient and to

cause heat to flow from the local area of the surface being cooled to the vaporizable fluid.

10. In an applicator as claimed in claim **9** wherein the probe means is removably connected to the support means and forms a highly conductive thermal joint therewith.

11. An applicator for withdrawing heat from a localized area on a surface comprising:

(a) a thermally insulated reservoir,

(b) an elongated tubelike inlet means connected substantially coaxially in said reservoir for charging a supply of vaporizable fluid into said reservoir, and means to vent vapors from said reservoir,

(c) said inlet means to form an annular storage chamber in the reservoir for vaporizable fluid when the applicator is not in vertical position,

(d) an insulated neck section connected at one end with the reservoir,

(e) said neck section including walls forming a chamber in fluid communication with the reservoir to receiver a portion of the vaporizable fluid present in said reservoir,

(f) a thermally conductive support means connected to and forming at least a portion of said walls in said neck section to permit heat exchange relation with the vaporizable fluid in the chamber,

(g) probe means for engaging the local area of the surface from which heat is to be removed,

(h) and said probe means secured to said support means to maintain a temperature gradient and to cause heat to flow from the local area of the surface being cooled to the vaporizable fluid,

(i) and means disposed about the neck section and the thermally conductive support means to define an air envelope for minimizing formation of frost on the portions of said applicator exposed to the atmosphere.

12. In an applicator as claimed in claim **11** wherein said means for minimizing formation of frost comprises:

(a) a cylindrical baffle having a length approximately equal to that of said elongated section,

(b) said cylindrical baffle connected at one end of said reservoir and disposed to extend about and in spaced relation to said elongated section to form said air envelope in the space therebetween.

13. An applicator for withdrawing heat from a localized area on a surface comprising:

(a) a thermally insulated reservoir,

(b) an elongated tubelike inlet means connected substantially coaxially in said reservoir for charging a supply of vaporizable fluid into said reservoir and to vent vapors from said reservoir,

(c) said inlet means to form an annular storage chamber in the reservoir for vaporizable fluid charged therein when the applicator is not in vertical position,

(d) an insulated neck section connected at one end with the reservoir,

(e) said neck section including walls forming a chamber in fluid communication with the reservoir to receive a portion of the vaporizable fluid present in said reservoir,

(f) a thermally conductive support means connected to and forming at least a portion of said walls in said neck section to permit heat exchange relation with the vaporizable fluid in the chamber,

(g) probe means for engaging the local area of the surface from which heat is to be removed,

(h) said support means having a substantially larger cross-sectional area than the cross-sectional area of the probe means,

(i) said probe means removably connected to and operatively associated with each support means to form a highly conductive thermal joint and to maintain a temperature gradient to cause heat to flow from the local area of the surface being cooled to the vaporizable fluid,

(j) and means disposed about the neck section and the thermally conductive support means to define an air envelope for minimizing formation of frost on the portions of said applicator exposed to the atmosphere.

14. In an applicator as claimed in claim **13** wherein

(a) the thermally conductive support means on said neck section has a bore in one side thereof,

(b) means in said bore defining a seating surface,

(c) and said probe means having one end formed to mate with said seating surface when the probe means and the support means are in assembled position.

15. In an applicator as claimed in claim **13** wherein said means for minimizing formation of frost comprises:

(a) a cylindrical sleevelike member disposed about and in spaced relation to said neck section,

(b) said sleevelike member connected to the thermally insulated reservoir about the end of said neck section connected wtih the reservoir and disposed to extend about the end of the neck section remote from the connected end to a point beyond the thermally conductive support means.

(c) and means holding said sleevelike member in predetermined spaced relation to said elongated section and to limit the flow of air from the atmosphere about said elongated section.

16. In an applicator as claimed in claim **13** including:

(a) a hand grip of low thermal conductivity formed about the exterior surface of the neck section,

(b) and an air cover about the probe end of said neck section and adapted to receive said probe therethrough, and to delimit flow of atmospheric air into the space formed about said neck section by the cylindrical baffle.

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