

(19)



(11)

EP 2 791 639 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:

12.09.2018 Bulletin 2018/37

(51) Int Cl.:

G01K 11/00 (2006.01) **G01K 13/00** (2006.01)
A61B 5/01 (2006.01) **A61B 5/00** (2006.01)
H01Q 1/27 (2006.01) **H01Q 13/10** (2006.01)
A61B 5/1455 (2006.01) **A61F 7/00** (2006.01)
A61F 7/02 (2006.01)

(21) Application number: **12806255.1**

(22) Date of filing: **04.12.2012**

(86) International application number:
PCT/US2012/067681

(87) International publication number:
WO 2013/090047 (20.06.2013 Gazette 2013/25)

(54) **LOW PROFILE TEMPERATURE TRANSDUCER**

TEMPERATURWANDLER MIT NIEDRIGEM PROFIL

TRANSDUCTEUR DE TEMPÉRATURE À PROFIL BAS

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

(30) Priority: **13.12.2011 US 201161569848 P**

(43) Date of publication of application:
22.10.2014 Bulletin 2014/43

(73) Proprietor: **Meridian Medical Systems, LLC
Woolwich, ME 04579 (US)**

(72) Inventors:

- **CARR, Kenneth L.
Woolwich, Maine 04579 (US)**
- **ALLISON, Robert C.
Rancho Palos Verdes, California 90275 (US)**

(74) Representative: **Rupprecht, Kay et al
Meissner Bolte Patentanwälte
Rechtsanwälte Partnerschaft mbB
Widenmayerstraße 47
80538 München (DE)**

(56) References cited:
WO-A1-86/04800 US-B2- 8 062 228

EP 2 791 639 B1

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

BACKGROUND OF THE INVENTION

5 Field of the Invention

[0001] This invention relates to apparatus for reliably detecting and monitoring the temperature of human or animal tissue, including but not limited to the brain of a neonatal patient.

10 Background Information

[0002] The development of early thermography or radiometry occurred at the IR frequency range, taking advantage of the higher levels of emission there. Nevertheless, detection at those frequencies and detection at millimeter and microwave frequencies are all considered to be passive microwave sensing for purposes of this application.

15 **[0003]** During pediatric cardiac surgery, it is usually necessary to obtain circulatory arrest so that no blood is flowing in the patient's blood vessels. In order to minimize the likelihood of injury to the patient's organs, particularly the brain, the patient is covered with a cooling blanket which reduces the patient's core temperature by hypothermic cooling prior to actual surgery. During surgery, the patient's heart is stopped and the intent is to maintain a brain temperature in the range of 15-18° C. Operating time is normally between 15 and 30 minutes. If the surgical procedure extends beyond
20 that time, the infant's chances of survival decrease.

[0004] During the operation, since the patient's heart is stopped, there is no longer cold blood circulating through the blood vessels in the patient's brain. To prevent the patient's head being warmed by the ambient air of the operating room, during circulatory arrest, brain cooling is usually augmented by a cooling cap placed on the patient's head and through which a cooling fluid is circulated. All the while, a temperature sensor monitors the patient's brain temperature
25 and the cooling may be adjusted in response thereto to maintain the desired temperature. Thus, the hypothermic cooling in combination with temperature monitoring can not only control brain temperature but also control the rate of cooling of the brain, as well as the rate to re-warm it.

[0005] There has recently been developed a dual mode intracranial temperature detection apparatus designed especially for neonatal patients. It uses microwave radiometry to monitor both intracranial temperature at depth and surface temperature enabling close to control over the hypothermia process; see U.S. Patent 8,062,228 B2.
30

[0006] A patient's core temperature is usually measured by a rectal or esophageal temperature probe. However, quite often due to trauma or insult, the brain temperature is elevated so that a temperature measurement at those remote locations is no longer a reliable indication of brain temperature. What is needed is a better way to measure brain temperature at depth. In a study, we found that to do so, it became necessary to establish a relationship between core
35 temperature, surface temperature and radiometric temperature thereby allowing a determination of temperature verses depth in the target tissue, e.g. the brain.

[0007] FIG. 7 is a diagrammatic view of the temperature probe used in that study. It includes seven thermocouples T₁ to T₇ which were inserted to the indicated depths in the head of a young anesthetized pig. The temperature versus depth curves shown in FIG. 8 were derived from the thermocouple measurements. We found that the difference in
40 temperature between the 2mm (near surface) and the temperature deep within the brain was about 2° C and that the curve for both the normothermic otherwise and cooled animal was identical.

[0008] FIG. 9 shows the fraction of total received signal power versus target tissue depth from antenna simulations. The radiometer does not measure the temperature at a specific point. Rather, it measures the average temperature based on the antenna pattern. This average temperature is the summation for all depths of the received power contributions from FIG. 9 multiplied by the temperatures at each depth from FIG. 8. With that and the surface temperature,
45 the temperature at depth may be calculated from:

Deep depth

50
$$T_{\text{radiometer}} = \int_{0 \text{ depth}}^{40 \text{ mm}} \text{antenna factor} \times \text{temp. at depth} \times d(\text{depth})$$

where:

55 antenna factor = fraction of total received power per mm of depth from FIG. 9;
temperature at depth = temperatures from FIG. 8.

[0009] The above-described patented apparatus employs a microwave transducer designed to be positioned on the

patient's head. However, if the patient is wearing a cooling blanket and/or cap as described the transducer, which has a relatively high profile, e.g. 2.5 cm, protrudes appreciably from the patient's head. This protrusion makes attachment of the device to the patient somewhat difficult and also interferes with the cooling blanket and/or cap in that it lifts the cooling blanket/cap away from the patient's head which results in improper cooling of the patient in the region where the transducer is applied.

[0010] Moreover, an apparatus for detecting the infiltration of the liquid through the vascular wall into perivascular tissues is known from WO 86/04800 A1, whereby the apparatus includes a non-invasive conformal microwave antenna means adapted to be positioned over the area where liquid infusion occurs. A microwave radiometer connects from the antenna means for detecting sub-cutaneous temperature at the side thereof whereby a reference antenna means is also employed so that a proper temperature differential can be established. Accordingly, there is a need to provide apparatus which can monitor a patient's intracranial and near surface temperatures using a single, low profile transducer able to be affixed to the patient's forehead without interfering with any EEG electrodes present on the patient's scalp and without lifting a cooling cap or blanket covering the patient's cranium.

SUMMARY OF THE INVENTION

[0011] It is thus an object of this invention to provide an improved cerebral temperature transducer for monitoring a patient's brain tissue temperature.

[0012] Another object of the invention is to provide such a transducer which has an especially low profile so that it does not protrude appreciably from the forehead of a small patient such as a neonate.

[0013] A further object of the invention is to provide a cerebral temperature transducer which does not interfere with ancillary medical devices such as EEG electrodes, cooling/warming coverings and the like.

[0014] Still another object of the invention is to provide a transducer of this type which can sense both deep and near surface temperatures of a selected area of a patient's body.

[0015] Other objects will, in part, be obvious and will, in part, appear hereinafter.

