United States Patent [19]

Stumpf et al.

[11] **3,807,403**

[45] **Apr. 30, 1974**

[54] **CRYOSURGICAL APPARATUS**

[75] Inventors: **Joseph C. Stumpf,** Fairfield; **Joseph F. Andera,** Trumbull, both of Conn.

[73] Assignee: **Frigitronics of Conn. Inc.,** Skelton, Conn.

[22] Filed: **June 14, 1972**

[21] Appl. No.: **262,543**

[52] **U.S. Cl.** **128/303.1,** 62/293, 62/514

[51] **Int. Cl.** **A61b 17/36,** A61f 7/12

[58] **Field of Search** 62/293, 514; 128/303.1, 128/400, 401

[56] **References Cited**

UNITED STATES PATENTS

3,393,679	7/1968	Crump et al.	128/303.1
3,502,081	3/1970	Amoils	128/303.1
3,575,176	4/1971	Crump et al.	128/303.1
3,696,813	10/1972	Wallach	128/303.1

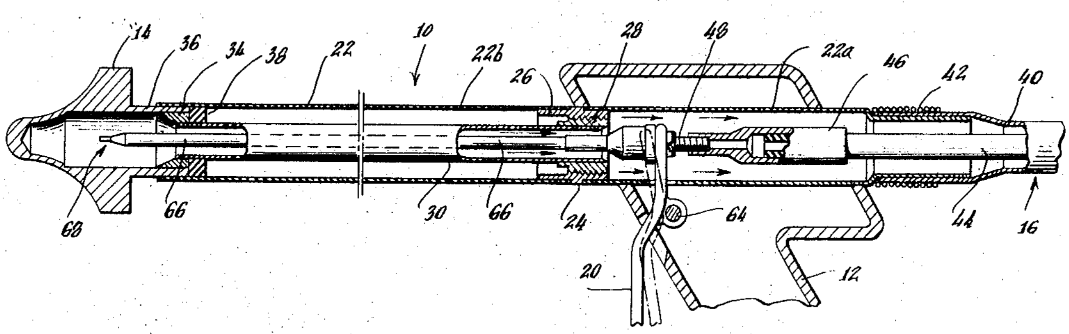
Primary Examiner—Channing L. Pace
Attorney, Agent, or Firm—Buckles and Bramblett

[57] **ABSTRACT**

There is disclosed a cryosurgical apparatus of the type which operates from a source of compressed gas. It includes an improved nozzle which is substantially less critical tnan prior art nozzles and permits simplified and less expensive construction. A defrost valve in the exhaust conduit permits easy and quiet operation by the surgeon. An insulator tube is resiliently secured to the probe to allow thermal expansion and contraction without stress.

The foregoing abstract is not to be taken either as a complete exposition or as a limitation of the present invention. In order to understand the full nature and extent of the technical disclosure of this application, reference must be had to the following detailed description and the accompanying drawings as well as to the claims.

