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(54) DEEP TISSUE TEMPERATURE PROBE CONSTRUCTIONS

SONDENKONSTRUKTIONEN FÜR TIEFENGEWEBETEMPERATUR

STRUCTURES DE SONDE DE TEMPÉRATURE POUR TISSU PROFOND

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(73) Proprietor: **3M Innovative Properties Company**
St. Paul, MN 55133-3427 (US)

(72) Inventor: **VAN DUREN, Albert, P.**
Chaska
MN 55318 (US)

(74) Representative: **Vossius & Partner**
Patentanwälte Rechtsanwälte mbB
Siebertstrasse 3
81675 München (DE)

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Description

PRIORITY

[0001] This application claims priority to US Provisional Application for Patent 61/212,704 filed 4/15/2009.

BACKGROUND

[0002] The subject matter relates to a temperature probe-a device placed on the skin of a subject to measure temperature. More particularly, the subject matter pertains to a deep tissue temperature (DTT) probe. Deep tissue temperature measurement is a non-invasive determination of the core temperature of a human body in which a probe is located over a region of deep tissue that is representative of the body core. The probe reads the temperature of that region as the core temperature.

[0003] A system for non-invasively measuring deep tissue temperature was described by Fox and Solman in 1971 (Fox RH, Solman AJ. A new technique for monitoring the deep body temperature in man from the intact skin surface. J. Physiol. Jan 1971:212(2): pp 8-10). The system, illustrated in the schematic diagram of FIG. 1, estimates body core temperature by indirect means using a specially designed probe that is placed upon the skin of a subject to stop or significantly neutralize heat flow through a portion of the skin in order to measure temperature. The components of the probe 10 are contained in a housing 11. The Fox/Solman probe 10 includes two thermistors 20 mounted on either side of a thermal resistance 22, which may be constituted of a layer of insulating material capable of supporting the thermistors 20. The probe 10 also includes a heater 24 disposed at the top of the probe 10, over the elements 20, 22, and 24. In use, the probe 10 is placed on a region of the skin of a person whose deep tissue temperature is to be measured. With the bottom surface 26 of the probe resting on a person's body, in contact with the skin, the thermistors 20 measure a temperature difference, or error signal, across the thermal resistance 22. The error signal is used to drive a heater controller 30, which, in turn, operates to minimize the error signal by causing the heater 24 to provide just enough heat to equalize the temperature on both sides of the thermal resistance 22. When the temperatures sensed by the thermistors 20 are equal or nearly so, there is no heat flow through the probe, and the temperature measured by the lower thermistor 20 by way of a temperature meter circuit constituted of an amplifier 36 and a temperature meter 38 is equivalent to DTT. The probe 10 essentially acts as a thermal insulator that blocks heat flow through the thermal resistor 22; DTT probes that operate in the same manner are termed "zero-heat-flux" ("ZHF") probes. Since the heater 24 operates to guard against loss of heat along the path of measurement through the probe, it is often referred to as a "guard heater".

[0004] Togawa improved the Fox/Solman design with a DTT probe structure that accounted for the strong multidimensional heat transfer of dermal blood flow through the skin. (Togawa T. Non-Invasive Deep Body Temperature Measurement. In: Rolfe P (ed) Non-Invasive Physiological Measurements. Vol. 1. 1979. Academic Press, London, pp. 261-277). The probe, illustrated in FIG. 2, encloses a ZHF sensor design 40, which blocks heat flow normal to the body, in a thick aluminum housing 42 with a disk-like construction that also reduces or eliminates radial heat flow from the center to the periphery of the probe.

[0005] ZHF deep tissue temperature measurement were improved in several ways, principally by decreasing the size and mass of a DTT probe to improve response and equilibrium times, and also by adding guard heating around the periphery of the probe to minimize radial heat losses. Nevertheless, ZHF probes have typically been expensive and non-disposable, and have not been widely adopted for clinical use, except for cardiac surgery in Japan. The sensors cannot be effectively heat sterilized, although they can be disinfected with a cold bactericidal solution.

[0006] Presently, ZHF probes based on the original Fox and Solman design comprise both software and hardware improvements. One such ZHF probe has a stacked planar structure that consists of a number of discrete layers. An advantage of this design is a narrow width, which helps minimize radial temperature differences from heat loss through the sides of the sensor. This probe includes an optimally-damped heater controller which is operated by use of a PID (Proportional-Integral-Derivative) scheme to maintain the heater temperature just slightly higher than the temperature of the skin. The small temperature difference provides an error signal for the controller. While the hardware design is not disposable, it does provide some basic improvements to the size and mass of the Fox/Solman and Togawa designs.

[0007] Maintenance of body core temperature in a normothermic range during a perioperative cycle has been shown to reduce the incidence of surgical site infection, and so it is beneficial to monitor a patient's body core temperature before, during, and after surgery. Of course non-invasive measurement is very desirable, for both the comfort and the safety of a patient. Deep tissue temperature measurement using a probe supported on the skin provides an accurate and non-invasive means for monitoring body core temperature. However, the size and mass of the Fox/Solman and Togawa probes do not promote disposability. Consequently, they must be sterilized after each use, and stored for reuse. As a result, use of these probes to measure deep tissue temperature may raise the costs associated with DTT measurement and may increase the risk of cross contamination between patients. It is therefore useful to reduce the size and mass of a DTT probe, without sacrificing its performance, so as to promote disposability.

[0008] US 3 933 045 A relates to an apparatus for measuring the temperature within a body by covering an area of the body surface with a layer of thermal insulation. The temperature is measured with the aid of two sensors located respectively at the insulation/body surface interface and at the opposite side of the insulating layer to indicate any temperature gradient along a path from within the body through the sensors. Heat is applied over the insulating layer/sensor sandwich to annul any such gradient. This exteriorises the desired deep body temperature, which is then indicated by the sensors.

SUMMARY OF THE INVENTION

[0009] The present invention relates to a deep temperature probe according to claim 1.

[0010] Disposable, zero-heat-flux, deep tissue temperature probes are constructed using a support assembly constituted of a flexible substrate that supports elements of the probe. The support assembly has multiple sections that may be folded together and/or separated to form a multi-level ZHF structure. The sections support elements of the probe, including thermal sensors separated by a layer of thermal resistance interposed between adjacent sensor-supporting sections. Preferably, at least one of the sections supports a heater.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIGS. 6 to 12 do not fall under the wording of the claims and are provided for illustrative purposes.

FIG. 1 is a schematic block diagram of a deep tissue temperature measurement system including a ZHF probe.

FIG. 2 is a schematic side sectional diagram of a second prior art deep tissue temperature measurement system including a ZHF deep tissue temperature probe with an aluminum cap.

FIG. 3 illustrates a thermal measurement support assembly embodiment for a ZHF probe constituted of a film of material including two sections joined by a hinge.

FIG. 4 illustrates the first embodiment with the two sections folded toward each other.

FIG. 5 illustrates the first embodiment with the two sections folded together.

FIG. 6 is a drawing showing, in plan, a second thermal measurement support assembly embodiment for a ZHF probe constituted of a film of material including three sections joined by two hinges, in which the sections are opened and lie in the same plane with a first surface of the film visible.

FIG. 7 is a drawing showing, in plan, the film of material of FIG. 6, in which the sections are opened and lie in the same plane with second surface of the film visible.

FIG. 8 is a perspective drawing of the film of material showing how the three sections are folded together.

FIG. 9 is a drawing showing, in plan, the top side of an assembled DTT probe with the second support assembly embodiment. The figure includes a table illustrating assignment of pins of the probe.

