

- [54] CATHETER DEVICE FOR USE IN
DETECTING GAS IN BODY FLUIDS AND
TISSUE
- [76] Inventor: John W. Brantigan, 914 Medical
Plaza, Salt Lake City, Utah 84112
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128/2.05 R, 348, 214

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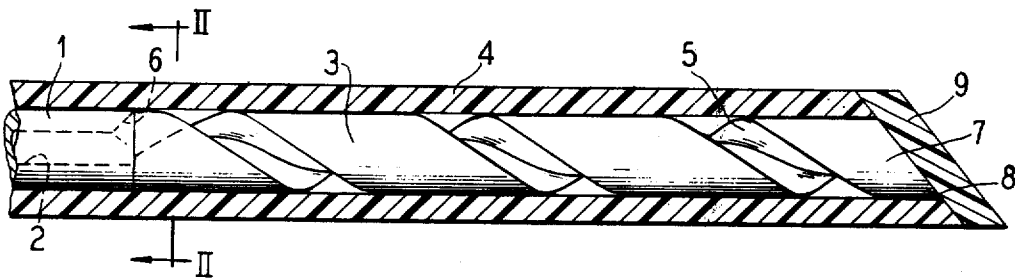
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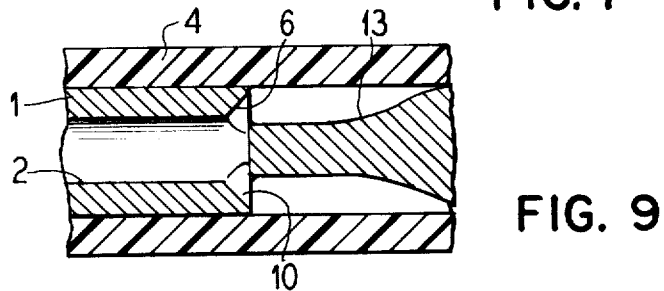