6 Claims, 13 Drawing Figures



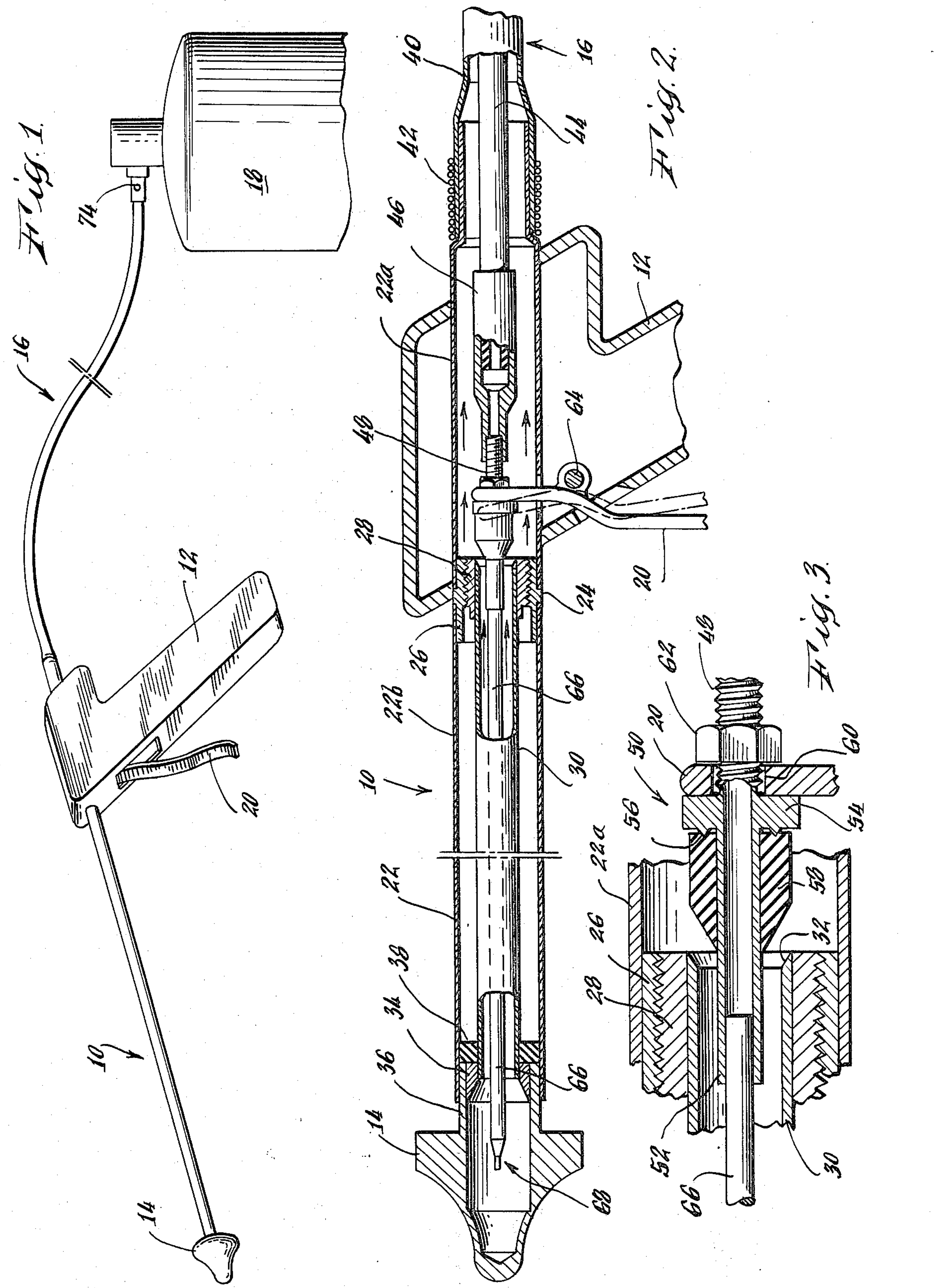


Fig. 1
Fig. 2
Fig. 3

Fig. 12.

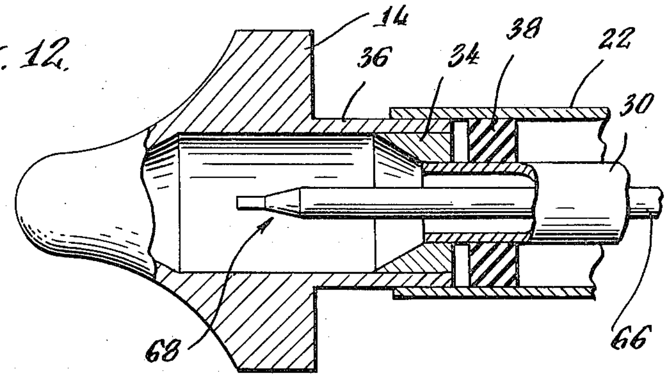


Fig. 13.