[0016] The invention accordingly comprises the features of construction, combination of elements and arrangement of parts as described in the appended claims, which will be exemplified in the construction hereinafter set forth.

[0017] Briefly, the present apparatus includes a temperature transducer which has an especially low profile enabling it to be releasably affixed to the forehead of a patient. While the apparatus has particular application to measuring the cerebral temperature of small patients such as neonates, it may also be used on adults and at other locations on the body.

[0018] The transducer includes one or more slotline antennas arranged and adapted to pick up thermal emissions from relatively deep in the patient's tissue as well as a separate sensor arranged to detect the skin or near surface temperature of the patient. The transducer is shaped and dimensioned so that it does not appreciably lift a cooling blanket or clothing that may cover the patient or otherwise interfere with ancillary sensors and other medical devices affixed to the patient.

[0019] In use, the transducer is connected to an external control unit which produces output signals reflecting the skin temperature and temperature at depth of the target area over to control a display which can present the two temperature to surgical personnel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] For a fuller understanding of the nature and objects of the invention, reference should be made to the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a diagrammatical view of monitoring apparatus comprising a dual mode temperature transducer incorporating the invention;

FIG. 2 is a perspective view from below, on a larger scale, showing the transducer in greater detail;

FIG. 3 is a sectional view taken along line 3-3 of FIG. 2, on a still larger scale, depicting the individual layers 1 to 9 of the transducer;

FIG. 4 is a bottom plan view of the transducer in FIG. 3 with layers 6-9 thereof removed;

FIG. 5 is a fragmentary perspective view, on an even larger scale, of the FIG. 3

transducer with layers 8 and 9 and half of layers 6 and 7 removed to show layer 5;

FIGS. 6A and 6B together illustrate an antenna field pattern that may be produced by the transducer;

FIG. 7, already described, is a diagrammatic view of a thermocouple probe used in animal studies to develop a temperature-at-depth algorithm for processing the output of the FIG. 1 transducer.

FIG. 8, already described, is a graph of temperature versus depth used with the FIG. 7 probe, and

FIG. 9 already described, is a graph showing the antenna factor used to develop the temperature-at-depth algorithm.

DETAILED DESCRIPTION OF AN ILLUSTRATIVE EMBODIMENT

[0021] Referring to FIGS. 1 and 2 of the drawings, the present apparatus includes a flat, low-profile, plural-layer laminated transducer shown generally at 10 which may be removably affixed to the forehead of a patient P, such as a neonate in preparation for pediatric cardiac surgery. Of course, the transducer may also be affixed to other parts of a human or animal body to measure the temperatures of the underlying tissue.

[0022] As best seen in FIG. 2, the transducer 10 may have a working surface 10_w formed to fit the contour of the placement site, in this case the forehead of patient P. The transducer may be held in place by an adhesive indicated by stippling 11 on surface 10_w and/or by an adjustable, and possibly flexible, headband H attached to the transducer and releasably engaged around the patient's head. If desired, the transducer including the headband may be formed as a low cost, disposable, one-time-use unit.

[0023] Also, it is sometimes desirable that a shallow dome (not shown) be present at the working surface 10_w of transducer 10 to minimize the likelihood that an air pocket will form between the transducer 10 and the skin surface of patient P.

[0024] Should the surface tissue of patient P not be sufficiently soft to allow proper placement of the transducer, a disposable interface similar to the interface described in the above patent may be interposed between the transducer and the patient.

[0025] As shown in FIG. 1, during surgery, the patient's cranium is preferably covered by a cooling cap or blanket C connected via tubing C_t to a cooling device C_d which circulates a cooling fluid through the cap or blanket to cool the patient's brain to maintain to a low temperature in the order of 15-18° C.

[0026] As we shall see, transducer 10 contains a pair of temperature sensors capable of detecting temperatures at two different depths in the patient's cranium, i.e. a temperature at depth (at least 15 mm deep) and a near surface or skin temperature (about 2mm deep), and producing corresponding output signals which are coupled via a cable 14 to a control unit 16. That unit includes a radiometric receiver 16a which, under the control of a processor/controller 16b, produces an output signal which reflects the brain temperature at depth. The processor/controller also receives the output of the near surface sensor and produces a signal reflecting the near surface temperature. Unit 16 may also include a display 16c which responds to those signals to provide a visible indication of the two temperatures. Unit 16 may be turned on and off and controlled by way of a keypad 16d.

[0027] The temperature detecting component of transducer 10 which detects temperature at depth comprises a stripline antenna assembly shown generally at 22 in FIGS. 2 and 4 and which will be described in detail later. This assembly receives microwave emissions picked up by the assembly from relatively deep in the patient's cranium. These signals are combined in a feed network 24 on a circuit board 26 extending from the transducer 10 before being applied to a conductor 14a of cable 14. Preferably, that feed network appendage 24, 26 does not contact the patient's body.

[0028] On the other hand, the sensor for detecting the near surface temperature may comprise a conventional thermistor, thermocouple or infrared (IR) sensing device 28 placed at or near the center of the transducer's working surface 10_w so that it will not perturb the aperture of antenna assembly 22. One suitable tiny (1.6 mm²) IR chip is Model TMP006 made by Texas Instruments. The device 28 may be connected by printed paths 28a on circuit board 26 to conductor 14b of cable 14.

[0029] When the transducer 10 is in contact with the patient's cranium as shown in FIG. 1, the device 28 senses the temperature at a single location near the surface of the patient's cranium. Also, the antenna assembly 22 creates a desirably shaped microwave field pattern extending relatively deep in the patient's brain tissue. This allows the collection of microwave energy for determining the temperature within the volume of the field pattern relatively deep in the patient's cranium using microwave radiometry.

[0030] Thus, transducer 10 is an advance over the previous transducer designs in that the physical volume and weight of the transducer are much less than those of prior dielectric-loaded waveguide transducers such as the ones disclosed in the above patent. More particularly, the thickness of the transducer 10 above the patient's skin is quite small, typically less than 2mm, and the contact area between the transducer and the skin is also minimized, i.e. 3.14 cm² vice 5.53 cm². As we shall see, transducer 10 functions also to provide an impedance transformation or match from the body tissue impedance to a convenient microwave transmission line impedance, e.g., 50 ohms.

[0031] Refer now to FIGS. 3 and 4 which show transducer 10 in greater detail. It comprises alternating layers of dielectric material and metal plating that can be manufactured using conventional multilayer circuit board technology. In FIG. 3, the metal layers are layers 1, 3, 5, 7 and 9 and the dielectric layers are layers 2, 4, 6 and 8. In FIG. 4 (and FIG. 5), the stippled areas comprise layer 2. The illustrated dielectric layers are of a low loss material. The circuit board extension 26 mentioned above may be an extension of the dielectric layer 4 or 6. The dielectric layers 2 and 8 may have a thickness in the order of 20 mils, while the dielectric layers 4 and 6 may be as thin as 5 mils. The metal layers may have a thickness of about 1 mil.