FIG. 10 is a sectional view in elevation showing the assembled DTT probe with the second support assembly embodiment.

FIGS. 11A and 11B are plan and side views of a third support assembly embodiment.

FIGS. 12A and 12B are plan and side views of a fourth support assembly embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] It is desirable that zero-heat-flux, deep tissue temperature probe (DTT probe) constructions be disposable. Thus the constructions should be easy and inexpensive to fabricate and assemble, have a low mass and a low profile, and comprise inexpensive materials and parts.

[0013] It is particularly desirable that disposable DTT constructions be assembled from low-profile, light weight, flexible assemblies that enable zero-heat-flux measurement at various locations on a human or animal body.

[0014] A thermal measurement support assembly for zero-heat-flux deep tissue temperature probe (DTT probe) constructions includes a flexible substrate with at least two thermal sensors disposed in a spaced-apart relationship and separated by one or more layers of thermally insulating material. Preferably the sensors are spaced apart vertically as in FIGS. 1 and 2, and they may further be spaced apart horizontally or radially with respect to a center of measurement of vertical heat flux. The substrate supports at least the thermal sensors and the separating thermal insulating material, and it may also support one or more heaters. Once constructed, the support assembly is ready to be incorporated into the structure of a DTT probe.

[0015] A first embodiment of a support assembly for a DTT probe is illustrated in Figure 3. The support assembly 200 includes a permanent heater (not shown) with an attachment mechanism (not shown) and is designed and manufactured to be disposable. The support assembly 200 includes a film of material coated with copper on both sides and fashioned into two disk-shaped sections 202 and 204 that are joined at a common peripheral location 206 disposed between the two sections. The disk shaped sections 202 and 204 include major supporting surfaces 203 and 205 respectively. The surfaces on the opposite sides of the major supporting surfaces 203, 205 (which are not seen in these figures) support respective thermocouples whose junctions 207, 209 are visible at the respective centers of the major supporting surfaces 203, 205. Signal leads 211, 213 are connected to the thermocouples at the junctions 207, 209, and a common lead 215 is electrically coupled to the thermocouples. Preferably, a pressure-sensitive adhesive (PSA)-backed, 0.001 inch thick piece of insulative material such as a polyimide layer (Kapton® film, for example) is disposed on one of the surfaces on the opposite side of one of the major supporting surfaces 203, 205, and the support assembly may be folded like a clam shell, on a crease at the common peripheral location 206, as shown in FIGS. 4 and 5. An insulating material with greater thermal resistance may also be interposed between the surfaces 203 and 205 to decrease the sensitivity of the support assembly. When the support assembly is so folded, the thermocouples are disposed in a stacked configuration, with the layer of insulative material disposed therebetween to provide thermal resistance. The copper disks are electrically continuous; therefore, the junction of each thermocouple is common to both disks, which makes it possible to eliminate one wire from the pair of thermocouples. Although the probe is designed to minimize radial heat losses and radial temperature differences, the placement of the thermocouples in the center of the copper disks minimizes fin effects that tend to reduce accuracy.

[0016] The thermocouples in the first support assembly embodiment illustrated in FIGS. 3-5 may be assembled with other elements of a DTT probe illustrated in FIG. 1, but the heater assembly is likely to become contaminated after use, and a disposable ZHF probe design is very desirable to avoid cross contamination between patients.

[0017] With reference to FIGS. 6-9, a second embodiment of a support assembly 500 for a DTT probe includes a heater integrated into the support assembly. There are no wires attached to this embodiment as both signal and power leads are available on a connector tab on the circumference of the assembly.

[0018] As best seen in FIGS. 6 and 7, the support assembly 500 includes a flexible substrate, preferably a sheet of flexible, thermally insulative material that is formed to include a plurality of contiguous sections. For example three contiguous paddle-shaped sections with disks 502, 504, and 506 of equal diameter are formed and aligned so that their centers lie on a straight line. Each disk transitions to a tab for supporting one or more electrical leads. The tabs are indicated by reference numerals 503, 505, and 507, respectively. The inner periphery of each disk is continuous with each adjacent inner periphery at a point that is tangent to the perimeter of the inner circle and which intersects the line upon which the centers are aligned. Thus, the inner periphery of the outer disk 502 is continuous with the periphery of the inner disk 504 at 509, and the inner periphery of the outer disk 506 is continuous with the periphery of the inner disk 504 at 511, which is diametrically opposite 509 on the periphery of the inner disk 504. Each disk has two opposite-facing, disk-shaped major surfaces. Thus, the outer disk 502 has major surfaces A and B, the inner disk 504 has major surfaces C and D, and the outer 506 has surfaces E and F. The major surfaces A, D, and E are on one side of the support assembly 500; the major surfaces B, C, and F are on the opposite side.

[0019] As seen in FIGS. 6 and 7, a heater 514 is formed on the major surface A by, for example, depositing a layer of copper on the surface and then etching the copper layer. The etching includes formation of leads 512 for the heater on the tab 503 that terminate in pins 513 at the outer edge of the tab 503. The etching also exposes a ring 510 of insulative material at the periphery of the major surface A. The layer 515 of copper on major surface C is etched to expose a ring 516 of insulative material at the periphery of the surface. The disk 517 of copper film inside the ring 516 is used as one element of a thermocouple 518. For example, the thermocouple 518 is fabricated by soldering, brazing, or welding one end of an insulated chromel wire 519 to the disk 517 of copper film, preferably, but not necessarily, at or near the center of the surface C. The other end of the chromel wire 519 is soldered, brazed, or welded to a chromel pin 520 mounted to the tab 505. Etching the copper on the major surface C also forms a lead 521 and a pin 522 for the copper portion of the thermocouple 518 on the tab 505. Another thermocouple 525 is similarly fabricated on the major surface E. Etching removes copper from the major surfaces B, D, and F so that those surfaces have no copper thereon.

[0020] With the heater 514 and thermocouples 518 and 525 thus formed, the support assembly 500 may be Z-folded as shown in FIG. 8. Preferably, the sections 502 and 504 are folded at 509 by swinging the major surfaces B and C together and the sections 504 and 506 are folded at 511 by swinging the major surfaces D and E together. The folded support assembly 500 is seen in the top plan view of FIG. 9. In this aspect, the support assembly 500 is preferably oriented with respect to a location on a body where a deep tissue temperature reading is to be taken by denominating the heater 514 as the top of the assembly, and major surface F as the bottom. In this aspect, the tabs 503, 505, and 507 are aligned by the folding place so as to align all of the leads and pins on a single side of a composite tab 520. Preferably, but not necessarily, the composite tab 520 is oriented with the aligned pins facing in the same direction as the heater on major surface A. The table in FIG. 9 sets forth the pin assignments. In the table, the lower thermocouple is on major surface E and the upper thermocouple is on major surface C. The connectors on the composite tab 520 provide electrical access to each of the thermal sensors and to the heater. A compression connector (not seen) may be received on the composite tab 520.

