

March 23, 1971

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3,572,315

INTRAVASCULAR CATHETER WITH GAS-PERMEABLE TIP

Filed Nov. 26, 1968

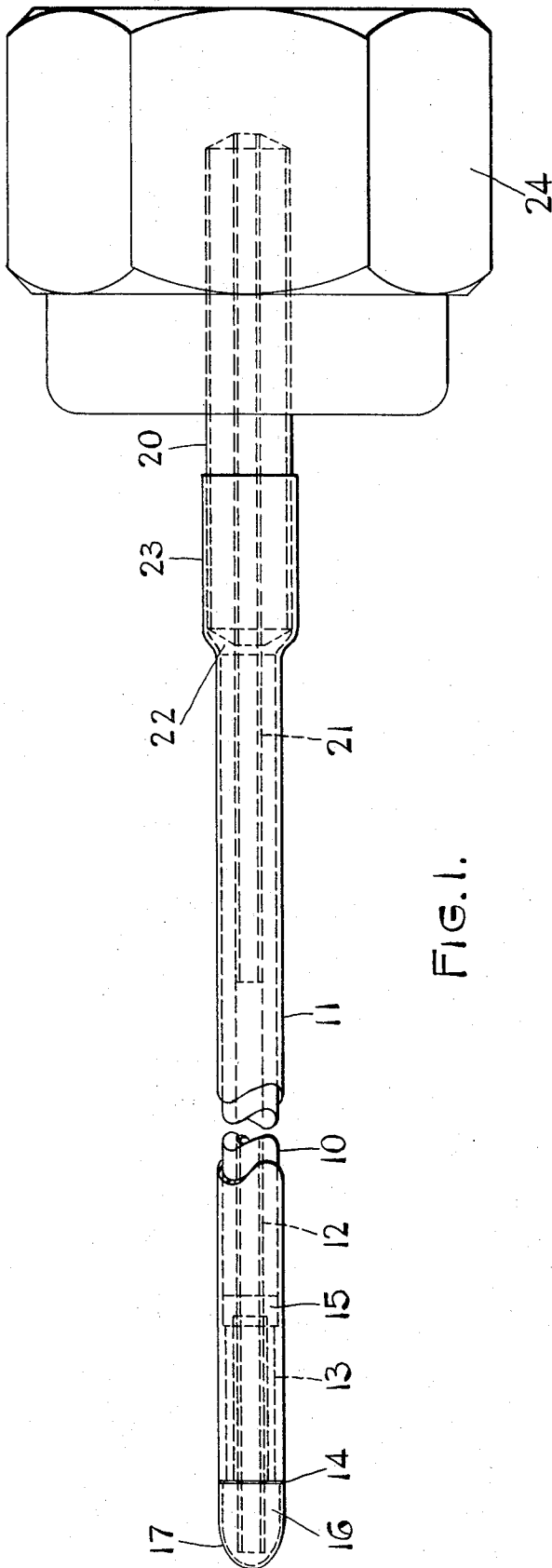


FIG. 1.

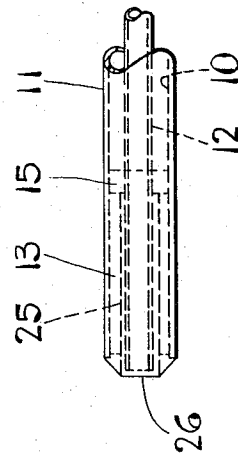


FIG. 2.



FIG. 3.

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INTRAVASCULAR CATHETER WITH GAS-PERMEABLE TIP

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Filed Nov. 26, 1968, Ser. No. 778,977

Int. Cl. A61b 5/14; A65m 25/00; G01n 33/16

U.S. Cl. 128—2

5 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for extracting gaseous components from a liquid for analysis. A catheter having a semi-permeable membrane at its leading end is inserted into the blood stream of a patient, the membrane being permeable to gases contained in whole blood but impermeable with respect to the blood itself. The opposite end of the catheter is connected to analysis apparatus, such as a mass spectrometer, and subatmospheric pressure means induces gaseous flow from the blood stream through the membrane and into the catheter and through the analysis apparatus.