[0032] The metal layer 1 at the working surface 10_w of the transducer faces the patient's skin and defines an aperture 34 of the transducer 10 that allows the microwave fields emanating from the patient to pass through to an array of metal slots 36 in metal layers 3 and 7 that comprise slotline antennas. These layers 3 and 7 constitute ground conductor layers forming a stripline structure comprised of layers 3, 4, 5, 6 and 7, the structure converting the microwave fields to stripline transmission line signals. In the illustrated transducer, there are four slots 36. However, there could be more or less depending upon size of the aperture 34 and the particular application. The primary mode in each slot transmission line or antenna formed by a slot 36 is the TE mode. As noted above, the skin temperature sensor 28 is located in the center area between adjacent slots 36 so that it does not perturb the transmit/receive paths of those antennas.

[0033] As shown in FIGS. 3 to 5, the two metal layers 3 and 7 are electrically connected together by metal plated holes 38 in the dielectric layers 4 and 6, the holes being spaced apart around the peripheries of the slots 36. In FIG. 5, layers 4, 6 and half of layer 7 have been removed for clarity and the holes 38 are shown as having square cross sections, but to the cross-section could also be round or some other shape.

[0034] Metal layer 5, which is midway between ground layers 3 and 7, is the stripline conductor layer. It may be printed on either layer 4 or 6. Layer 5 forms two stripline conductors 5a and 5b which span each slot and connect to the ground layers 3 and 7 on one side of the associated slot by way of selected ones of the plated holes 38 to form the transition from slot transmission line to stripline with impedance matching. These two conductors are optimally located along the corresponding slot to produce a desirable body tissue field pattern in the direction of the slot length.

[0035] As best seen in FIGS. 4 and 5, the stripline conductors 5a and 5b at each slot connect to impedance matching circuits created from stripline stubs 5c and 5d formed by metal layer 5 to efficiently couple the slot transitions to the characteristic impedance of the stripline feed network 24. More particularly, the two stubs at the uppermost slot 36 are connected by a bridging trace 5e to one leg 24a of feed network 24. Similar traces 5e associated with the other three slots 36 are likewise connected to branches 24b-24d, respectively, of network 24. The branches 24a and 24h are combined at a leg 24e of the network and the branches 24c and 24d are combined at a leg 24f and the outputs of those legs are combined at conductor 14a of cable 14 which carries the two transducer outputs.

[0036] Thus, the network 24 is a reactive power combiner network that brings the signals from each of the stripline/slot transitions in transducer 10 together at a single output. If additional bandwidth is required, this network may be replaced by a broad band Wilkinson combiner network; See H. Howe, "Stripline Circuit Design," pp. 94, 95. In the illustrated transducer 10, the output transitions to a coaxial cable, but it could transition to a connector or other conventional transmission line scheme. In any event, the feed network 24 and the stubs and traces 5c to 5e and 28a formed by the metal layer 5 are routed in the stripline areas between the slots 36 to avoid interfering with the slot function.

[0037] The dielectric layer 8 best seen in FIG. 3 forms a dielectric-filled cavity with the metal layer 9 behind the stripline. Edge plating 46 connects metal layers 1 and 9 to form a grounded metal enclosure or shield around the transducer 10 to exclude interference from exterior sources. Spaced-apart plated through holes or screws (not shown) in the dielectric layers connecting layers 1 and 9 at the peripheries thereof could also perform this function.

[0038] Although the illustrated transducer has four slots 36, each fed by a pair of stripline conductors 5a, 5b, other numbers of slots and feed points (conductors 5a, 5b) are possible depending upon the particular application. As mentioned above, the transducer 10 should conform to the shape of the patient's cranium. To facilitate this, the dielectric layers 2, 4, 6 and 8 may be of a somewhat pliable or conformable material such as Rogers 5880 material.

[0039] Each slot 36 produces a dipole-like antenna pattern and the patterns of the four slots are additive. FIGS. 6A and 6B illustrate the shape of combined field pattern produced by the four-slot antenna assembly 22, taken along the Y/Z and X/Z axes, respectively.

[0040] In control unit 16 (FIG. 1), the output of the antenna assembly 22 is applied to radiometer 16a under the control of the processor/controller 16b to cause the display 16c to display the temperature at depth in the patient's cranium. At the same time, the output signal from sensing device 28, representing the near surface temperature of the patient, is coupled to display 16c so that both intracranial temperature and the near surface temperature of patient P are presented simultaneously to medical personnel. Desirably, the processor/controller 16b, using the algorithm described above, processes the near surface temperature signal from sensing device 28 and the intracranial temperature provided by the radiometer to provide a more accurate representation of the temperature at depth that is displayed by display 16c.

[0041] It will thus be seen that the objects set forth above among those made apparent from the preceding description are efficiently attained. Also, certain changes may be made in the above construction. For example, slot(s) 36 may be present only in metal layer 3 in which case layers 6 and 7 may be omitted thereby placing layer 8 against layer 5. Also,

the transducer may incorporate an oxygen saturation sensor as described in application No. 13/459,391, filed 04/30/2012.

Claims

5

1. A low profile temperature transducer (10) having a working surface (10w) for placement against a body surface to pick up thermal emissions at depth and produce a corresponding first transducer (10) output, **characterized by** said transducer (10) comprising a flat laminate composed of alternating conductive (1, 3, 5, 7, 9) and dielectric (2, 4, 6, 8) layers which define at least one slotline antenna (22) having at least one slot (36) formed in at least one conductive layer (3, 7) adapted to receive thermal radiation emanating from said body surface and produce a corresponding antenna (22) output, a feed network (24) having a characteristic impedance connected to said first transducer (10) output and a slotline-to-stripline transition (5a, 5b, 38) connected between the at least one antenna (22) and the feed network (24), said transition (5a, 5b, 38) providing a match between the impedance at the at least one antenna (22) and said characteristic impedance, wherein

10

15

- a first metal layer (1) at the working surface (10w) defines an antenna aperture;
- a second metal layer (3) beyond the first metal layer (1) is slotted to form the at least one slotline antenna (22), said first and second layers (1, 3) being grounded, and
- a third metal layer (5) beyond the second metal layer (3) includes said feed network (24) and said transition (5a, 5b, 38),

20

and wherein

25

- said transition (5a, 5b, 38) comprises a pair of stripline traces (5a, 5b) which bridge each slotline antenna (22) at selected spaced-apart locations along the length thereof, one end of each stripline trace (5a, 5b) being connected to the second metal layer (3), and a stub trace (5c, 5d) connected to the other end of each stripline trace (5a, 5b) to provide said impedance match, and
- said feed network (24) comprises electrical connections between the stub traces (5c, 5d) associated with each pair of stripline traces (5a, 5b) and said first transducer (10) output.

30

2. The transducer (10) defined in claim 1, wherein said at least one antenna (22) comprises two or more similar antennas, and the feed network (24a, 24b, 24c, 24d, 24e, 24f) combines the outputs of all the antennas at said first transducer (10) output.

35

3. The transducer (10) defined in any one of claims 1 or 2, wherein a fourth metal layer (7) beyond the third metal layer (5) is slotted in the same configuration as the second metal layer (3) and the corresponding slots of the second and fourth metal layers (3, 7) are connected electrically at the slot perimeters to form the at least one antenna (22).