[0021] Final assembly of a DTT probe construction with a support assembly 500 according to the second embodiment is illustrated in FIG. 10. In the unfolded assembly, there are three circular disks and six surface regions. Layers formed by folding the support assembly are labeled as shown in the figures. The layers are, as follows:

Major surface A is the electric heater
Major surface B is plastic film
Major surface C is a copper layer that supports a thermal sensor
Major surface D is a plastic film
Major surface E is a copper layer that supports a thermal sensor
Major surface F is plastic film

[0022] The assembled DTT probe may include additional layers added to the structure of the probe during assembly. For example, layers of pressure-sensitive adhesive (PSA) 527 may be disposed between the folded sections and on the top and bottom major surfaces, an insulating layer may be disposed on the layer of PSA above the heater, and a further layer of PSA may be disposed on the top of the insulating layer. Further, a release liner may be provided on the bottom PSA layer, and an aluminum radiation shield may be supported on the top PSA layer. The exemplary embodiment of the DTT probe shown in FIG. 10, with the second support assembly embodiment, includes sixteen separate layers. The materials and constructions described for the support assembly and representative dimensions for the layers which are shown in Table I below illustrate the achievement of a disposable DTT probe with a very low vertical profile, an inexpensive construction, and a flexible structure that can adapt to differing contours of various measurement locations on the body of a person.

TABLE I

Layer	Thickness (in.) (est.)
Aluminum foil radiation shield	0.001
Pressure-sensitive adhesive	0.0005
Insulating foam	0.010
Pressure-sensitive adhesive	0.0005
Heater - Surface A	0.001
Plastic film - Surface B	0.002*
Pressure-sensitive adhesive	0.0005
Upper Thermocouple	0.0005
Metal foil (copper) - Surface C	0.001
Plastic film -Surface D	0.002*
Pressure-sensitive adhesive	0.0005
Lower thermocouple	0.0005
Metal Foil (copper) - Surface E	0.001
Plastic film - Surface F	0.002*
Pressure-sensitive adhesive	0.0005

(continued)

Layer	Thickness (in.) (est.)
Release liner	0.001
TOTAL	0.0235
* This dimension is the thickness of the substrate, which may vary with the design goals of the DTT probe.	

[0023] The second support assembly embodiment illustrated in FIGS. 6-10 may be assembled with other elements of a DTT probe system, as illustrated in FIG. 1.

[0024] FIGS. 11A, 11B, 12A, and 12B illustrate third and fourth support assembly embodiments. Each of the third and fourth embodiments is characterized by a structure with a single substrate layer formed into a plurality of contiguous sections that are separated into strata on which the thermal sensors are disposed in a spaced-apart relationship. Preferably, the thermal sensors are disposed on two contiguous elongate support members, disposed in a spaced-apart, an opposing or an adjacent relationship, inwardly of the periphery of the support assembly. Preferably, the substrate has the shape of an annulus with a circumferential heater disposed thereon and the two sensor support members projecting inwardly thereof and separated by a thermally insulating layer separate from the substrate. It is desirable to provide a lead support tab projecting outwardly of the annulus and supporting leads for the heater and the thermal sensors.

[0025] In FIGS. 11A and 11B, a two-sided, planar sheet 601 of flexible substrate material is provided and one side of the sheet is coated with a layer of conductive metal such as copper. The copper sheet is etched to form a heater 602, thermocouple traces, leads, and pins. Chromel traces, leads, and pins are deposited on the substrate, and a single paddle-shaped section with a disk 600 is formed by cutting, stamping or machining the planar sheet. The disk 600 transitions to a tab 603 for supporting the copper and chromel leads and pins. The heater 605 is defined along the circular circumference of the disk 600 by a conductive trace having a triangle wave shape. The heater 605 surrounds the thermocouple junctions 607 and 608. The thermocouple junctions 607 and 608 are aligned with respect to a diameter of the disk 600 and disposed on either side of its center. The inner section 606 of the substrate is die cut and removed leaving the heater 605 supported on an annulus of substrate material and the thermocouple junctions 607 and 608 disposed on two thermal sensor support tabs 611 and 613 that project inwardly of the annulus, in an opposing relationship. The two tabs 611 and 613 are then separated into strata and a film or layer 615 of thermally insulating material that is separate from the substrate is interposed therebetween, which produces a vertical separation, and inserts a thermal resistance, between the thermocouples. Assignments of the pins in FIG. 11A are given in Table II.

TABLE II

PIN	DESCRIPTION
1	HEATER
2	THERMOCOUPLE 607
3	THERMOCOUPLE 607
4	THERMOCOUPLE 609
5	THERMOCOUPLE 609
6	HEATER

[0026] FIGS. 12A and 12B illustrate a fourth support assembly embodiment similar to the single-layer probe structure of the third embodiment seen in FIGS. 11A and 11B, but with elongated, oppositely-directed thermal sensor support tabs 711 and 713 offset in an adjacent relationship on respective sides of the diameter on which the tabs 611 and 613 are aligned. This arrangement allows a thicker layer 715 of thermally insulating material to be placed between the tabs. Thicker insulation decreases the sensitivity of the probe and increases the amplitude of the error signal. This is an advantage because it makes it easier to operate a control algorithm when zero-heat-flux conditions prevail. The disadvantage is that increased thermal resistance increases equilibration time. The pin assignments for the fourth embodiment correspond essentially to those of the third.

[0027] The two embodiments of FIGS. 11A, 11B, 12A, and 12B are for a sensor assembly. A DTT probe with either embodiment may be assembled into a construction with fewer layers than that disclosed in FIG. 10. The expected advantages of these embodiments are 1) ease of construction, 2) minimization of radial temperature differences, 3) minimization of materials, and 4) because each embodiment is based on a single layer, no folding of the substrate is required during assembly or operation, although steps of tab separation and insertion of a thermally insulating layer are necessary. Each of these designs is intended to be disposable; each is designed to use circumferential heating as opposed to full diametric heating.

[0028] A support assembly according to any of the four embodiments may be constructed using a substrate constituted of a single double-sided sheet of plastic film such as Kapton® polyimide, Kaptrex® polyimide, polyester or another film of flexible, thermally insulating material. The sheet may be coated on one or both sides with a copper film and various elements such as heaters, copper disks, and copper leads and pins may be made by photo-etching before the support assembly is folded or separated. The sheet may then be die-cut to the required shape and folded or separated as described above. Other metals with high thermal conductivities, like gold or aluminum, may also be used, although copper is preferred because it can form one half of a T-type thermocouple; however, other types of thermocouples are possible, and it may be possible to dispense with metal films altogether if other thermal sensors such as balanced RTD's, thermistors, and/or point junction thermocouples are used to measure temperature. Chromel traces and leads may be formed by deposition, or by peening.

[0029] A disposable DTT probe may be easily and inexpensively made using the support assembly construction embodiments described above. Disposability makes the commercialization of a DTT probe possible. Also, a single-use probe limits the potential for cross-contamination and makes it possible for more patients to benefit from perioperative temperature monitoring.

The invention disclosed herein also comprises features as set out in the following numbered paragraphs:

1. A deep tissue temperature probe with a support structure comprising: a substrate with two sides; a heater disposed on a periphery of the substrate; two support sections defined in the substrate and disposed within the periphery; two thermal sensors, each supported on a respective one of the support sections; and, a thermal resistor disposed between and separating the respective sections supporting the thermal sensors into strata.

2. The deep tissue temperature probe of paragraph 1, in which the substrate has a circumferential periphery and the two support sections are disposed in an opposing or an adjacent relationship, inwardly of the periphery.

3. The deep tissue temperature probe of paragraph 2, in which the substrate has the shape of an annulus with the heater disposed thereon and the two support sections project inwardly of the annulus.

4. The deep tissue temperature probe of paragraph 1, further comprising a lead support tab projecting outwardly of the circumferential periphery and leads on the lead support tab for the heater and the thermal sensors.