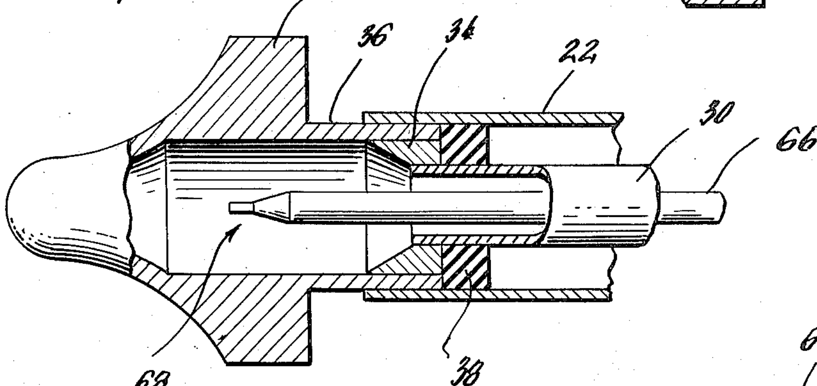
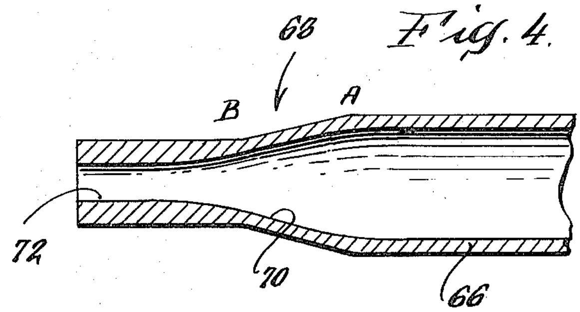


Fig. 4.



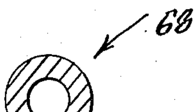
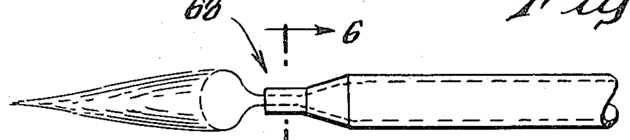


Fig. 6.

Fig. 5.



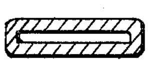
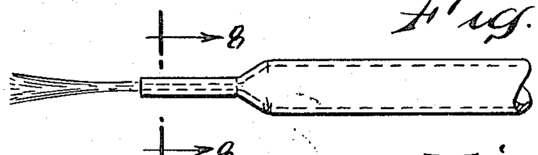


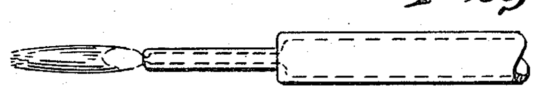
Fig. 8.

Fig. 7.



PRIOR ART

Fig. 9



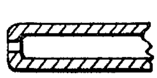
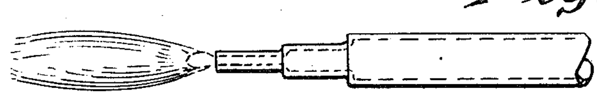


Fig. 10.

Fig. 11



CRYOSURGICAL APPARATUS

BACKGROUND OF THE INVENTION

This invention pertains to cryosurgical instruments of the type which are cooled under the influence of high pressure gas escaping from an orifice. Instruments of this type are well known in the art and are widely employed for a number of surgical procedures such as the necrosis of diseased tissue. Several gases exhibit the Joule Thomson effect and may be used in the operation of the instrument. The most common, however, are nitrous oxide and carbon dioxide.

In instruments of this type, the gas expansion orifice is of an extremely small size and in all prior art instruments the spacing between the orifice and the inner wall of the cooling tip is extremely critical. For example, with prior art instruments, the orifice is positioned approximately 0.050 inch from the inner wall of the tip and the permitted tolerance is only 0.010 inch. This results in such instruments being difficult and costly to manufacture. For example, the parts of such instruments are commonly threaded so that they may be factory adjusted prior to shipment.

Another problem connected with prior art instruments of this type is found in the exhaust valve of intruments which have controlled defrost. For example, one such instrument is normally warm, which means that the exhaust valve is normally closed and the device is filled with compressed gas at bottle pressure. As the bottle gas prssure may be commonly as high as 800 psi, it will be quite apparent that this creates an explosion hazard. The exhaust valve used in this prior art device comprises a cylindrical piston which seats against a small exhaust orifice and is retained in the seated position by means of a heavy spring. The piston is raised against the force of a spring by means of a finger operated toggle. When the surgeon wishes to cool the probe tip, he must apply substantial force to depress the toggle which is, itself, detrimental, particularly in the case of very delicate surgical procedures. Secondly, as soon as the piston begins to leave the orifice, the full bottle pressure, which was formerly applied only to a small area of the piston, is now applied to the full area of the piston end, slamming the piston open with an explosive-like report.