40

4. The transducer (10) defined in claim 3, wherein plated through holes (38) are provided in the dielectric layers (2, 4, 6, 8) between the second and fourth metal layers (3, 7) to electrically connect the perimeters of those metal layers.

45

5. The transducer (10) defined in any one of claims 1 to 4, wherein said first metal layer (1) is part of a grounded conductive shield that surrounds all the other layers to exclude outside electrical effects.

50

6. The transducer (10) defined in any one of claims 1 to 5 and further including a temperature sensor (28) affixed to said working surface (10w) for sensing the temperature of the body surface under the transducer (10), an output of the sensor constituting a second transducer output.

55

7. The transducer (10) defined in claim 6, wherein said temperature sensor (28) is selected from the group consisting of the infrared sensor, thermister and thermocouple.

55

8. The transducer (10) defined in any one of claims 1 to 7 and further including a blood oxygen saturation sensor at said working surface (10w).

9. Temperature measuring apparatus comprising:

- the transducer (10) defined in any one of claims 1 to 8, and
- a radiometer (16a) connected to receive the first transducer (10) output and produce a corresponding temperature signal and a processor (16b) for processing the temperature signal and said temperature sensor (28) output to provide an indication of the actual temperature at depth under the transducer (10).

Patentansprüche

1. Temperaturwandler (10) mit niedrigem Profil mit einer Arbeitsoberfläche (10w) zur Anordnung gegen eine Körperoberfläche zum Aufnehmen von thermischen Emissionen in einer Tiefe und zum Erzeugen einer entsprechenden ersten Ausgabe des Wandlers (10),

dadurch gekennzeichnet, dass

der Wandler (10) ein flaches Laminat aufweist, das aus abwechselnden leitenden (1, 3, 5, 7, 9) und dielektrischen (2, 4, 6, 8) Schichten besteht, die mindestens eine Schlitzleitungsantenne (22) mit mindestens einem Schlitz (36) definieren, der in mindestens einer leitenden Schicht (3, 7) ausgebildet ist, ausgelegt, um Wärmestrahlung aufzunehmen, die von der Körperoberfläche ausgeht, und eine entsprechende Antennenausgabe (22) zu erzeugen; ein Speisernetz (24) mit einer charakteristischen Impedanz, die mit der ersten Ausgabe des Wandlers (10) verknüpft ist, und einen Schlitzleitungs-Streifenleitungs-Übergang (5a, 5b, 38), der zwischen der mindestens einen Antenne (22) und dem Speisernetz (24) verbunden ist, wobei der Übergang (5a, 5b, 38) eine Anpassung zwischen der Impedanz an der zumindest einen Antenne (22) und der charakteristischen Impedanz bewirkt, wobei

- eine erste Metallschicht (1) auf der Arbeitsoberfläche (10w) eine Antennenöffnung definiert;
- eine zweite Metallschicht (3) jenseits der ersten Metallschicht (1) mit Schlitz versehen ist, um die mindestens eine Schlitzleitungsantenne (22) zu bilden, wobei die erste und die zweite Schicht (1, 3) an Erde gelegt sind; und
- eine dritte Metallschicht (5) jenseits der zweiten Metallschicht (3) das Speisernetz (24) und den Übergang (5a, 5b, 38) aufweist,

und wobei

- der Übergang (5a, 5b, 38) ein Paar von Streifenleiterbahnen (5a, 5b) aufweist, die jede Schlitzleitungsantenne (22) an ausgewählten, im Abstand angeordneten Stellen entlang deren Länge überbrücken, wobei ein Ende jeder Streifenleiterbahn (5a, 5b) mit der zweiten Metallschicht (3) verbunden ist und eine Stichleiterbahn (5c, 5d) mit dem anderen Ende jeder Streifenleiterbahn (5a, 5b) verbunden ist, um die Impedanzanpassung zu bewirken, und
- das Speisernetz (24) elektrische Verbindungen zwischen den jedem Paar von Streifenleiterbahnen (5a, 5b) zugeordneten Stichleiterbahnen (5c, 5d) und der ersten Ausgabe des Wandlers (10) umfasst.

2. Wandler (10) nach Anspruch 1, wobei die mindestens eine Antenne (22) zwei oder mehrere ähnliche Antennen aufweist und das Speisernetz (24a, 24b, 24c, 24d, 24e, 24f) die Ausgaben aller Antennen an der ersten Ausgabe des Wandlers (10) kombiniert.

3. Wandler (10) nach einem der Ansprüche 1 oder 2, wobei eine vierte Metallschicht (7) jenseits der dritten Metallschicht (5) in der gleichen Anordnung wie die zweite Metallschicht (3) mit Schlitz versehen ist und die entsprechenden Schlitz der zweiten und vierten Metallschicht (3, 7) an den Schlitzumfängen elektrisch verbunden sind, um die zumindest eine Antenne (22) zu bilden.

4. Wandler (10) nach Anspruch 3, wobei die durchkontaktierten Löcher (38) in den dielektrischen Schichten (2, 4, 6, 8) zwischen der zweiten und vierten Metallschicht (3, 7) vorgesehen sind, um die Umfänge dieser Metallschichten elektrisch zu verbinden.

5. Wandler (10) nach einem der Ansprüche 1 bis 4, wobei die erste Metallschicht (1) Teil einer geerdeten, leitenden Abschirmung ist, die alle anderen Schichten umgibt, um elektrische Wirkungen von außen auszuschließen.

6. Wandler (10) nach einem der Ansprüche 1 bis 5, und des Weiteren umfassend einen an der Arbeitsoberfläche (10w) befestigten Temperatursensor (28) zum Fühlen der Temperatur der Körperoberfläche unter dem Wandler (10),

wobei eine Ausgabe des Sensors eine zweite Ausgabe des Wandlers darstellt.

- 5 7. Wandler (10) nach Anspruch 6,
wobei der Temperatursensor (28) aus der Gruppe ausgewählt ist, die aus dem Infrarotsensor, Thermistor und
Thermoelement besteht.
8. Wandler (10) nach einem der Ansprüche 1 bis 7 und des Weiteren umfassend einen Blutsauerstoffsättigungssensor
an der Arbeitsoberfläche (10w).
- 10 9. Temperaturmessvorrichtung, umfassend:
- den Wandler (10), der in einem der Ansprüche 1 bis 8 definiert ist, und
 - einen Strahlungsmesser (16a), der zum Empfangen der ersten Ausgabe des Wandlers (10) und zum Erzeugen
eines entsprechenden Temperatursignals verbunden ist, und einen Prozessor (16b) zur Verarbeitung des Tem-
peratursignals und der Ausgabe des Temperatursensors (28), um eine Anzeige der aktuellen Temperatur in
15 einer Tiefe unter dem Wandler (10) bereitzustellen.