Claims

1. A deep tissue temperature probe (500) with a support assembly (200) comprising:

a two-sided substrate being coated with copper on both sides;
a plurality of sections (202, 204) defined in the substrate, in which each section is joined to at least one adjacent section at a common peripheral location (206);
two thermal sensors, each supported on a respective one of two adjacent sections and whose junctions (207, 209) are at the respective centers of the adjacent sections; the two adjacent sections folded together at the common peripheral location (206) joining the two sections; and
a thermal resistor disposed between the two thermal sensors when the two adjacent sections are folded,
at least one of the sections supports a heater,
wherein a first and a second signal lead (211, 213) are connected to the respective junction (207, 209) of each thermal sensor and a third common lead (215) is coupled to the common peripheral location (206) thereby electrically coupling both thermal sensors.

2. The deep tissue temperature probe of claim 1, wherein the plurality of sections are the two adjacent sections (202, 204), each of the two thermal sensors (207, 209) is mounted on a major support surface (203, 205) of a respective one of the two sections, and the sections are folded together in clam shell fashion such that the two thermal sensors face each other.

3. The deep tissue temperature probe of claim 1, wherein the substrate is comprised of a sheet of flexible material (601) with two sides.

4. The deep tissue temperature probe of claim 3, wherein the thermal sensors are thermocouples and the two sections (202, 204) are folded together in clam shell fashion such that the thermocouples are disposed in a stacked configuration.

5. The deep tissue temperature probe of claim 3, comprising: at least three sections (502, 504, 506) defined in the sheet; the three sections being folded together.

6. The deep tissue temperature probe of claim 1 or claim 5, wherein each section has opposing major support surfaces, a first thermal sensor is mounted on a first major support surface of a first section of the two adjacent sections, the second thermal sensor is mounted on a second major support surface of the second section of the two adjacent sections, and the three sections are folded together such that the two thermal sensors face in the same direction.

7. The deep tissue temperature probe of claim 6, further comprising a heater positioned to sandwich one of the two adjacent sections (506) between itself and the other of the two adjacent sections (504).

8. The deep tissue temperature probe of claim 7, wherein the heater is supported on a support surface of the third section (502).

9. The deep tissue temperature probe of claim 3, wherein the sheet is a flexible sheet of thermally insulating material (615).

10. The deep tissue temperature probe of claim 9, wherein each copper film is etched to form an element (517) of a respective one of the thermal sensors (518).

11. The deep tissue temperature probe of claim 10, in which the heater is positioned to sandwich one of the two thermal sensors (607, 608) between itself and the other of the two thermal sensors.

12. The deep tissue temperature probe of claim 11, wherein one copper film is etched to form the heater.

13. The deep tissue temperature probe of anyone of claims 5 to 12, in which the thermal sensors are thermocouples (518, 525; 607, 608; 711, 713).

14. The deep tissue temperature probe of claim 13, wherein each thermocouple includes a copper disk (517) supported on a surface of the respective section and a chromel wire (519) attached to the copper disk at a thermocouple junction.

Patentansprüche

1. Tiefgewebe-Temperatursonde (500) mit einer Stützanordnung (200), umfassend:

   ein zweiseitiges Substrat, das auf beiden Seiten mit Kupfer beschichtet ist;
   mehrere Abschnitte (202, 204), die in dem Substrat bestimmt sind, wobei jeder Abschnitt mit mindestens einem benachbarten Abschnitt an einer gemeinsamen peripheren Stelle (206) verbunden ist;
   zwei Wärmesensoren, die jeweils auf einem jeweiligen von zwei benachbarten Abschnitten gestützt werden und deren Verbindungsstellen (207, 209) an den jeweiligen Mittelpunkten der benachbarten Abschnitte liegen;
   wobei die zwei benachbarten Abschnitte an der gemeinsamen peripheren Stelle (206), welche die zwei Abschnitte miteinander verbindet, zusammengefaltet sind; und
   einen Heizwiderstand, der zwischen den zwei Wärmesensoren angeordnet ist, wenn die zwei benachbarten Abschnitte gefaltet sind,
   mindestens einer der Abschnitte stützt eine Heizvorrichtung,
   wobei eine erste und eine zweite Signalleitung (211, 213) mit der jeweiligen Verbindungsstelle (207, 209) jedes Wärmesensors verbunden sind und eine dritte, gemeinsame Leitung (215) an die gemeinsame periphere Stelle (206) gekoppelt ist, wodurch beide Wärmesensoren elektrisch gekoppelt sind.

2. Tiefgewebe-Temperatursonde nach Anspruch 1, wobei die mehreren Abschnitte die zwei benachbarten Abschnitte (202, 204) sind, wobei jeder der zwei Wärmesensoren (207, 209) auf einer Hauptstützfläche (203, 205) eines jeweiligen der zwei Abschnitte befestigt ist, und die Abschnitte muschelschalenartig derart zusammengefaltet sind, dass die zwei Wärmesensoren einander zugewandt sind.

3. Tiefgewebe-Temperatursonde nach Anspruch 1, wobei das Substrat aus einer Lage aus flexiblem Material (601) mit zwei Seiten besteht.

4. Tiefgewebe-Temperatursonde nach Anspruch 3, wobei die Wärmesensoren Thermoelemente sind und die zwei Abschnitte (202, 204) muschelschalenartig derart zusammengefaltet sind, dass die Wärmeelemente in einer gestapelten Konfiguration angeordnet sind.

5. Tiefgewebe-Temperatursonde nach Anspruch 3, umfassend: mindestens drei Abschnitte (502, 504, 506), die in der Lage bestimmt sind; wobei die drei Abschnitte zusammengefaltet sind.

6. Tiefgewebe-Temperatursonde nach Anspruch 1 oder Anspruch 5, wobei jeder Abschnitt einander entgegengesetzte Hauptstützflächen aufweist, wobei ein erster Wärmesensor auf einer ersten Hauptstützfläche eines ersten Abschnitts der zwei benachbarten Abschnitte befestigt ist, der zweite Wärmesensor auf einer zweiten Hauptstützfläche des zweiten Abschnitts der zwei benachbarten Abschnitte befestigt ist, und die drei Abschnitte derart zusammengefaltet sind, dass die zwei Wärmesensoren in dieselbe Richtung zeigen.

7. Tiefgewebe-Temperatursonde nach Anspruch 6, ferner umfassend eine Heizvorrichtung, die so angeordnet ist, dass einer der zwei benachbarten Abschnitte (506) zwischen ihr selbst und dem anderen der zwei benachbarten Abschnitte (504) liegt.

8. Tiefgewebe-Temperatursonde nach Anspruch 7, wobei die Heizvorrichtung auf einer Stützfläche des dritten Abschnitts (502) gestützt wird.

9. Tiefgewebe-Temperatursonde nach Anspruch 3, wobei die Lage eine flexible Lage aus thermisch isolierendem Material (615) ist.

10. Tiefgewebe-Temperatursonde nach Anspruch 9, wobei jede Kupferfolie geätzt ist, um ein Element (517) eines jeweiligen der Wärmesensoren (518) zu bilden.

11. Tiefgewebe-Temperatursonde nach Anspruch 10, bei der die Heizvorrichtung so angeordnet ist, dass einer der zwei Wärmesensoren (607, 608) zwischen ihr selbst und dem anderen der zwei Wärmesensoren liegt.

12. Tiefgewebe-Temperatursonde nach Anspruch 11, wobei ein Kupferfilm geätzt ist, um die Heizvorrichtung zu bilden.

13. Tiefgewebe-Temperatursonde nach einem der Ansprüche 5 bis 12, bei der die Wärmesensoren Thermoelemente (518, 525; 607, 608; 711, 713) sind.