BACKGROUND OF THE INVENTION

This invention relates to apparatus for withdrawing gaseous constituents from a liquid for analysis of the gaseous constituents. More particularly, the invention relates to intravascular catheters which are adapted to withdraw gaseous constituents from the blood stream of a patient for continuous qualitative and quantitative analysis.

In the prior art, blood gas analysis is usually carried on by withdrawing blood samples from a patient and then separating the gaseous constituents therefrom for analysis and measurement. This method is subject to numerous objections. In the first place, great care must be taken to preserve the extracted blood and its gaseous constituents in the same proportionate conditions as exist in the blood stream. Secondly, the method itself is cumbersome and time-consuming and accordingly the ultimate gas analysis results are obtained at some time period subsequent to the actual existing condition in the blood stream.

A further objection to prior art methods of attempting to determine the gas analysis of a patient's blood resides in the fact that as a matter of convenience and practical necessity, the blood sample for gas analysis is often taken from a portion of the patient's body which is remote from the area which is the special subject of interest.

For instance, in the case of brain damage, the blood sample according to present methods will be taken from an area remote from the patient's brain. Such gas analysis will not accurately reflect the quantity and quality of gases present in the blood immediately surrounding the critical area. This inaccuracy may be somewhat reduced by continuous sampling and analysis but the procedure is extensive and time-consuming and in critical cases cannot be practiced for that reason.

The present apparatus permits the extraction of gas for analysis to be made from the patient's blood at or near the immediate area which is of special interest.

SUMMARY OF THE INVENTION

The present invention provides a catheter wherein the conduit or body portion comprises a cannula made of a relatively gas-tight material having a gas-permeable but liquid-impervius membrane at its leading end and subatmospheric pressure means connectible with the opposite end for inducing gaseous flow from the blood stream through the cannula and through suitable gas analysis apparatus, such as a mass spectrometer.

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The principles of the invention may be applied to other applications wherein accurate continuous gas analysis readings of the gaseous contents of a liquid are desired.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a general elevational view of one form of the gas extraction catheter of the present invention;

FIG. 2 is a fragmentary elevational view of the proximal end portion of a modified form of catheter; and

FIG. 3 is a fragmentary elevational view of another modified form of catheter of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Reference will first be had to the principal embodiment illustrated in FIG. 1 of the drawing. In this embodiment the principal conduit member of the catheter is designated 10 and comprises a cannula of a material which is substantially impervious to the gases which are to be conducted thereto from within the blood stream of a patient to external analysis means. A representative material which is suitable for this purpose is a fluorinated hydrocarbon, specifically chlorotetrafluoroethylene. While dimensions may vary to suit various conditions and purposes, merely by way of example, cannula 10 may be .040" outside diameter and .020" inside diameter.

In the embodiment here set forth by way of example, the cannula 10 is provided with an external silicone sheath 11 having a wall thickness of approximately .005", for example, which provides an external catheter surface which is resistant to clotting of blood at the surface thereof.

The proximal end of the catheter which is introduced into a blood vessel is provided, in the present instance, with a stainless steel cannula or tube 12 which is inserted snugly within cannula 10. This cannula may, again by way of example, be of the same outside diameter as the inside diameter of cannula 10, namely .020", and .010" inside diameter, and of a length of about 5".

In the present embodiment the external sheath 11 extends substantially beyond cannula 10 and an annular elastic binder 13 is inserted within the end of sheath 11 and about the stainless steel cannula 12. A silicone adhesive is preferably provided at opposite ends of tip 13, as indicated at 14 and 15.

The outer end of stainless steel cannula 12 provides support for a porous tip member 16 which may be of compressed rayon fibers or sintered or porous metal or plastic and which provides a porous substrate for a semi-permeable membrane 17 which encases member 16 and is sealed to the outer end of sheath 11 by the adhesive 14.

Membrane 17 is of a material which is pervious to gases in the blood of a patient, which gases are to be withdrawn from the blood, but impervious to the blood itself. The membrane 17 may be of the general order of .001" in thickness and of various materials such as type alpha resin (ethylenevinylacetate), polypropylene, tetrafluoroethylene, or polyethylene.

In the foregoing structure the stainless steel cannula 12 will serve as a radio-opaque material for radiological purposes although in variant structures the substrate 16 may be of porous metal or plastic having the desired radio-opacity.

The opposite end of the catheter is connected with gas analysis apparatus and pump means for inducing gas flow through the catheter and the gas analysis means. By way of example, the analysis section of the apparatus may comprise a mass spectrometer of a type which is known in the art for this purpose connected in series with an ion pump or a diffusion pump which induces gas flow through the mass spectrometer.

In FIG. 1 the cannula 10 is connected with a bushing 20 by means of a stainless steel tube 21 which fits at its

opposite ends within cannula 10 and bushing 20. The joint may be cemented with a silicone adhesive as indicated at 22 and, in the present instance, the silicone sheath 21 extends about bushing 20 in sealing relation therewith, as indicated at 23. Bushing 20 is part of a standard pressure fitting 24 which connects with the inlet passage of the mass spectrometer.

An alternative permeable-tip structure is illustrated in FIG. 2. Ordinarily a maximum gas flow from the blood stream into the catheter is desirable but in certain instances, as in tissue gas analysis, somewhat restricted gas flow is dictated. In extracting gas from tissue if the rate of withdrawal is too rapid, it tends to impoverish the area from which gas is being extracted and thus produces unreliable readings.

In FIG. 2 the cannula 10, the silicone sheath 11 and the stainless steel tube 12 correspond to like parts in the embodiment of FIG. 1, as does the silicone rubber tip 13 and the silicone adhesive 15. However, in FIG. 2 the semi-permeable membrane which corresponds to the membrane 17 of FIG. 1 and may be of the same material, is designated 25 and comprises a tubular portion fitting closely about the outer end of stainless steel cannula 12 and closed at the outer end to provide a limited permeable gas-extraction surface 26.

In the modification of FIG. 3 the general structure is similar to those of FIGS. 1 and 2 but the porous substrate 16 which comprises the tip member in FIG. 1 is replaced with an ultraminiature transducer.

This transducer is provided for measuring blood pressure. The gaseous component is still extracted through a semi-permeable membrane and out through the catheter for analysis as in the previous embodiments.

In this embodiment the membrane may comprise a cast silicone elastomer of approximately .030" in thickness. This thickness will give the optimum gas permeation without "starving" the fluid in the immediate vicinity of the tip during diagnostic use.

What is claimed is:

1. A catheter for extracting gaseous components from a patient's blood stream for analysis comprising a relatively gas-tight cannula having a tip portion including a semi-permeable membrane extending over the open end of said cannula, said membrane being relatively impervious to whole blood but pervious to gases contained in the blood, the opposite end of said catheter being connected to a source of sub-atmospheric pressure for inducing

ing gaseous flow from the blood stream through said membrane and through the catheter.

2. Means for extracting gaseous components from a liquid for continuous mass spectrometer analysis comprising a relatively gas-tight catheter having a tip portion for insertion in the liquid to be tested, said tip portion including a semipermeable membrane extending over the open end of said catheter, said membrane being relatively impervious to the liquid being tested but permeable to gases contained therein, the opposite end of said catheter being connected to a source of subatmospheric pressure for inducing gaseous flow from the liquid through said membrane and said catheter and through a mass spectrometer.

3. A catheter according to claim 1 wherein said membrane comprises a resin of the class consisting of type alpha resin (ethylenevinylacetate), polypropylene, polyethylene, and tetrafluoroethylene.

4. A catheter according to claim 1 wherein said cannula comprises a flexible tube of gas-tight resin enclosed in a silicone sheath.

5. A catheter according to claim 1 wherein said cannula comprises a fluorinated hydrocarbon resin having an external silicone resin sheath.

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U.S. Cl. X.R.

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