Revendications

- 20 1. Transducteur de température à profil bas (10) ayant une surface de travail (10w) destinée à être placée contre une
surface du corps pour capter des émissions thermiques en profondeur et produire une première sortie du transducteur
(10) correspondante, **caractérisé en ce que** ledit transducteur (10) comprend un stratifié plat composé de couches
conductrices (1, 3, 5, 7, 9) et diélectriques (2, 4, 6, 8) alternées qui définissent au moins une antenne à ligne-fente
25 (22) ayant au moins une fente (36) formée dans au moins une couche conductrice (3, 7), adaptée à recevoir un
rayonnement thermique émanant de ladite surface du corps et produire une sortie d'antenne (22) correspondante,
un réseau d'alimentation (24) ayant une impédance caractéristique connectée à ladite première sortie du transduc-
teur (10) et une transition de ligne-fente à ligne-ruban (5a, 5b, 38) connectée entre ladite au moins une antenne
(22) et le réseau d'alimentation (24), ladite transition (5a, 5b, 38) assurant une adaptation entre l'impédance à ladite
30 au moins une antenne (22) et ladite impédance caractéristique, dans lequel
- une première couche métallique (1) sur la surface de travail (10w) définit une ouverture d'antenne ;
 - une deuxième couche métallique (3) au-delà de la première couche métallique (1) est fendue pour former
ladite au moins une antenne à ligne-fente (22), lesdites première et deuxième couches (1, 3) étant mises à la
35 terre, et
 - une troisième couche métallique (5) au-delà de la deuxième couche métallique (3) inclut ledit réseau d'ali-
mentation (24) et ladite transition (5a, 5b, 38),
- et dans lequel
- 40 - ladite transition (5a, 5b, 38) comprend une paire de pistes de ligne-ruban (5a, 5b) qui pontent chaque antenne
à ligne-fente (22) à des emplacements espacés sélectionnés sur sa longueur, une extrémité de chaque piste
de ligne-ruban (5a, 5b) étant connectée à la deuxième couche métallique (3), et une piste de souche (5c, 5d)
connectée à l'autre extrémité de chaque piste de ligne-ruban (5a, 5b) pour fournir ladite adaptation d'impédance,
45 et
- ledit réseau d'alimentation (24) comprend des connexions électriques entre les pistes de souche (5c, 5d)
associées à chaque paire de pistes de ligne-ruban (5a, 5b) et ladite première sortie du transducteur (10).
- 50 2. Transducteur (10) selon la revendication 1,
dans lequel ladite au moins une antenne (22) comprend deux antennes similaires ou plus, et le réseau d'alimentation
(24a, 24b, 24c, 24d, 24e, 24f) combine les sorties de toutes les antennes à ladite première sortie du transducteur (10).
- 55 3. Transducteur (10) selon l'une quelconque des revendications 1 ou 2,
dans lequel une quatrième couche métallique (7) au-delà de la troisième couche métallique (5) est fendue dans la
même configuration que la deuxième couche métallique (3) et les fentes correspondantes des deuxième et quatrième
couches métalliques (3, 7) sont connectées électriquement au niveau des périmètres de fentes pour former ladite
au moins une antenne (22).

EP 2 791 639 B1

4. Transducteur (10) selon la revendication 3, dans lequel des trous traversants métallisés (38) sont prévus dans les couches diélectriques (2, 4, 6, 8) entre les deuxième et quatrième couches métalliques (3, 7) pour connecter électriquement les périmètres de ces couches métalliques.

5

5. Transducteur (10) selon l'une quelconque des revendications 1 à 4, dans lequel ladite première couche métallique (1) fait partie d'un blindage conducteur mis à la terre qui entoure toutes les autres couches pour exclure les effets électriques extérieurs.

10 6. Transducteur (10) selon l'une quelconque des revendications 1 à 5 et incluant en outre un capteur de température (28) fixé sur ladite surface de travail (10w) pour détecter la température de la surface du corps sous le transducteur (10), une sortie du capteur constituant une deuxième sortie du transducteur.

15 7. Transducteur (10) selon la revendication 6, dans lequel ledit capteur de température (28) est choisi dans le groupe constitué par : capteur à infrarouge, thermistance et thermocouple.

20 8. Transducteur (10) selon l'une quelconque des revendications 1 à 7 et incluant en outre un capteur de saturation en oxygène du sang sur ladite surface de travail (10w).

20

9. Appareil de mesure de température comprenant :

- le transducteur (10) selon l'une quelconque des revendications 1 à 8, et
- un radiomètre (16a) connecté pour recevoir la première sortie du transducteur (10) et produire un signal de température correspondant et un processeur (16b) pour traiter le signal de température et ladite sortie du capteur de température (28) pour fournir une indication de la température actuelle en profondeur sous le transducteur (10).