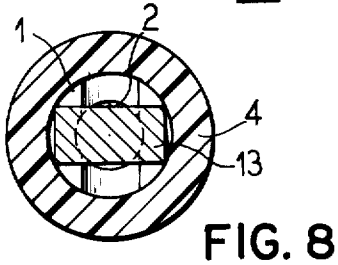
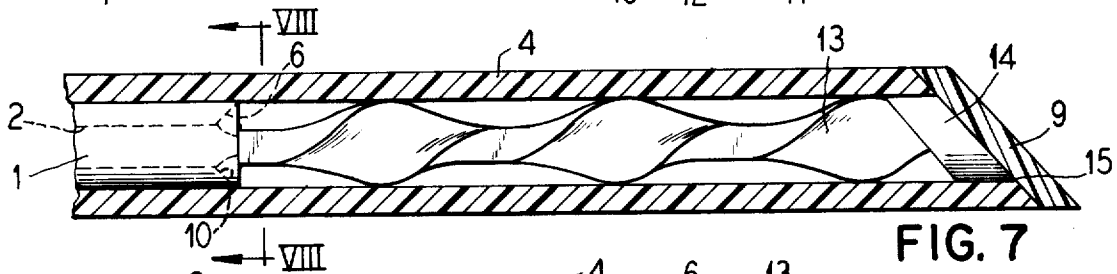
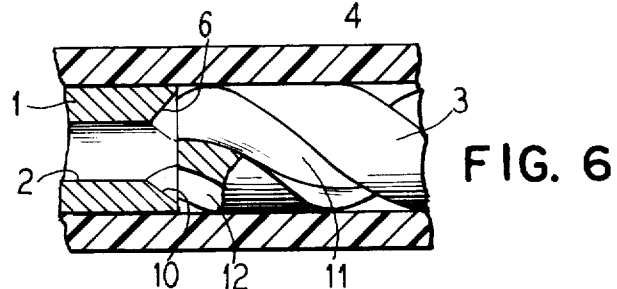
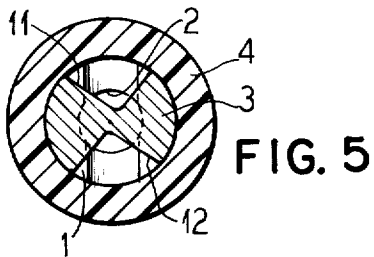
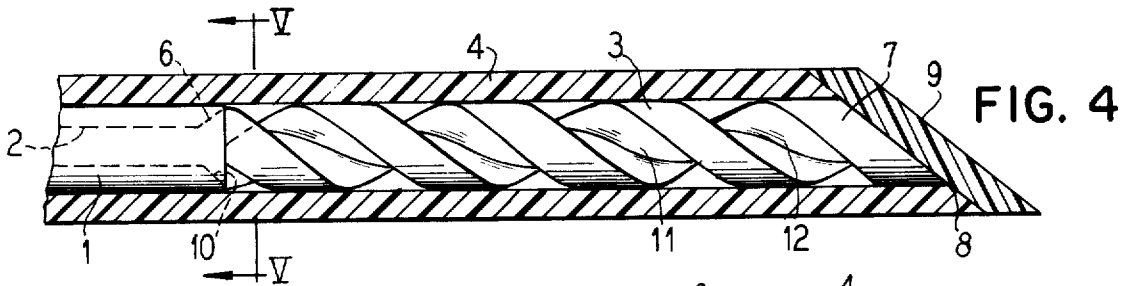
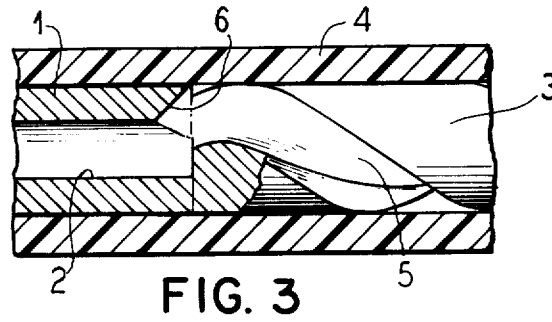
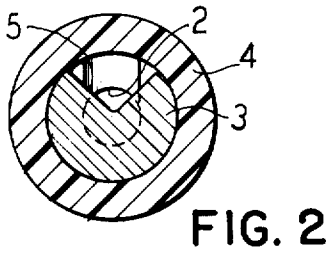
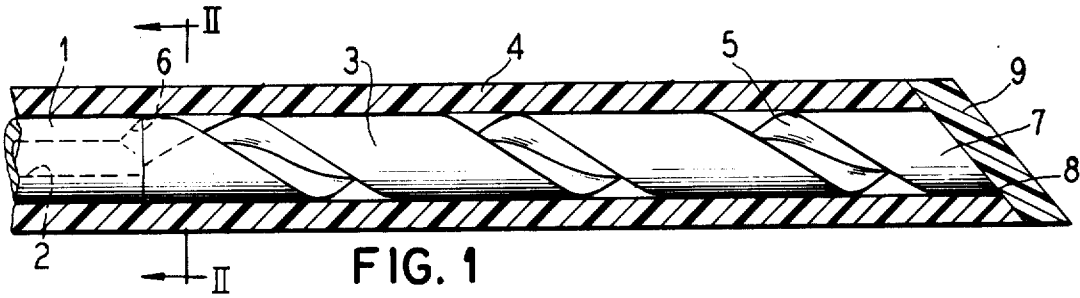
Primary Examiner—Kyle L. Howell
Attorney, Agent, or Firm—Hill, Gross, Simpson, Van
Santen, Steadman, Chiara & Simpson