14. Tiefgewebe-Temperatursonde nach Anspruch 13, wobei jedes Thermoelement eine Kupferscheibe (517) umfasst, die auf einer Oberfläche des jeweiligen Abschnitts gestützt wird, und einen Chromeldraht, der an einer Thermoelement-Verbindungsstelle an der Kupferscheibe befestigt ist.

Revendications

1. Sonde de température pour tissu profond (500) avec un ensemble support (200) comprenant:

   un substrat à deux faces étant revêtu de cuivre sur l'un et l'autre des côtés ;
   une pluralité de sections (202, 204) définies dans le substrat, dans laquelle chaque section est jointe à au moins une section adjacente au niveau d'un emplacement périphérique commun (206) ;
   deux capteurs thermiques, supportés chacun sur une section respective parmi deux sections adjacentes et dont les jonctions (207, 209) sont au niveau des centres respectifs des sections adjacentes ; les deux sections adjacentes pliées conjointement au niveau de l'emplacement périphérique commun (206) joignant les deux sections ; et
   une résistance thermique disposée entre les deux capteurs thermiques lorsque les deux sections adjacentes sont pliées,
   au moins une des sections supporte un élément chauffant,
   dans laquelle des premier et deuxième conducteurs de signal (211, 213) sont connectés à la jonction respective (207, 209) de chaque capteur thermique et un troisième conducteur commun (215) est couplé à l'emplacement

périphérique commun (206) ce qui, de ce fait, couple électriquement l'un et l'autre des capteurs thermiques.

2. Sonde de température pour tissu profond selon la revendication 1, dans laquelle la pluralité de sections sont les deux sections adjacentes (202, 204), chacun des deux capteurs thermiques (207, 209) est monté sur une surface de support principale (203, 205) d'une section respective parmi les deux sections, et les sections sont pliées conjointement à la façon d'une double coque de telle sorte que les deux capteurs thermiques se font face l'un l'autre.

3. Sonde de température pour tissu profond selon la revendication 1, dans laquelle le substrat est constitué d'une feuille de matériau souple (601) avec deux côtés.

4. Sonde de température pour tissu profond selon la revendication 3, dans laquelle les capteurs thermiques sont des thermocouples et les deux sections (202, 204) sont pliées conjointement à la façon d'une double coque de telle sorte que les thermocouples sont disposés dans une configuration empilée.

5. Sonde de température pour tissu profond selon la revendication 3, comprenant : au moins trois sections (502, 504, 506) définies dans la feuille ; les trois sections étant pliées conjointement.

6. Sonde de température pour tissu profond selon la revendication 1 ou la revendication 5, dans laquelle chaque section a des surfaces de support principales opposées, un premier capteur thermique est monté sur une première surface de support principale d'une première section des deux sections adjacentes, le deuxième capteur thermique est monté sur une deuxième surface de support principale de la deuxième section des deux sections adjacentes, et les trois sections sont pliées conjointement de telle sorte que les deux capteurs thermiques font face à la même direction.

7. Sonde de température pour tissu profond selon la revendication 6, comprenant en outre un élément chauffant positionné pour intercaler une des deux sections adjacentes (506) entre elle-même et l'autre des deux sections adjacentes (504).

8. Sonde de température pour tissu profond selon la revendication 7, dans laquelle l'élément chauffant est supporté sur une surface de support de la troisième section (502).

9. Sonde de température pour tissu profond selon la revendication 3, dans laquelle la feuille est une feuille souple de matériau thermiquement isolant (615).

10. Sonde de température pour tissu profond selon la revendication 9, dans laquelle chaque film de cuivre est gravé pour former un élément (517) d'un capteur respectif parmi les capteurs thermiques (518).

11. Sonde de température pour tissu profond selon la revendication 10, dans laquelle l'élément chauffant est positionné pour intercaler un des deux capteurs thermiques (607, 608) entre lui-même et l'autre des deux capteurs thermiques.

12. Sonde de température pour tissu profond selon la revendication 11, dans laquelle un film de cuivre est gravé pour former l'élément chauffant.

13. Sonde de température pour tissu profond selon l'une quelconque des revendications 5 à 12, dans laquelle les capteurs thermiques sont des thermocouples (518, 525 ; 607, 608 ; 711, 713).

14. Sonde de température pour tissu profond selon la revendication 13, dans laquelle chaque thermocouple inclut un disque de cuivre (517) supporté sur une surface de la section respective et un fil de Chromel fixé au disque de cuivre au niveau d'une jonction de thermocouple.

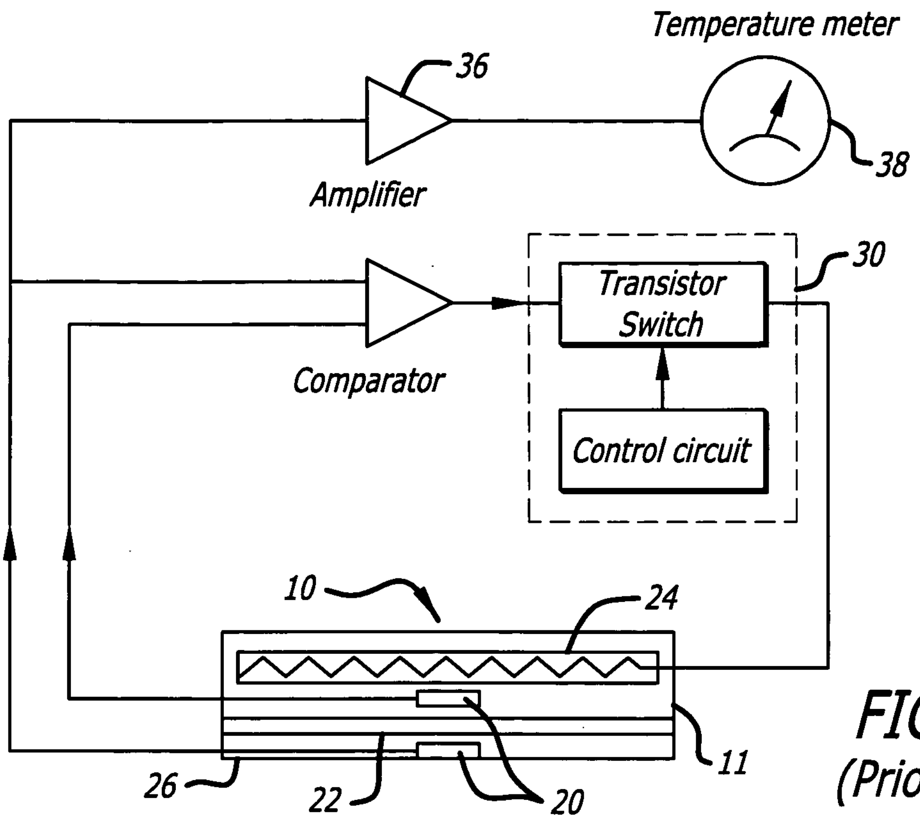


FIG. 1
(Prior Art)