Still another problem with prior art devices arises from the fact that they are subject to considerable thermal stress. For example, it is usually desirable to provide an insulated housing to prevent adherence to healthy tissue. This housing should preferably remain at room temperature. However, the tip and exhaust conduit may be cooled to temperatures as low as −89°C. The resultant contraction may result in substantial stresses at the junctures of the cold and warm parts.

Accordingly, it is a primary object of the present invention to provide an improved cryosurgical instrument of the gas operated type having much less critical tolerances, permitting it to be assembled in a much less expensive manner such as by electron beam welding. Other objects are to provide such an instrument which is only intermittently exposed to full bottle gas pressure, which has a substantially silent and easily operated exhaust valve, and which has substantially no thermal stresses between the cooled parts and the insulator housing. The manner in which these objects are achieved will be apparent from the following description and appended claims.

SUMMARY OF THE INVENTION

The invention comprises a gas operated cryosurgical instrument including a tubular exhaust conduit terminating at one end in a hollow probe tip of high thermal conductivity. A high pressure gas delivery conduit extends through the exhaust conduit and terminates at a nozzle within the probe tip. The nozzle has a cylindrical gas discharge passage of smaller diameter than the delivery conduit and a smoothly curved reduction passage therebetween. A normally open valve is connected in fluid flow relationship with the exhaust conduit. An insulator tube surrounds but is spaced from the exhaust conduit and is connected thereto by a resilient connection.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a cryosurgical instrument in accordance with the present invention shown connected to a source of bottled gas;

FIG. **2** is an enlarged cross section taken through the instrument of FIG. **1**;

FIG. **3** is an enlarged cross section of the exhaust valve of FIG. **2**;

FIG. **4** is a greatly enlarged cross section of the nozzle portion of the apparatus;

FIG. **5** is an illustration of the gas jet obtained with the nozzle of FIG. **4**;

FIG. **6** is a cross section taken substantially along the line **6—6** of FIG. **5**;

FIG. **7** is an illustration of one type nozzle used in the prior art;

FIG. **8** is a cross section taken substantially along the line **8—8** of FIG. **7**;

FIG. **9** is an illustration of another type of nozzle used in the prior art;

FIG. **10** is an enlarged cross section showing the orifice of the FIG. **9** nozzle;

FIG. **11** shows still another type of nozzle used in the prior art;

FIG. **12** illustrates the resilient connection between the warm insulator tube and the cold portions of the probe; and

FIG. **13** is an illustration similar to FIG. **12** showing the manner in which the resilient connection operates.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With particular reference to FIG. **1**, there is disclosed an instrument of the type utilized in treating cervicitis. It comprises an elongated probe **10** mounted in a handle **12** and terminating in a substantially conical applicator tip **14**. The other end of the probe extends from the handle and is connected to a line **16** which, in turn, is connected to a suitable source **18** of pressurized gas. A trigger **20** extends from the handle for selective defrosting as will be explained.

Turning now to FIG. **2**, the handle **12** will be seen to support the rear portion **22*a*** of a stainless steel insulator tube **22**. The rear portion **22*a*** and a forward portion **22*b*** are each welded to the circumferential flange **24** of an internally threaded sleeve **26**. Threaded into sleeve **26** is a bushing **28** which is welded to the end of an exhaust tube **30**. The end of exhaust tube **30** has a bevelled valve seat **32** as shown in FIG. **3.** The other end of exhaust tube **30** is welded to a bushing **34** which, in turn, is welded to the cylindrical stem **36** of the hollow copper tip **14.** The forward end of the insulator tube **22** extends over the surface of stem **36** but is not secured thereto. Instead, a resilient bushing **38** frictionally engages both the exhaust tube **30** and the insulator tube **32.**