25

30

35

40

45

50

55

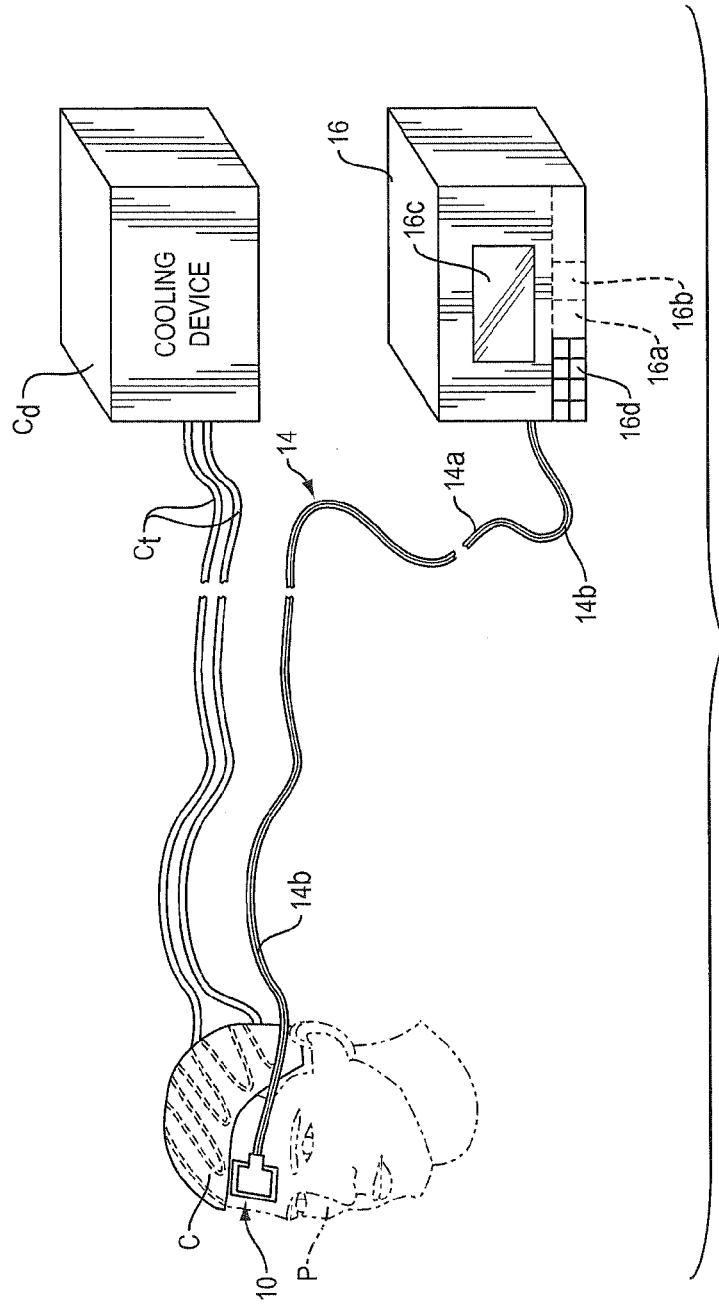


FIG. 1

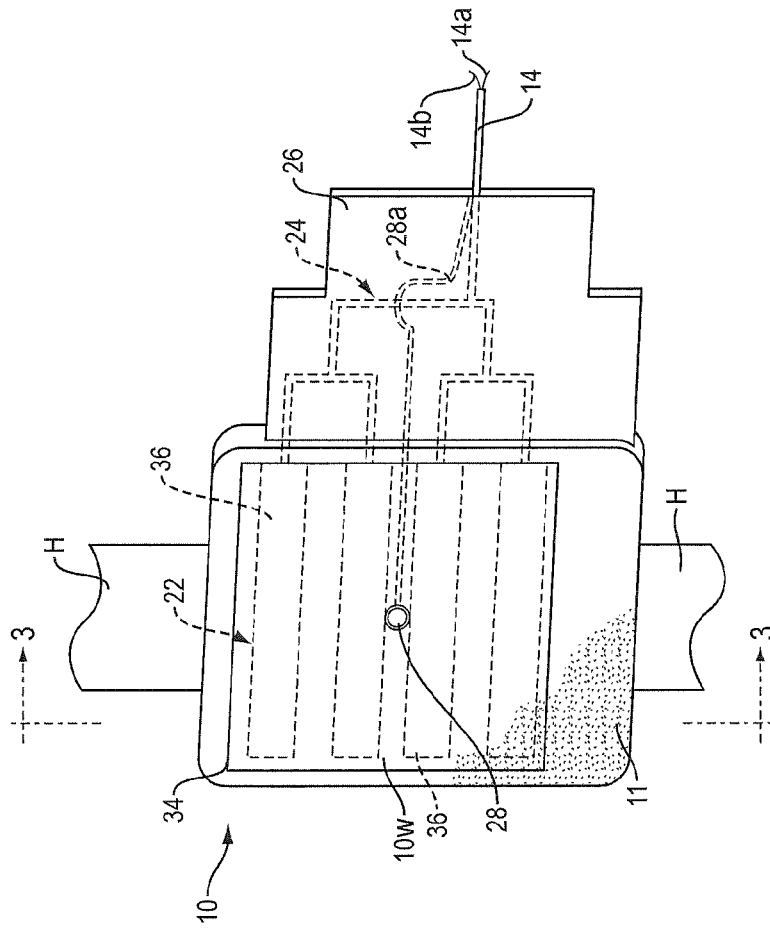


FIG. 2

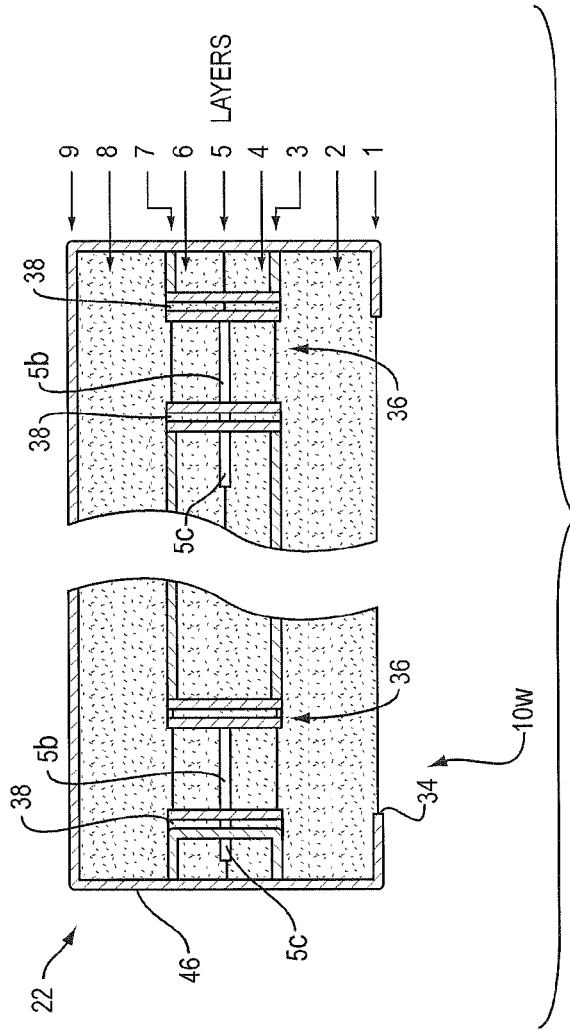


FIG. 3

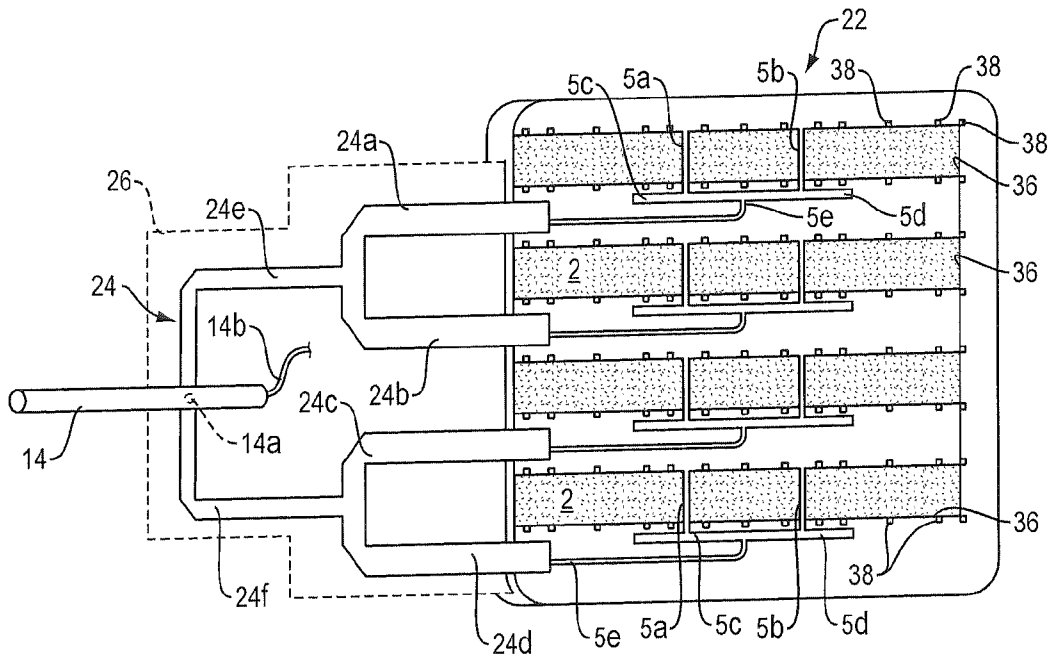


FIG. 4

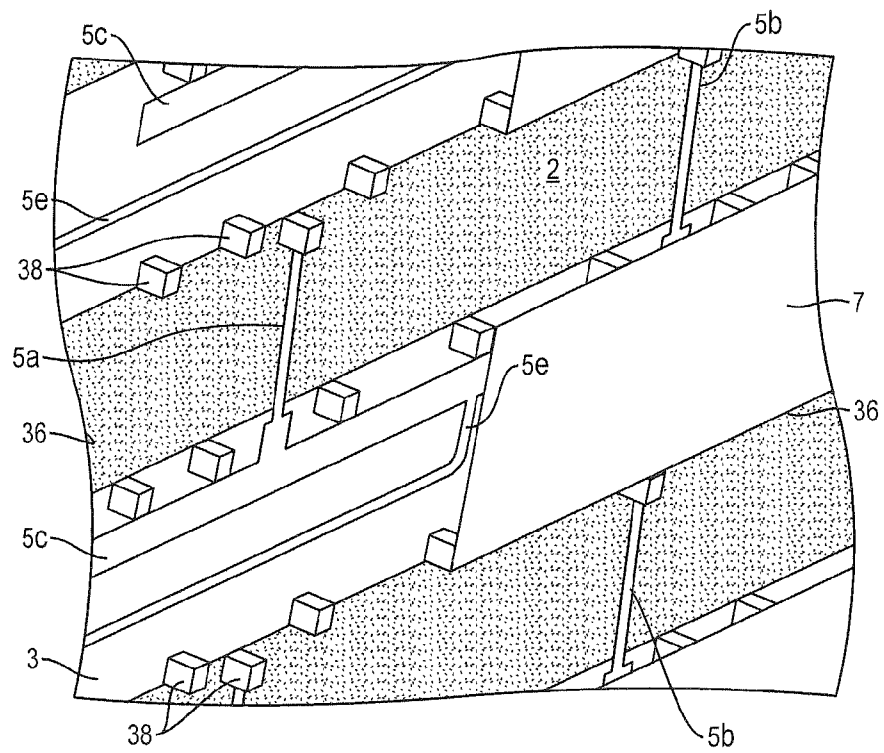


FIG. 5

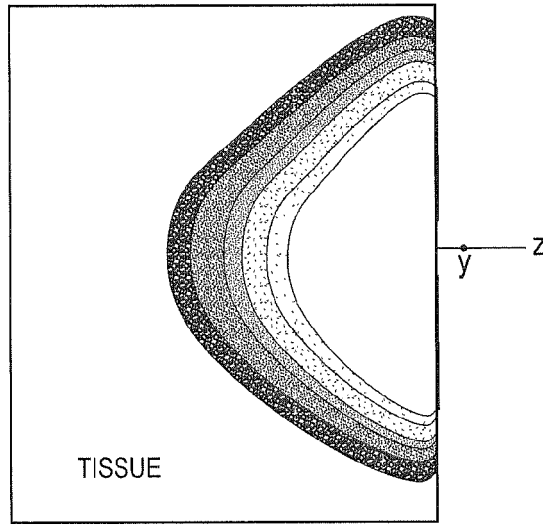


FIG. 6A

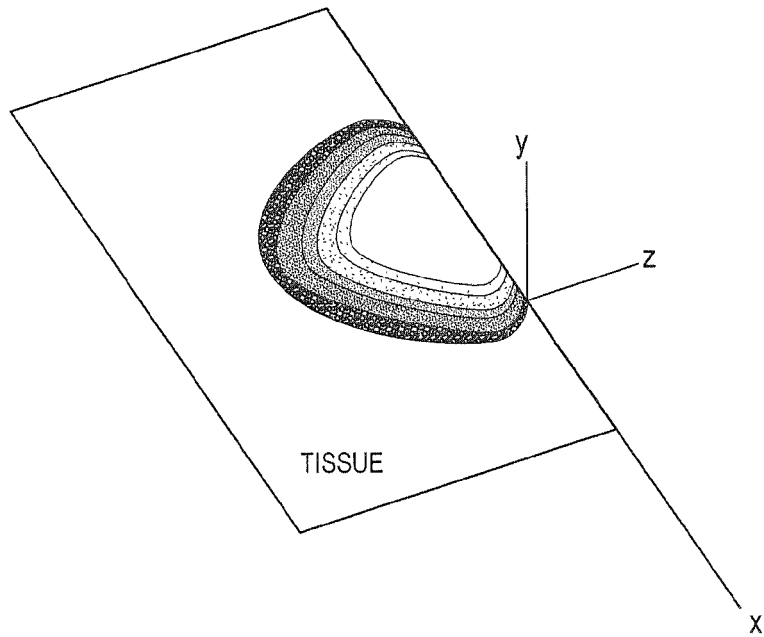


FIG. 6B

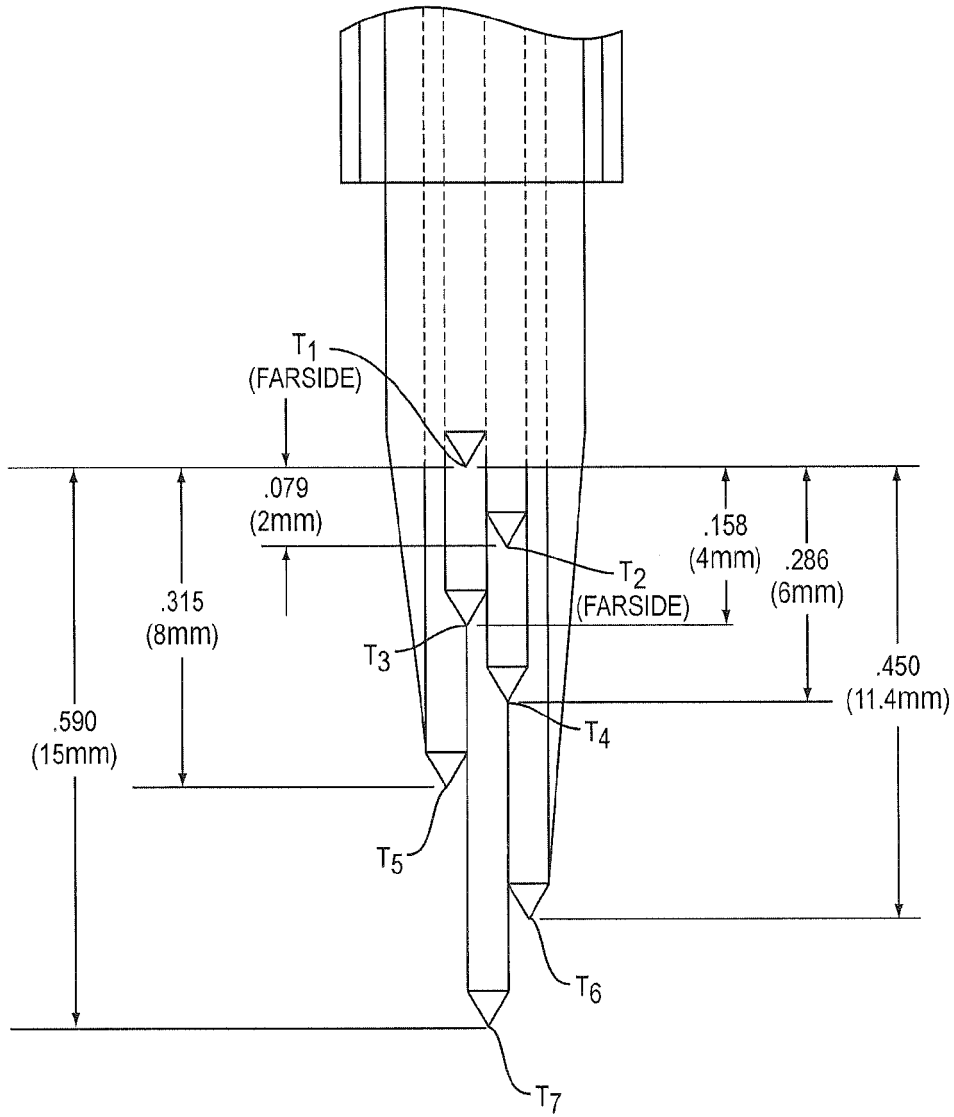


FIG. 7

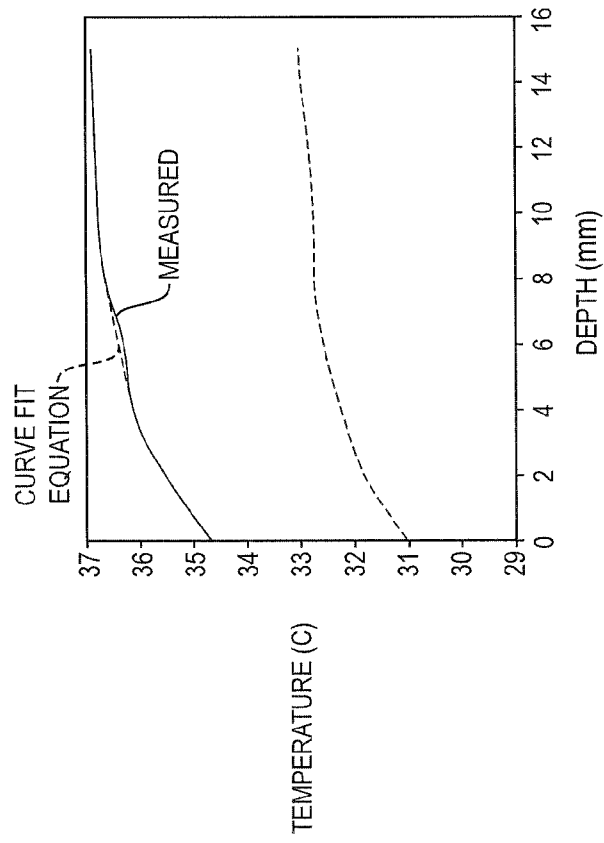


FIG. 8