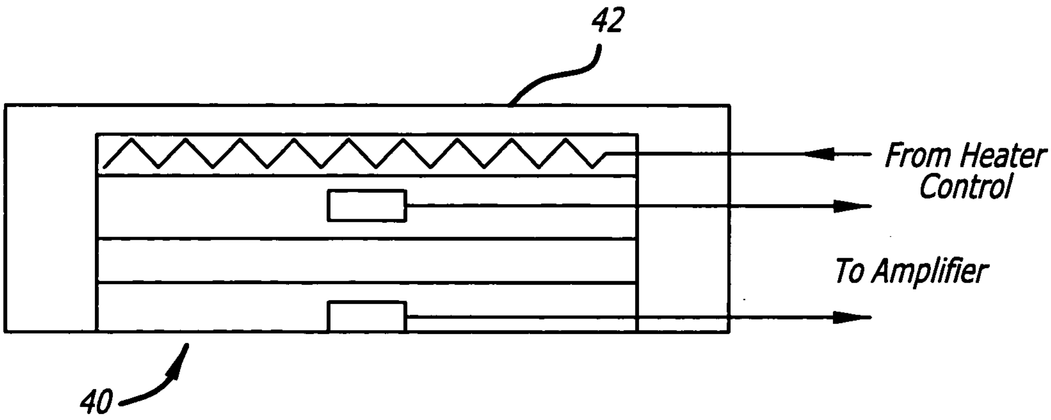


FIG. 2
(Prior Art)

