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(54) **Measuring probe**

(57) A measuring probe has a first tube (2) one end of which is pointed, and a second tube (3) which partially encloses and is secured to the first tube (2). An end region of the first tube (2), including said one end, extends beyond the second tube (3). At least one electrode is secured within and insulated from the first tube (2). The second tube (3) supports the

first tube (2) which can be of a sufficiently small diameter, for example less than 150 μm for a puncture or opening made by a probe in an artery to be self-sealing without bleeding. The electrodes may sense oxygen, sodium or calcium, and a thermocouple and light guide may also be located in tube 2 so that flow may be measured from the rate of temperature change when the radiation is passed down the light guide from LED 22.

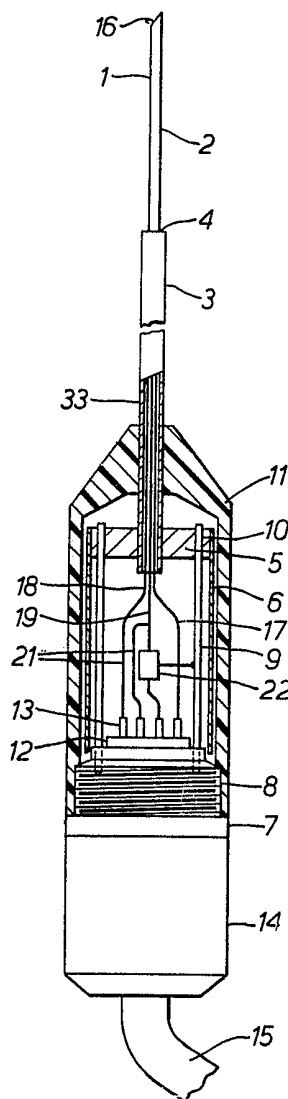
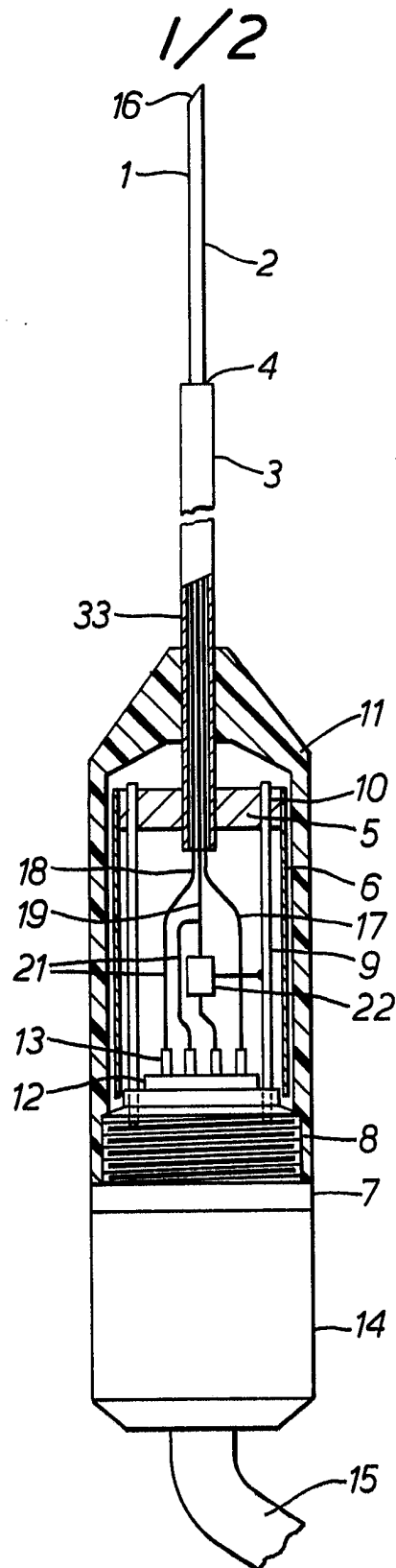


Fig. 1.

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*FIG. 1.*

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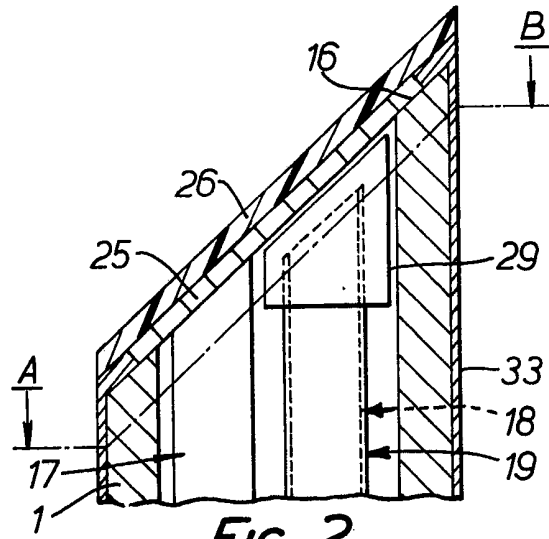


FIG. 2.