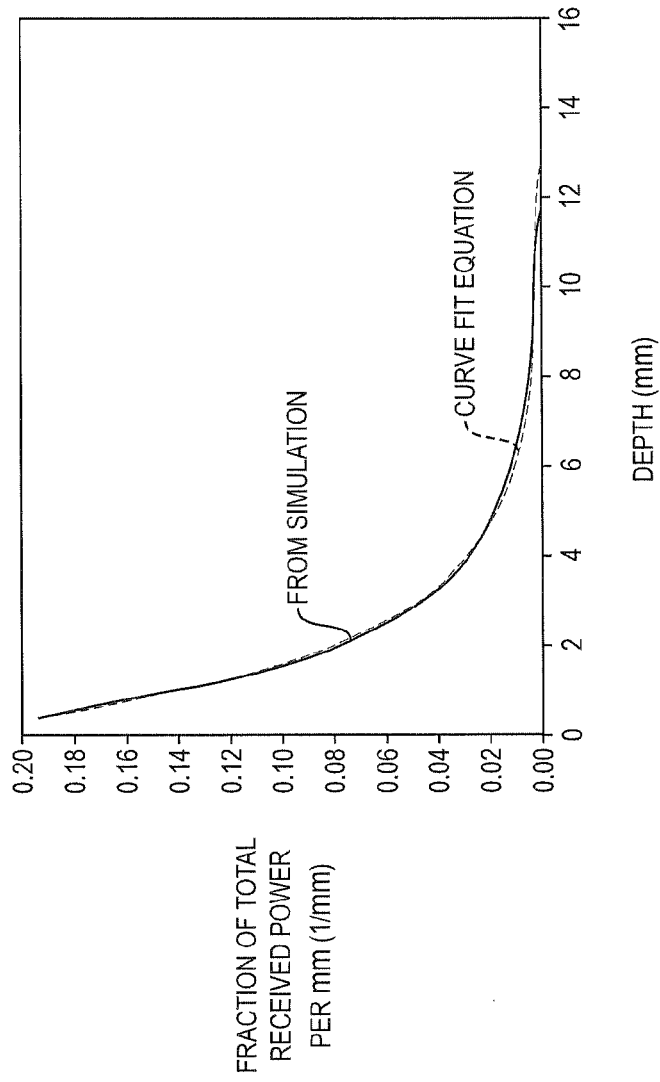


FIG. 9

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 8062228 B2 [0005]
- WO 8604800 A1 [0010]
- WO 13459391 A [0041]

专利名称(译)	薄型温度传感器		
公开(公告)号	EP2791639A2	公开(公告)日	2014-10-22
申请号	EP2012806255	申请日	2012-12-04
[标]申请(专利权)人(译)	默里蒂安医疗系统有限责任公司		
申请(专利权)人(译)	MERIDIAN医疗系统有限责任公司		
当前申请(专利权)人(译)	MERIDIAN医疗系统有限责任公司		
[标]发明人	CARR KENNETH L ALLISON ROBERT C		
发明人	CARR, KENNETH L. ALLISON, ROBERT C.		
IPC分类号	G01K11/00 G01K13/00 A61B5/01 A61B5/00 H01Q1/27 H01Q13/10 A61B5/1455 A61F7/00 A61F7/02		
CPC分类号	A61B5/01 A61B5/6814 A61B5/6831 A61F2007/0002 A61F2007/0056 A61F2007/0095 A61F2007/0288 G01K11/006 G01K13/002 H01Q1/273 H01Q13/10 A61B5/14552		
代理机构(译)	迈斯纳, BOLTE & PARTNER GBR		
优先权	61/569848 2011-12-13 US		
其他公开文献	EP2791639B1		
外部链接	Espacenet		

摘要(译)

薄型温度传感器具有用于放置在身体表面上的工作表面和第一输出。换能器是由交替的导电层和介电层组成的扁平叠层。该叠层限定至少一个槽线天线，用于暴露于体表以在深度处拾取来自下层组织的热辐射。具有特征阻抗的馈电网络连接到第一输出，并且在至少一个天线和馈电网络之间连接槽线到带状线过渡，该过渡提供至少一个天线处的阻抗与特征阻抗。而且，温度传感器可以存在于工作表面以检测换能器下的体表温度，该表面温度用于计算深度处的实际温度。