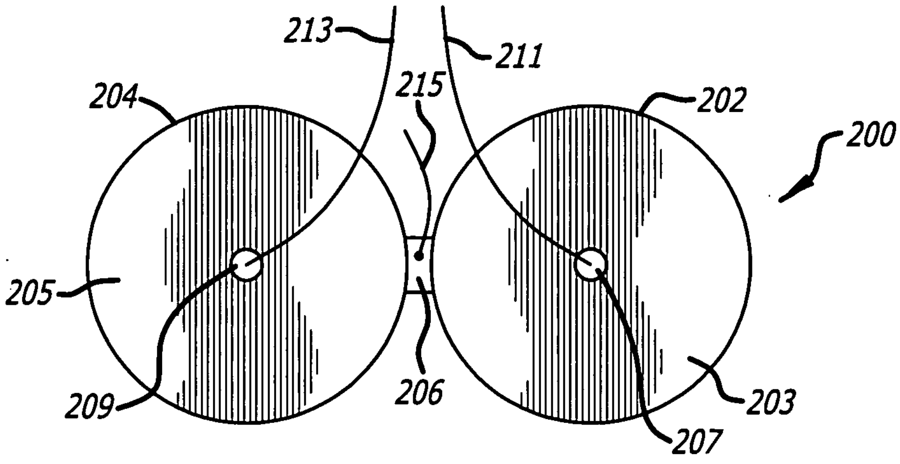

213
211
215
204
202
200
205
209
206
203
207

FIG. 3

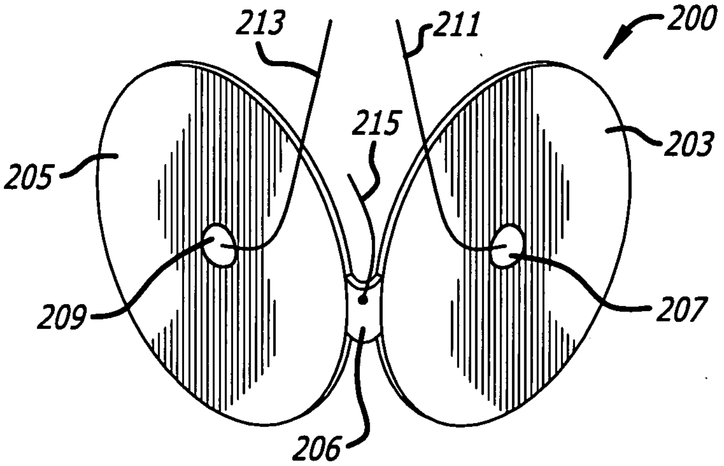

213
211
200
215
205
203
209
207
206

FIG. 4

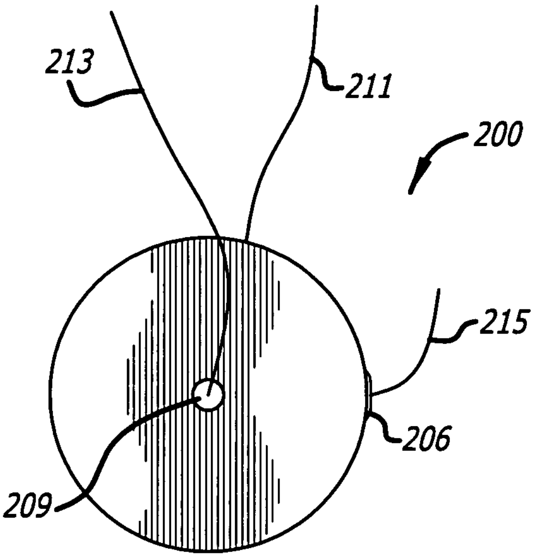

213
211
200
215
206
209

FIG. 5

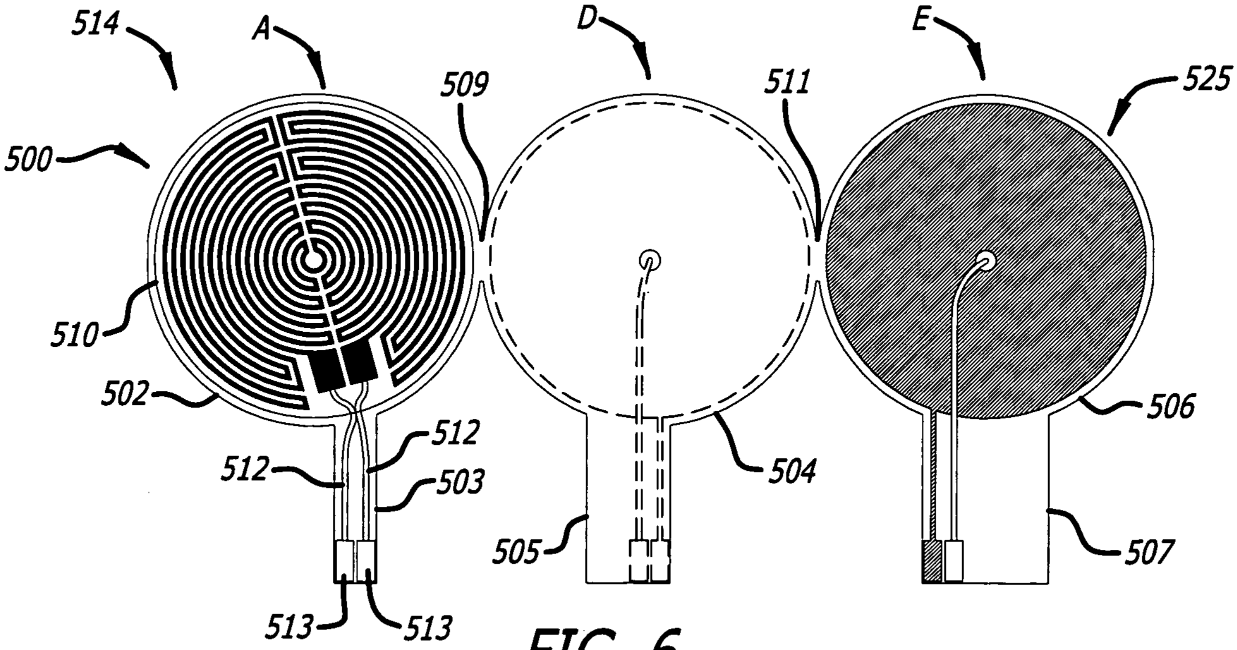

514
A
D
E
525
509
511
500
510
502
512
512
503
504
505
506
507
513
513

FIG. 6

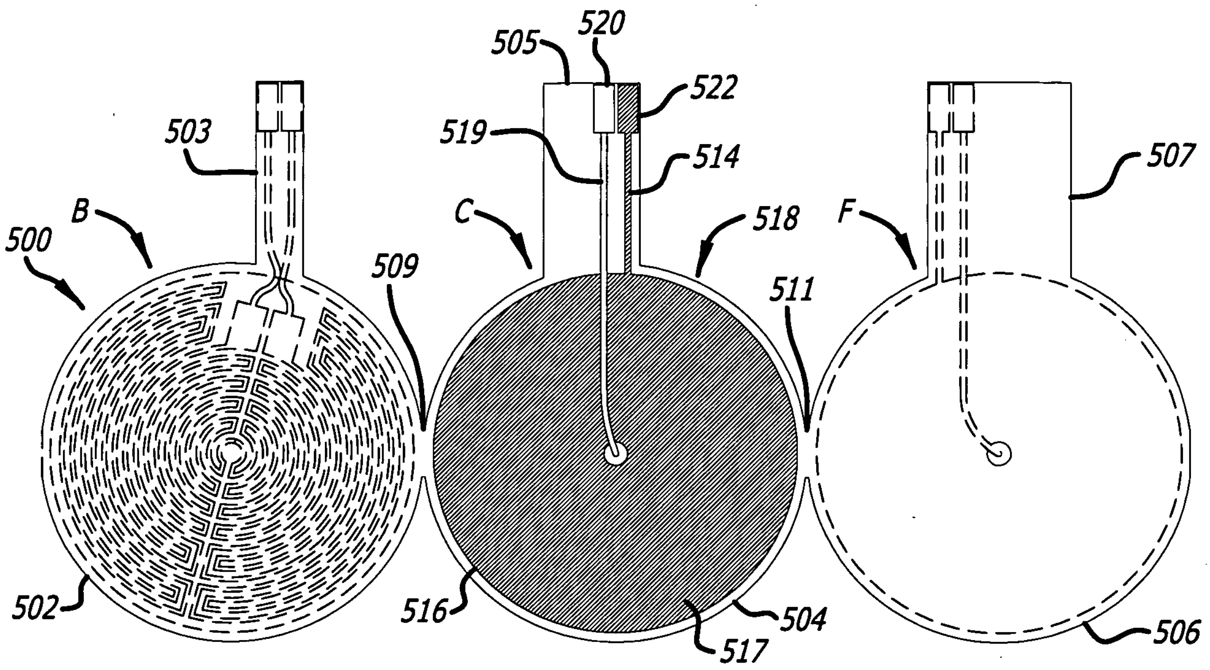

500
B
503
502
505
520
522
519
514
C
518
509
516
517
504
511
F
507
506

FIG. 7

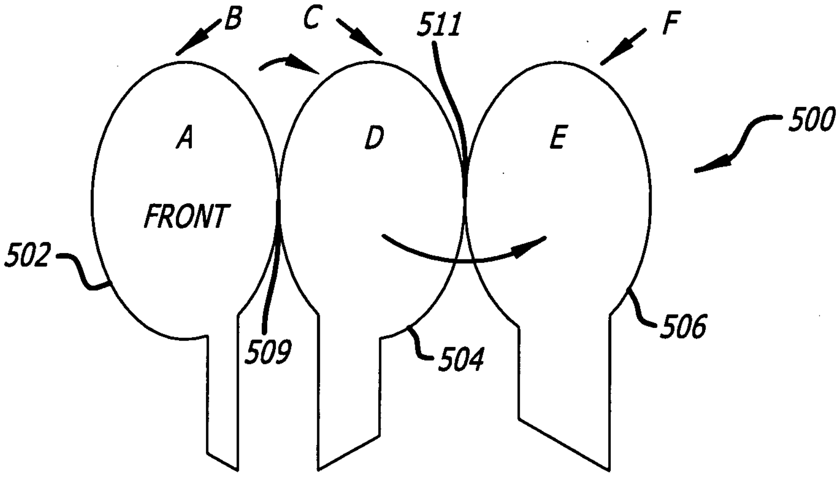
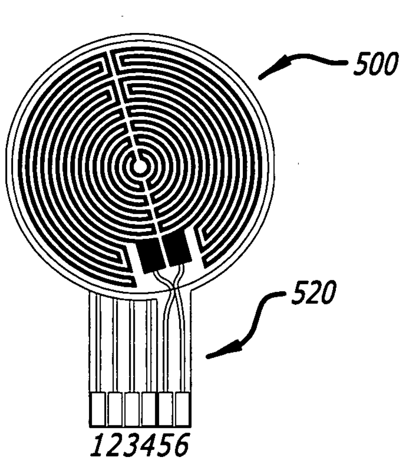

B
C
511
F
A
D
E
500
FRONT
502
509
504
506

FIG. 8



PIN	DESCRIPTION
1	COPPER-OUTER THERMOCOUPLE
2	CHROMEL-OUTER THERMOCOUPLE
3	COPPER-INNER THERMOCOUPLE
4	CHROMEL-INNER THERMOCOUPLE
5	HEATER
6	HEATER

FIG. 9

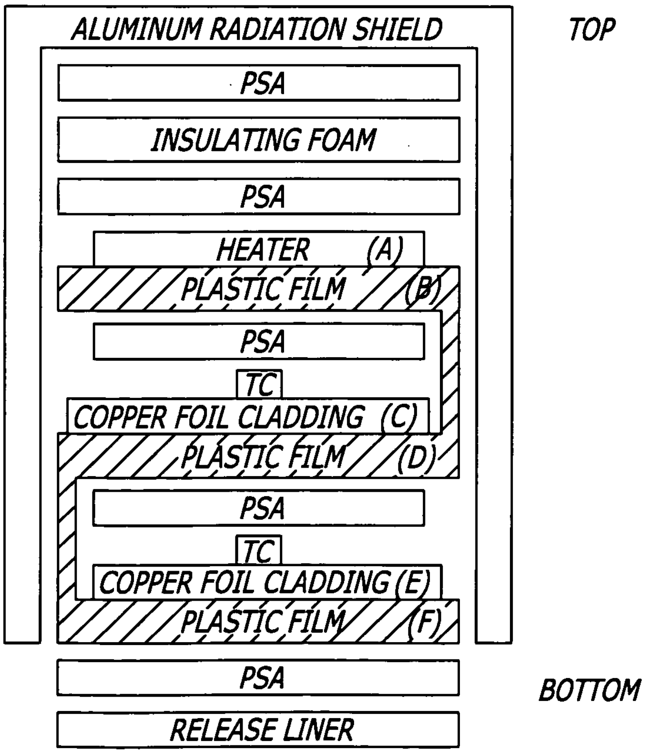


FIG. 10

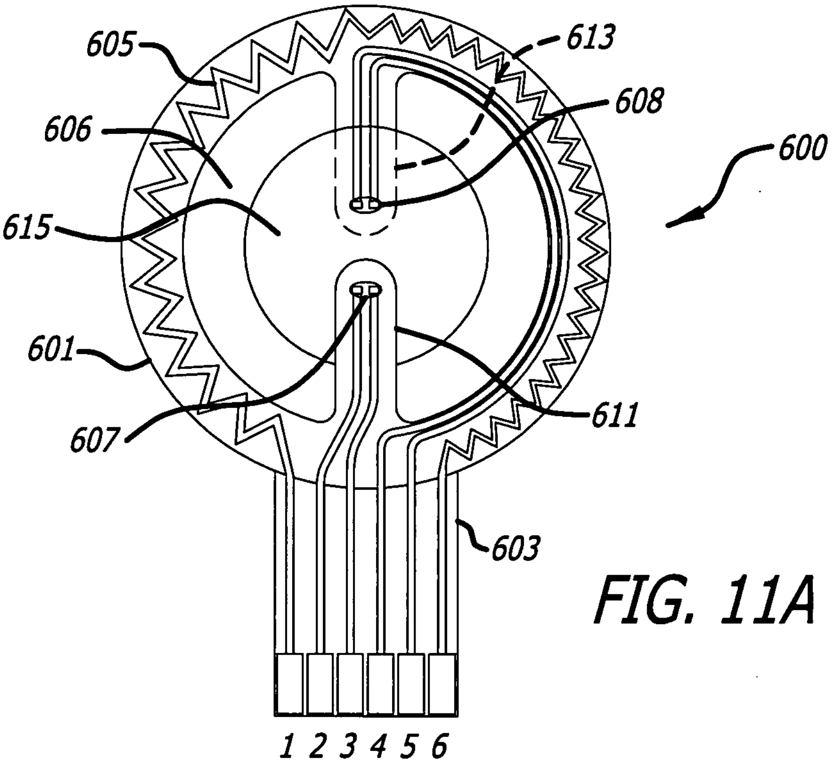


FIG. 11A

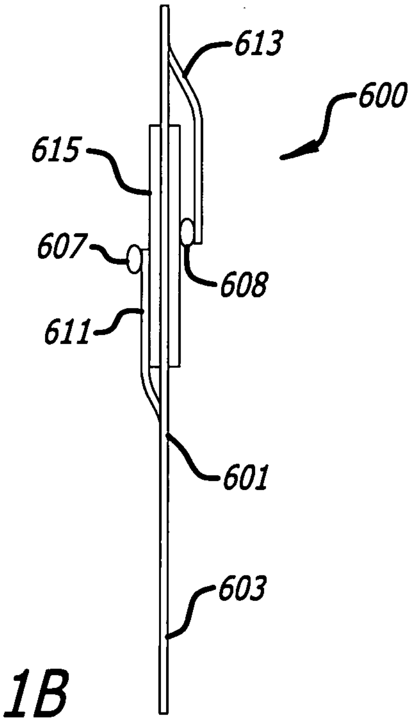


FIG. 11B

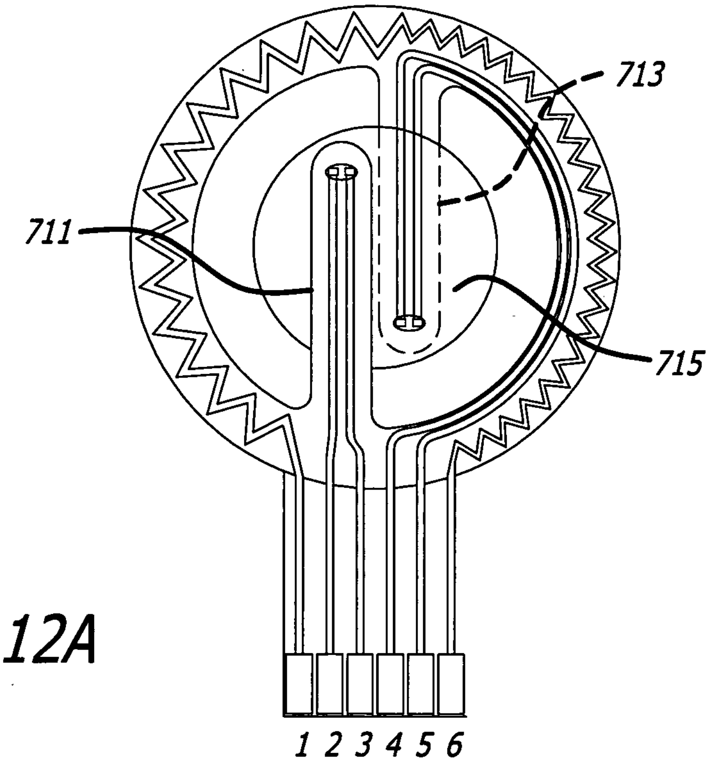


FIG. 12A

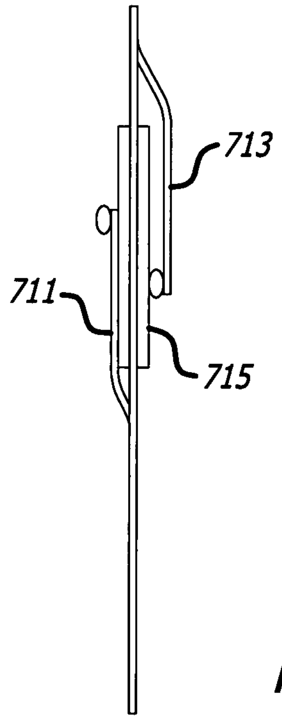


FIG. 12B

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 61212704 B **[0001]**
- US 3933045 A **[0008]**

Non-patent literature cited in the description

- **FOX RH ; SOLMAN AJ.** A new technique for monitoring the deep body temperature in man from the intact skin surface. *J. Physiol.,* January 1971, vol. 212 (2), 8-10 **[0003]**
- Non-Invasive Deep Body Temperature Measurement. **TOGAWA T.** Non-Invasive Physiological Measurements. Academic Press, 1979, vol. 1, 261-277 **[0004]**

专利名称(译)	深层组织温度探针结构		
公开(公告)号	EP2419004B1	公开(公告)日	2017-07-19
申请号	EP2010716132	申请日	2010-04-14
[标]申请(专利权)人(译)	阿里贊特保健公司		
申请(专利权)人(译)	ARIZANT HEALTHCARE INC.		
当前申请(专利权)人(译)	3M创新有限公司		
[标]发明人	VAN DUREN ALBERT P		
发明人	VAN DUREN, ALBERT, P.		
IPC分类号	A61B5/00 G01K13/00		
CPC分类号	A61B5/01 A61B5/6833 A61B2562/0271 A61B2562/0276 A61B2562/164 G01K1/16 G01K1/165 G01K13/002		
优先权	61/212704 2009-04-15 US		
其他公开文献	EP2419004A1		
外部链接	Espacenet		

摘要(译)

使用支撑组件构造一次性零热通量深组织温度探针（500），其中多个部分（502,504,506）折叠在一起或在探针组装期间分成层。这些部分支持探头元件，包括热传感器和热传感器之间的热敏电阻（517）。可选地，其中一个部分支撑加热器（514）。

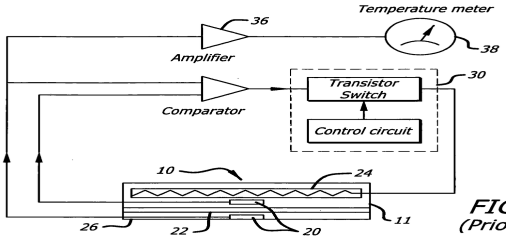


FIG. 1
(Prior Art)

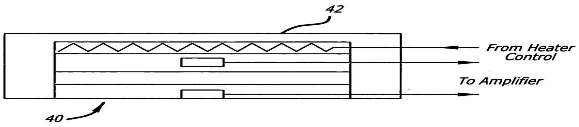


FIG. 2
(Prior Art)