[57] **ABSTRACT**

A blood or tissue gas diffusion catheter device comprising a catheter having a lumen therethrough and provided with a solid distal end portion enclosed within a membrane permeable to gases that might be found in blood or tissue, said distal end portion being shaped to provide a helical path over the outside thereof communicating with the lumen of the catheter, and said end portion being shaped to permit direct insertion of the distal end portion into the body of a patient without the use of a cannulated needle or an otherwise preformed entry.

10 Claims, 9 Drawing Figures





CATHETER DEVICE FOR USE IN DETECTING GAS IN BODY FLUIDS AND TISSUE

BRIEF SUMMARY OF THE INVENTION

Heretofore, catheter devices were constructed in which the catheter was a complete cannula up to a closed distal end and the distal portion of the catheter was covered by a membrane permeable to gases in body fluids such as blood, or extracellular fluid of tissue. These catheters were used to acquire samples of the gas which passed through the membrane and then through the lumen of the catheter. In most instances, holes were drilled, or otherwise provided through the wall of the catheter leading into the lumen thereof through which the gas passed into the lumen of the catheter. Catheter devices so constructed were severely limited in minimum overall diameter by virtue of the lumen in the catheter, required extreme difficulty in providing small apertures through the wall of the catheter leading into the lumen, and there was consequent weakening of the cannular tubing by virtue of those apertures. Such catheters were also objectionably expensive to manufacture.

Minimum trauma to the blood vessel or tissue in which the distal end portion of the catheter device is inserted is highly desirable. With that in mind, an optimum catheter device is one that provides a sufficient membrane diffusion area with a minimum overall diameter. By way of the instant invention, applicant has reduced that overall diameter to a minimum not heretofore reached. Also, in the instant invention the provision of apertures through the wall of the cannula has been eliminated along with its difficulty and expense, and the distal end portion of the catheter has not been weakened to an objectionable extent. Furthermore, the instant invention is so constructed that it may be directly inserted in a patient's body without the aid of a preferred entry or the use of a cannulated needle.

The instant invention comprises a catheter device including an elongated catheter or cannular having a lumen therethrough with a solid distal end portion integral with the catheter or attached to the end thereof in a known manner. The solid end portion, and preferably the catheter itself, are entirely covered with a membrane of a material permeable to body gases such as oxygen, carbon dioxide, nitrogen, argon, helium, anesthetic agents, inter alia. The solid end portion terminates on the slant so that the lower part thereof is the equivalent of a pointed end which, notwithstanding being covered by the membrane, may be directly inserted into the body of the patient. The solid end portion is also formed to provide a helical path leading to the lumen of the catheter between the outside surface of the end portion and the membrane. Preferably, this is accomplished by providing a single or double helical groove in the solid end portion. In effect, the lumen of the cannula heretofore used, has been transferred to the outside of the solid end portion. This provides a smaller overall diameter of the device than was heretofore obtainable, and also provides ample diffusion area for the gas passing through the membrane when the opposite end of the catheter is connected to the vacuum system of a mass spectrometer or other analyzing device.

There is one other way of providing the instant invention by way of connecting a rectangular piece of mate-

rial to the end of the catheter and then twisting that rectangular piece of material to form the helical path. This method requires the attachment of a sloping end to the twisted rectangular member so that the device may be placed in the body of a patient directly and without the use of a needle or a preformed entry.

Other objects, features and advantages of the invention will be readily apparent from the following description of certain preferred embodiments thereof, taken in conjunction with the accompanying drawing, although variations and modifications may be effected without departing from the spirit and scope of the novel concepts of the disclosure.

BRIEF DESCRIPTION OF THE DRAWING

All figures in the drawing are extremely enlarged for purposes of clarity in illustration.

FIG. 1 is a fragmentary vertical sectional view, with parts shown in elevation, of a catheter device having a solid distal end portion with a helical groove therein;

FIG. 2 is a vertical sectional view taken substantially as indicated by the line II—II of FIG. 1, looking in the direction of the arrows;

FIG. 3 is a fragmentary sectional view of the structure of FIG. 1 showing the same from a different angle;

FIG. 4 is a view similar in character to FIG. 1, but illustrating the solid distal end portion on the catheter device as having a double helical groove in the surface thereof;

FIG. 5 is a vertical sectional view taken substantially as indicated by the line V—V of FIG. 4;

FIG. 6 is a view similar in character to FIG. 3, but showing the connection of the double helical groove with the lumen of the catheter;

FIG. 7 is a view similar in character to FIGS. 1 and 4, but illustrating the solid portion at the distal end of the catheter as being a rectangular piece of material twisted to provide the helical path for gas;

FIG. 8 is a vertical sectional view taken substantially as indicated by the line VIII—VIII of FIG. 7; and

FIG. 9 is a fragmentary sectional view illustrating the connection of the helical path with the lumen in the catheter or cannula.

DETAIL DESCRIPTION OF THE SEVERAL EMBODIMENTS

In the first embodiment of the invention, illustrated in FIGS. 1, 2 and 3, there is shown a catheter device including a catheter in the form of a cannula 1 having a lumen 2 extending therethrough. The cannula 1 carries a solid distal end portion 3 having no lumen. Both the cannula 1 and end portion 3 are preferably made of stainless steel, but a suitable plastic material might also be utilized, if desired. Stainless steel is preferred because of its strength, the diameter of both the cannula 1 and solid end portion 3 are the same and quite small.

Over both the solid end portion 3 and the cannula 1 is a tubular membrane 4 which may well be of polytetrafluoroethylene, silicone rubber, a silicone polymer substance, or equivalent material that is permeable to gases found in the body and which are to be sampled and analyzed. The solid end portion 3 is provided with a helical groove 5 forming a helical path between the outer surface of the groove and the membrane 4 leading to the lumen 2 in the cannula 1, and the cannula 1 is beveled at a point 6 in order to establish good communication between the helical groove and the lumen.

It should also be noted that the groove 5 starts rearwardly of the distal end of the portion 3 which distal end remains fully solid as shown at 7 to entirely fill the end of the membrane 4 and is cut off on the slant to provide a lower sharp point 8. The monofilament 9 of the same material as the membrane 4 may be placed over the end 7 of the portion 3 to prevent contact of the stainless steel or other material forming the portion 3 with the blood or tissue of the patient, and the membrane 4 extends a material distance or fully over the surface of the cannula 1 for the same reason. The monofilament 9 is so thin and sufficiently strong as not to interfere with the direct insertion of the distal end portion of the catheter into the body of the patient without the aid of a cannulated needle or any other preformed entry. The groove 5 as represented in FIG. 2 may be shaped in the form a 60° to approximately 90° angle and of a depth equal to or less than the radius of the solid portion 3. The angle between the sides of the groove is not critical but 60° to 90° appears a satisfactory angle. The entire length of the catheter device including the cannula 1 and end portion 3 is rather arbitrary, and depends upon how far the attending surgeon wishes to insert the device into the blood vessel or tissue of a patient. The end portion 3 may be attached to the distal end of the cannula 1 in a known manner, held in position by the structural integrity of the tubular membrane 4, or in certain instances might possibly be formed integral with the cannula.

In use, the catheter device is entered into the body of a patient to a desired location, and gases contained in the body permeate through the membrane 4 and enter the helical groove 5 which provides ample diffusion area. The gas then travels along the groove 5 into the lumen of the cannula 1 which is connected to a mass spectrometer or other analyzing device. Usually the analyzing device has a source of suction to assist the flow of gas to the device.

As stated above, an optimum catheter device is one that provides a sufficient membrane diffusion area for gases with a minimum overall diameter. With a small diameter catheter device that may be placed in the body of a patient without the use of something else to establish an entry point some structural strength is required. By providing a cannula with a solid distal end portion and giving that end portion a configuration so as to establish a path of travel for the gas between the outer surface of the end portion and the diffusion membrane surrounding it results in sufficient structural strength and a desirable small diameter. The sufficient strength is obtained by eliminating a lumen through the solid end portion and boring holes or providing slots leading from the outside of the end portion to the lumen, as was heretofore done. For example, if the distance between the sides of the groove 5, as seen in FIG. 2, is 60° it would be a solid cross sectional area of $\frac{5}{6} \pi R^2$ throughout the length of the end portion 3. If the distance between the sides of the groove 5 at the circumference of the element 3 was 90° , it would be $\frac{3}{4} \pi r^2$ of solid material throughout the end portion. Either of these amounts is far greater than can be obtained by an end portion of the same diameter with a lumen therethrough and apertures or slots leading to that lumen. The membrane tube 4 and monofilament 9 can be reduced to approximately 0.002 inch and the overall outside diameter of the entire catheter device may be reduced to approximately 0.020 inch, considerably less

than any gas sampling catheter device made heretofore, insofar as I am aware. While the showing in the drawings may not be to the proper scale, the above stated figures are possible.

Should more diffusion area be desired, it is a simple expedient to provide the same without objectionably sacrificing a portion of the structural strength throughout the distal end portion 3, as shown in FIGS. 4, 5 and 6. This is accomplished by double helical grooving of the end portion 3. In this instance, the structure is the same as that above described in connection with FIGS. 1, 2 and 3, with the exception that the cannula 1 is provided with an additional inward bevel 10 directly opposite the bevel 6; and the solid end portion 3 is provided with a pair of helical grooves 11 and 12 one communicating with the lumen 2 of the cannula 1 at the bevel portion 6 and the other on the opposite side at the bevel portion 10. If the space between the grooves 11 and 12, in each case, is 60° at the outer circumference of the cannula 1, then the solid area remaining entirely through the end portion 3 up to the solid end 7 thereof is $\frac{2}{3} \pi R^2$ in cross sectional area, and that is more than has heretofore been obtained by way of a cannulated end portion with slots or holes drilled through the wall of the cannula. There need be no sacrifice in smallness of diameter. The device of FIGS. 4-6 functions the same as above described in connection with FIGS. 1-3 with the exception that there is more room to accommodate gas diffusing through the membrane 4.

A structure highly economical to manufacture, and embodying the instant invention, is shown in FIGS. 7, 8 and 9. Here the membrane 4, monofilament 9, and cannula 1 are the same as illustrated in FIGS. 4-6. The only difference is the provision of a solid distal end portion 13 which is simply a strip or rod of material rectangular in cross-section and twisted as seen clearly in FIG. 7 to provide a helical path for gas or gases diffusing through the membrane 4. In this instance, it is necessary to attach a closed end portion 14 to the twisted rod in any suitable manner to close the end of the tubular membrane 4 and provide a sharp point 15 whereby the device itself may be entered into the body of a patient. The twisted bar 13 is secured at its proximal end to the cannula 1 in a known manner. This bar 13 has a greater solid cross-sectional area than has heretofore been obtained by utilizing a cannulated end portion with slots or holes through the wall thereof leading to the lumen.

Accordingly, it will be noted that the instant invention comprises a catheter device for sampling gases in the blood or tissue of a patient, and which is of a diameter smaller than heretofore utilized, which provides ample diffusion area, and which is itself insertable into the body of a patient without aid from some other instrument to provide an entryway.

I claim:

1. A catheter device for use with analyzing apparatus to obtain samples of gases from the blood or tissue of a patient, said device including a cannula carrying a distal end portion covered by a tubular membrane permeable to body gases and insertable into a blood vessel or tissue of a patient, wherein the improvement comprises:

said distal end portion being solid throughout its length, and
said solid end portion being shaped to provide a path for gases between its external surface and said

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- membrane covering it leading to the lumen of said cannula.
2. The catheter device in claim 1, wherein said solid end portion is grooved externally to provide the path for gases.
3. The catheter device of claim 1, wherein said solid end portion is provided with a helical groove in its external surface to provide the path for gases.
4. The catheter device of claim 1, wherein said solid end portion contains a plurality of helical grooves in its external surface to provide the path for gases.
5. The catheter device of claim 1, wherein said distal end portion comprises a solid bar of material polygonal in cross section and of less size than the inside diameter of said tubular membrane, said bar being twisted to contact said membrane at spaced intervals.
6. The catheter of claim 1, wherein said solid distal end portion terminates in an end of sufficient size to close the end of said tubular membrane, and which end slopes at its distal face to pro-

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- vide a sharp point, whereby said catheter device may itself be positioned in the body of a patient without aid from other entry establishing means.
7. The catheter device of claim 1, wherein said distal end portion has a solid portion extending throughout the length of the distal end portion of an area in the range of 0.54 to 0.833 of the cross sectional area of the inside of said tubular membrane.
8. The catheter device of claim 1, which has an overall outside diameter less than 0.035 inch.
9. The catheter device of claim 5, including an end member attached to said solid twisted bar of a size to close the end of said tubular membrane and having a sloping distal face terminating in a sharp point.
10. The catheter device of claim 6, including a monofilament covering the sloping face of said end but made of sufficiently thin and strong material as not to interfere with the insertion of the device into the body of a patient.

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