The line **16** is a coaxial conduit comprising a silicon coated fiberglass exhaust line **40** secured by a spring **42** to the end of insulator tube **22.** Carried within the exhaust line is a high pressure delivery line **44** secured by means of a high pressure connector **46** to the threaded end **48** of a steel valve member **50** which is illustrated in more detail in FIG. **3.**

The valve member **50,** in addition to the threaded end **48,** has an unthreaded forward portion **52** and a central circumferential flange **54.** The forward surface of flange **54** carries a circular knife edge **56.** A Teflon valve member **58** is press fitted over the forward portion **52** and has a flat rear surface which engages the knife edge **56.** The forward surface of valve seat **58** is tapered to engage the valve seat **32** on exhaust tube **30.** The upper end of trigger **20** defines a drilled opening **60** through which the threaded end **48** of valve member **50** extends. It is held in place by a nut **62.** The trigger **20** is mounted on a pivot **64** positioned approximately one inch below its upper end. The length of trigger **20** below the pivot **64** is approximately 4 inches in the described embodiment. Welded to the unthreaded forward portion **52** of valve member **50** is the end of a delivery tube **66** which in one embodiment is a **15** gauge stainless steel hypodermic tube having an internal diameter of 0.059 inch. The forward end of delivery tube **66** has a reduced diameter portion forming a nozzle **68** positioned within the hollow probe tip **14.**

The construction of nozzle **68** will be best understood by reference to FIG. **4.** As will be seen therein, the internal diameter of the delivery tube **66** is reduced via a smooth wall reduction passage **70** to a cylindrical gas discharge passage **72.** This configuration is achieved by inserting into the end of the hypodermic tube a hardened wire having an external diameter equal to the desired diameter of the gas discharge passage. The end of the tube is then swaged onto the wire and the wire is removed. In one actual embodiment, the tube **66** has an internal diameter of 0.059 inch and the internal diameter of the gas discharge passage **72** is 0.01065 inch. The distance from the nozzle to the beginning of reduction ("A" FIG. **4**) is 0.20 inch and the distance between the nozzle tip and the end of reduction ("B") is 0.12 inch.

The performance of the nozzle **68** is strikingly superior to those of the prior art. The reason for this is not fully understood but is believed to be due to the smooth continuous inner surface formed by the reduction passage **70** and the gas discharge passage **72.** This is believed to prevent gas turbulence and permit laminar flow out of nozzle **68.**

FIG. **5** illustrates the gas flow from the nozzle **68** as actually observed in practice. As will be seen, it presents an elongated "flame like" appearance and shape. FIGS. **7–11** illustrate three prior art nozzle constructions and the jets obtained thereby. FIGS. **7** and **8** illustrate a pinched tube configuration. FIGS. **9** and **10** illustrate a rolled end construction and FIG. **11** illustrates a type of orifice known as a "double reduction" orifice which comprises a series of tubes of reduced diameter. The jets from these prior art nozzles appear as indicated. In these prior art nozzles the distance from the orifice to the wall of the applicator tip is very critical and the spacing must be quite close. As an example, this distance may be 0.050 inch with a tolerance of + or −0.010 inch. In contrast, when utilizing the nozzle of this invention, the distance from the nozzle tip to the wall may be 0.250 inch with a tolerance of + or −0.060 inch. Accordingly, by means of this invention, manufacture and assembly are greatly simplified, resulting in a highly effective instrument at a much lower cost.

The resilient tip construction is illustrated in detail in FIGS. **12** and **13.** As seen in FIG. **12,** the insulator tube **22** is spaced from exhaust tube **30,** providing an insulating air space therebetween. The end of the insulator tube **22** slidingly encircles the stem **36** of tip **14.** A resilient bushing **38** engages both the insulator tube and the exhaust tube. As the probe tip is cooled, the tip **14** and the exhaust line **30** will both cool and contract. This is shown in an exaggerated manner in FIG. **13** wherein it will be seen that the normal resilience of bushing **38** compensates for expansion and contraction and prevents stresses from building up in the instrument.