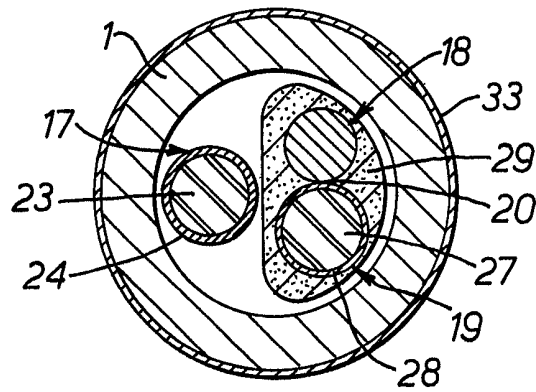


FIG. 3.

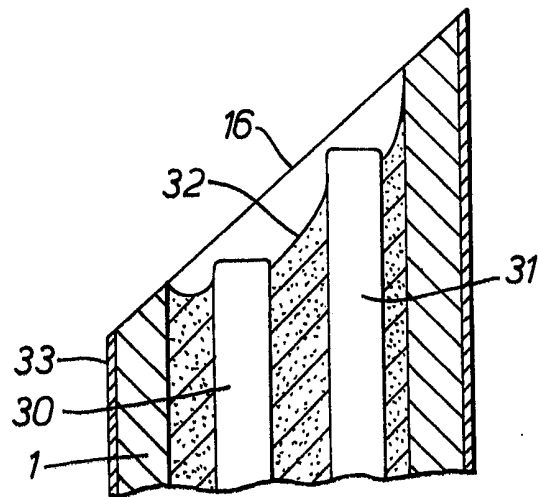


FIG. 4.

SPECIFICATION

Measuring probe

This invention relates to a measuring probe.

It is known that arteries can be punctured by measuring or puncturing probes which have a diameter of less than 150 μm , without subsequent bleeding; the puncture closes again by itself. The known probes for measurements in the blood stream exceed this diameter and do not therefore allow measurement to be made without subsequent bleeding. Measuring probes, which are to puncture must also overcome the resistance of the arterial wall. Their length has to be equivalent to several times the thickness of the arterial wall in order to penetrate it, particularly when the puncture is made at an angle. Glass puncturing probes do not fulfill the above requirements. The risk of these probes breaking is too high for clinical application. Silver probes are too soft and bend. Long, thin probes made of stainless steel tend to glance resiliently off the arterial wall.

A known puncturing probe for measuring pO_2 in the body tissue is described in J. Appl. Physiol:Respirat.Environ. Exercise Physiol. 48 (1): 186—187, 1980. It has as the puncturing body a probe tube in the form of a stainless steel tube. Several glass-covered gold wires are glued into this with synthetic resin. They are in parallel connection with a screened, shared line and form the measuring electrode. The steel tube connected to the screen is used as the reference electrode. The steel tube makes a poor reference electrode because of the material of which it is made, and optimal measuring accuracy is not achieved. The stability of the probe tube is inadequate, but with a larger diameter a puncture without bleeding would no longer be possible. There is no facility for simultaneously carrying out different measurements. Different types of measuring electrodes are not provided.

German Offenlegungsschrift 25 58 947 describes a measuring probe, which can have several different designs and sizes and can be a micro-probe or a macro-probe. It is intended for the simultaneous measurement of several gases and ions in biological media such as blood or tissue. Its carrier is made of glass into which one or more electrode wires are fused. On the outside, the carrier body is covered with concentric electrode and insulation layers in the form of thin films, and also with a membrane. As however, the thin films which are applied do not result in increased strength, the mechanical stability of this measuring probe lies in the glass carrier body alone. At diameters of less than 1 mm the risk of this breaking is so great that their application has to be limited to research and test purposes, but an application for measurements without bleeding in the clinical field is not suggested.

A known probe, described in German Patent Specification 25 49 559, for measuring the heat transfer or blood flow through living tissue, more

particularly in people, has an electrically and thermally insulated, pointed carrier body in the form of a light-conducting fibre. A thermo-couple made of conductive thin films is formed thereon. This is heated by the radiation conducted on the fibre from a light source arranged on the shank end of the probe. The risk of the carrier body breaking when it has a small diameter does not allow it to be used for a clinical application for a measurement without bleeding.

It is desirable that a measuring probe having a probe tube should have sufficient stability for puncturing arteries and a diameter which remains so small at the puncture that the puncture point re-seals itself to prevent bleeding.

According to the present invention, there is provided a measured probe capable of penetrating tissue and comprising: a first tube, one end of which is pointed; a second tube, which partially encloses and is secured to the first tube, with an end region of the first tube including said one end extending beyond the second tube; and one or more electrode secured within and insulated from the first tube.

Preferably, the first and second tubes are secured together so that electrical conduction can occur between them. They may be glued together.

The first tube and/or the second tube can be formed of stainless steel, for example a chrome-nickel steel.

The exterior surfaces of the first and second tubes are preferably covered with a layer of chlorinated silver, i.e. Ag/AgCl .

By graduating the probe in two diameters and thus in corresponding bending stabilities, a rigidity is achieved which also enables the arterial walls to be penetrated. The diameter of the first, pointed tube can be small enough to ensure that the puncture point re-seals itself. Moreover, it is very important that with the smaller diameter the natural flow ratios or, for tissue measurements, the micro-circulation are virtually undisturbed even during the insertion. The measuring results are therefore accurate.

The tubular design of the probe enables the electrodes to be passed through to the measuring tip in a simple manner. The probe tube allows the use of, for example, electrodes for gas measurement, for ion measurement and also, via a thermo-couple, measurements to be made of blood flow, as well as optional combinations of different measuring devices.

For a better understanding of the present invention, and to show more clearly how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 shows, in partial section, a measuring probe according to the present invention;

Figure 2 shows a cross-section through a tip of the measuring probe of Figure 1;

Figure 3 shows a section along the line A—B of Figure 2; and

Figure 4 shows a cross-section through an alternative embodiment of the tip.

The measuring probe, shown in Figure 1, comprises a probe tube 1 comprising a first tube 2, with a pointed end and a diameter of approximately $150\text{ }\mu\text{m}$ and a shank or second tube 3, with a diameter of $400\text{--}500\text{ }\mu\text{m}$. These tubes 2 and 3 are inserted into one another so that they overlap up to the point 4, with one end region of the first tube 2 extending beyond the second tube 3. The tubes 2 and 3 are glued or otherwise secured together, so that electrical conduction can occur between them. The probe tube 1 is made of stainless steel, is covered with a layer of silver and chlorinated on the outside. The steel could be a chrome-nickel steel. In this way an Ag/AgCl layer 33 (see Figure 2) is formed which acts both as a reference electrode and a screen. The second tube 3 is welded into a central through-opening of a metal holding disc 5 which carries on its periphery a metal screen cylinder 6. A metal housing 7 of a conventional four terminal connector is provided with two inserted metal guide pins 9 and has an outer thread 8. Ends of the guide pins 9 are located in two through-openings 10 of the holding disc 5. The holding disc 5 may be displaced longitudinally on the guide pins 9 when the measuring probe is fitted by insertion into a subject's body. After fitting the holding disc 5 is fixed in position by a conductive adhesive. A cap 11 made of insulating plastics is pushed over the probe tube 1 by means of a central through-opening and screwed onto the thread 8 of the housing 7. The housing 7 of the four terminal connector carries connector terminals 13 in an insulation body 12. The connector may be coupled with a coupling 14 in a known manner by means of the connector pins and, via this coupling, it is connected to a connection cable 15. With reference to Figure 2, an electrode 17 for oxygen and two branches 18 and 19 of a thermocouple 20 are located in the probe tube 1, and they are sealed therein by an insulating bonding agent, up to obliquely ground tip 16 of the pointed first tube 2. The electrode 17 and the branches 18 and 19 are connected by welding to corresponding connector terminals 13. A light emitting diode 22 is connected to a further connector terminal 13 and a guide pin 9. An end of the branch 19 of the thermocouple 20 is attached and glued onto the emitting top surface of the light emitting diode 22. The positioning of the terminals and, more particularly, of the branch 19 during assembly is made possible by the fact that the holding disc 5 may be displaced on the guide pins 9.

Figure 3 shows the arrangement of the electrode 17 and the branches 18 and 19 in the probe tube 1. The remaining space or cavities in the probe tube 1 are filled with insulating adhesive. The electrode 17 for oxygen consists of a fibre optical waveguide 23 which is covered with a layer of gold 24. The measuring surface is formed by grinding the tip 16 together with the

electrode 17. After grinding it is covered with salt crystals 25 from a dried solution, to form the electrolyte, and a membrane 26 made of polyvinyl methylal. When placed into a physiological medium and when the salt crystals 25 have redissolved, the arrangement forms, together with the Ag/AgCl layer 33 as the reference electrode, a Clark cell for measuring oxygen partial pressure.

The thermo-couple 20 is located just under the tip 16. The branch 18 consists of a thin copper wire. The branch 19 is a fibre optical waveguide 27 covered with a nickel layer 28. Their ends are joined by a conductive adhesive 29 and form the thermo-couple 20. With the exception of the contact means the branches 18, 19 are covered with insulating adhesive before being inserted into the probe tube 1. The thermoelectric voltage occurring at the contact 21 of the branches 18 and 19 is a measure for the temperature of the tip 16. The branch 19 also abuts the light-emitting diode 22. During the periodic operation of the light-emitting diode 22, the thermo-couple 20 and a tip 16 are heated periodically by the radiation energy conducted via the fibre optical waveguide 27. The pattern of the temperature change is a measure of the flow condition prevailing in the region of the tip 16, for example a blood flow.

The construction shown in Figure 4 is used for the measurement of ions and comprises an electrode 30 for Na ions and an electrode 31 for Ca ions. Each of the electrodes 30 and 31 comprises a fibre optical waveguide which is covered with a layer of gold as a conductor and enclosed externally by a PVC membrane. Each membrane is provided with the respective, known ion-specific doping. The ends of the electrodes 30 and 31 are set slightly back from the tip 16 and project out, uncovered, from the end surface 32 of insulating adhesive. The Ag/AgCl layer 33 acts as a reference electrode for each of the electrodes 30 and 31 and, in use, is connected to these via an electrolyte in which the measurement probe is immersed.

It is possible for a measuring probe to include the electrode 17, the branches 18 and 19 of the thermocouple 20, as shown in Figures 2 and 3, and the electrodes 30 and 31 shown in Figure 4.

The electrode 17 and branches 18 and 19 of the thermocouple 20 can each have a diameter of approximately $70\text{ }\mu\text{m}$. Similarly, for the Figure 4 construction, each electrode 30 or 31 can have a diameter of approximately $70\text{ }\mu\text{m}$.

Claims

1. A measuring probe capable of penetrating tissue and comprising: a first tube, one end of which is pointed; a second tube, which partially encloses and is secured to the first tube, with an end region of the first tube including said one end extending beyond the second tube; and one or more electrode secured within and insulated from the first tube.

2. A measuring probe as claimed in claim 1, wherein the first and second tubes are secured

together so that electrical conduction can occur between them.

3. A measuring probe as claimed in claim 1 or 2, in which the first and second tubes are glued together.

4. A measuring probe as claimed in claim 1, 2 or 3 wherein one or each of the first tube and the second tube is formed of stainless steel.

5. A measuring probe as claimed in claim 1, 2, 3 or 4, wherein exterior surfaces of the first and second tubes are covered with a layer of Ag/AgCl.

6. A measuring probe as claimed in any preceding claim, in which the external diameter of the first tube is less than or equal to $150\text{ }\mu\text{m}$ and the external diameter of the second tube is less than or equal to approximately $500\text{ }\mu\text{m}$.

7. A measuring probe as claimed in any preceding claim, wherein an end of the second tube remote from said one end of the first tube is located in an opening in a holding disc.

8. A measuring probe as claimed in claim 7, wherein the holding disc is axially displaceable on guide pins and a cylindrical metal screen is attached to the holding disc.

9. A measuring probe as claimed in claim 8, which includes a light-emitting diode.

10. A measuring probe as claimed in claim 9, wherein light-emitting diode is located within the cylindrical metal screen.

11. A measuring probe as claimed in any preceding claim, which includes, within the first tube adjacent said one end thereof, a first electrode and a thermocouple comprising second and third electrodes which are connected together.

12. A measuring probe as claimed in claim 11 when appendant to claim 5, wherein in use the Ag/AgCl layer acts as a reference electrode for gas measurement and an electrical connection is provided between the first electrode and the Ag/AgCl layer by an electrolyte.

13. A measuring probe as claimed in claim 11 or 12, wherein said one end of the first tube is covered with a layer of salt which, in use, acts as an electrolyte.

14. A measuring probe as claimed in claim 13, wherein the layer of salt is covered with a membrane.

15. A measuring probe as claimed in claim 11, 12, 13 or 14 when appendant to claim 10, wherein the first electrode comprises an optical fibre covered with a layer of gold, one end of the optical fibre being arranged to receive light from the light-emitting diode.

16. A measuring probe as claimed in any one of claims 11 to 15 when appendant to claim 10, wherein the second electrode, being one of the two electrodes of the thermocouple, comprises a copper wire and the third electrode comprises an optical fibre which is covered with a layer of nickel and one end of which is arranged to receive light from the light-emitting diode.

17. A measuring probe as claimed in any preceding claim, which includes fourth and fifth electrodes, each of which includes a coating to make it sensitive to a particular ion or ions.

18. A measuring probe substantially as hereinbefore described with reference to, and as shown in, Figures 1, 2 and 3 or Figures 1 and 4 of the accompanying drawings.