The nozzle and the resilient tip construction may be utilized in connection with either a non-defrostable or a defrostable cryosurgical probe. The probe illustrated herein is of the defrostable type. Defrosting is obtained by means of the valve illustrated in detail in FIG. **3.** When the valve is in its normally open position, high pressure gas entering through delivery line **44** passes through the hollow passage in the valve member **50** an through delivery tube **66** to nozzle **68.** From the nozzle it expands into tip **14,** causing the tip to be cooled by the Joule Thomson effect. The expanded gas then passes rearwardly through exhaust tube **30** and out the exhaust line **40.** It may then be exhausted to atmosphere through any suitable opening such as the vent **74** shown in FIG. **1.** The high pressure exhaust gas tends to maintain the exhaust valve in its normally open position without the need for springs or similar devices. In order to defrost the instrument, the trigger **20** is depressed by the surgeon, whereupon it assumes the dashed line position illustrated in FIG. **2** and forces the Teflon valve member **58** against the bevelled valve seat **32** of the exhaust tube **30.** The circular knife edge **56** forms a gas tight seal with the rear of the valve member. With the exhaust valve closed, the gas pressure within tip **14** rises to bottle pressure and the heat of compression causes rapid defrosting of the probe tip. In one embodiment, the diameter of the valve member **58** which is exposed to gas pressure is approximately 0.187 inch. With a bottle pressure of 800 psi, this results in 27 pounds force tending to drive the valve member to the rear. The 4:1 lever ratio of the trigger **20** results in only 6.8 pounds of force being required to close the valve and maintain it in the closed position. As the valve is normally open, it will be closed only for the period of time during which the surgeon desires to defrost the probe tip. Therefore, the instrument is exposed to full bottle pressure only intermittently and for short periods of time, greatly increasing the safety of the apparatus.

It is believed that the construction and operation of this invention will now be apparent to those skilled in the art. It will also be apparent that a number of variations and modifications may be made in this invention without departing from its spirit and scope. Accordingly, the foregoing description is to be construed as illustrative only, rather than limiting. This invention is limited only by the scope of the following claims.

We claim:

1. A gas operated cryosurgical instrument which comprises: a tubular exhaust conduit terminating at one end in a hollow probe tip of high thermal conductivity; a remote source of high pressure gas; a gas delivery conduit extending through said exhaust conduit in fluid flow communication with said source and terminating at a nozzle within said probe tip; normally open valve means connected in fluid flow relationship between said exhaust conduit and atmosphere; and means for controllably closing and opening said valve means.

2. The instrument of claim 1 wherein said valve means comprises: a stationary valve seat defined by said exhaust conduit; and a moveable valve member carried by said delivery conduit.

3. The instrument of claim 2 wherein said closing means comprises a manually operable trigger connected to advance both of said delivery conduit and valve member.

4. A gas operated cryosurgical instrument which comprises: a tubular exhaust conduit terminating at one end in a hollow probe tip of high thermal conductivity; a gas delivery conduit extending through said exhaust conduit and terminating at a nozzle within said probe tip, said nozzle including a cylindrical gas discharge passage of smaller diameter than said delivery conduit and a smoothly curved reduction passage therebetween; normally open valve means connected in fluid flow relationship between said exhaust conduit and atmosphere; an insulator tube surrounding, but spaced from, said exhaust conduit; resilient means interconnecting said insulator tube and exhaust conduit; and means for controllably closing and opening said valve means.

5. The instrument of claim 4 wherein said resilient means comprises an annular bushing encircling said exhaust conduit adjacent said probe tip and frictionally engaging both of said exhaust conduit and insulator tube to permit relative motion therebetween.

6. The instrument of claim 5 wherein said probe tip includes a substantially cylindrical stem and said insulator tube encircles one end of said stem in sliding relationship therewith.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,807,403 Dated April 30, 1974

Inventor(s) Joseph G. Stumpf and Joseph F. Andera

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below: In Title Page, Column 1, change inventor's name from "Joseph C. Stumpf" to --Joseph G. Stumpf--; change address of Assignee from "Skelton" to --Shelton--. In Abstract, Line 4, change "tnan" to --than--. Column 3, line 49, after "nozzle" insert --tip--. Column 4, line 31, change "an" to --and--. Column 5, line 20, after "closing" insert --and opening--.

Signed and sealed this 3rd day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents