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O'Neill et al.

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(54) **REUSABLE MR SAFE TEMPERATURE PROBE FOR SURFACE AND BODY TEMPERATURE MEASUREMENT**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 432 days.

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A61B 5/00 (2006.01)
A61B 5/01 (2006.01)
A61B 5/055 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 5/01*** (2013.01); ***A61B 5/055*** (2013.01)

(58) **Field of Classification Search**
CPC A61B 51/01; A61B 5/055; A61B 90/39; A61B 2090/3954; G01K 13/002; G01R 33/285
See application file for complete search history.

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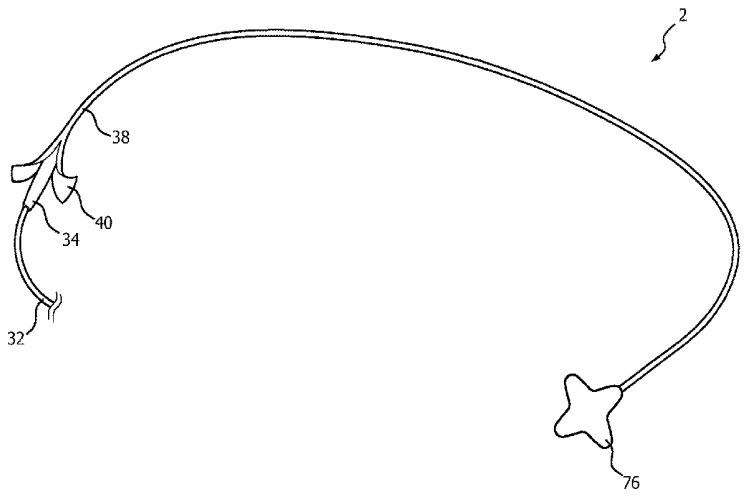
Primary Examiner — Joanne M Hoffman

(57) **ABSTRACT**

A magnetic resonance probe (**2**) includes a fiber optic sensor probe (**32**) and a sheath (**38**). The fiber optic sensor probe (**32**) includes a non-ferrous sensor (**42**) on a distal portion (**36**) configured for insertion into a subject, a locking element (**34**) connected to the distal portion (**36**), and a proximal portion (**44**) connected to the locking element (**34**) and in light communication via an optical fiber (**48**) with the
(Continued)



non-ferrous sensor (**42**) and includes a connector (**46**). The sheath (**38**) covers the distal portion (**36**) of the fiber optic sensor probe (**32**), engages the locking element (**34**), and provides a sterile outer surface (**70**).

14 Claims, 9 Drawing Sheets

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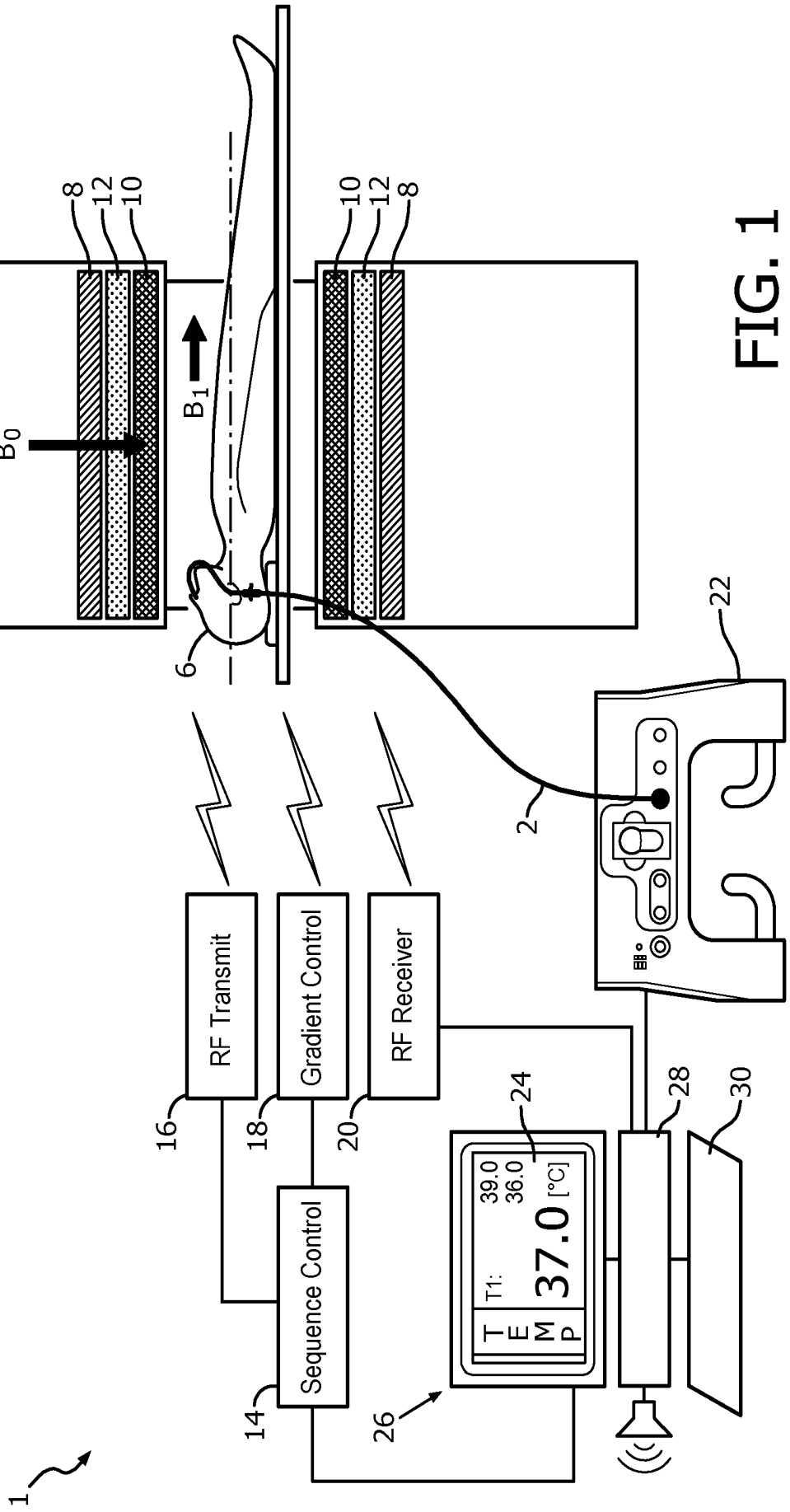

4
8
12
10
10
12
8
B0
B1
6
22
2
RF Transmit
Gradient Control
RF Receiver
16
18
20
24
28
30
Sequence Control
14
26
TEMP
T1:
37.0
39.0
36.0
[°C]
1

FIG. 1

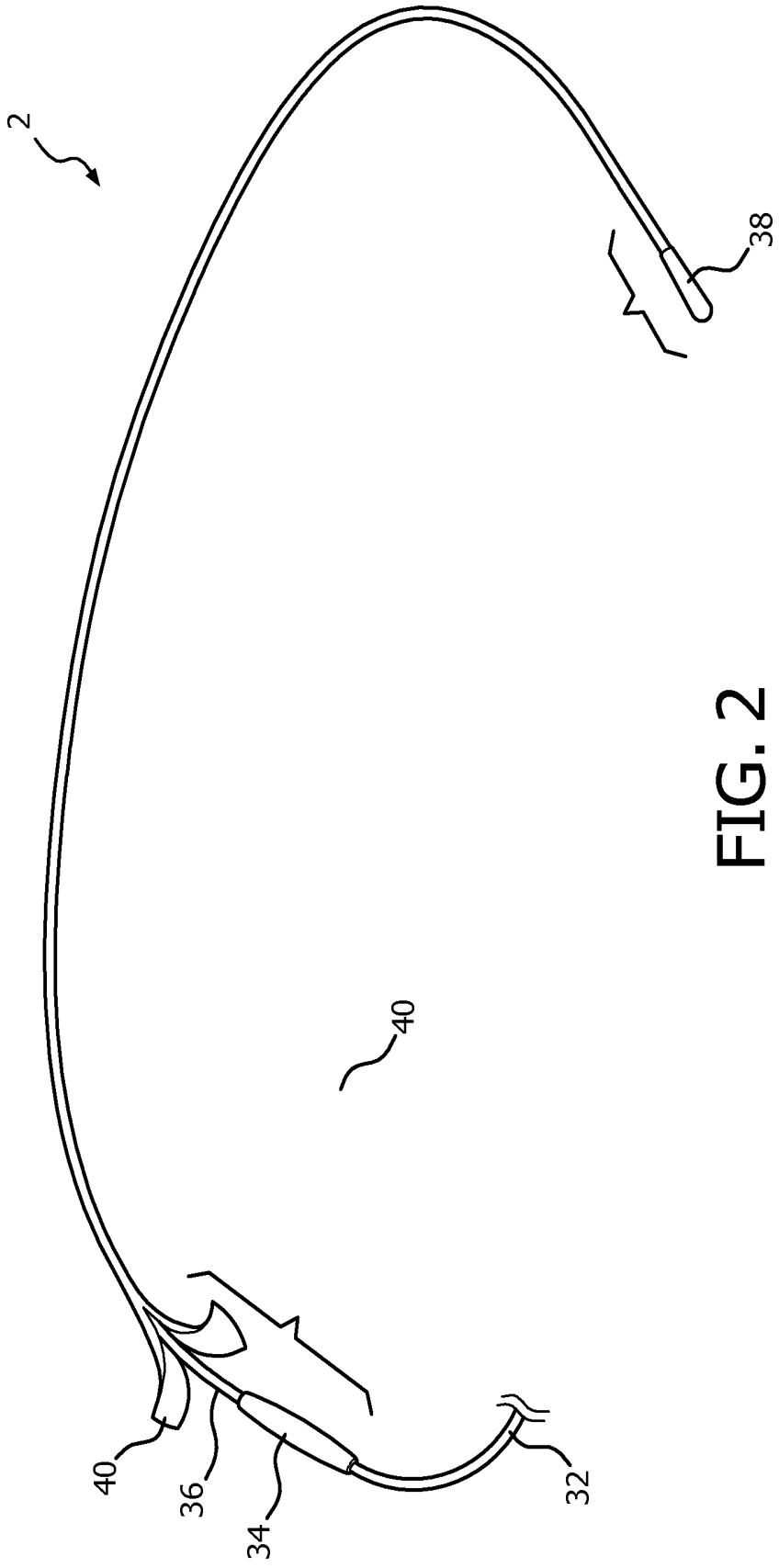


FIG. 2

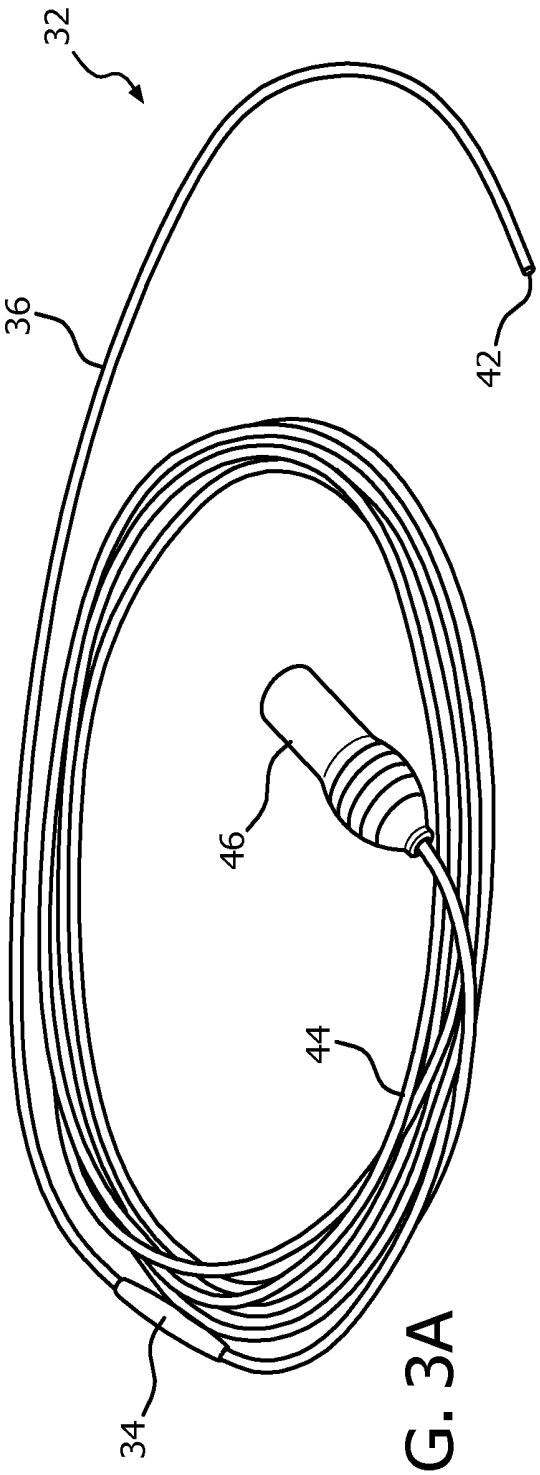


FIG. 3A

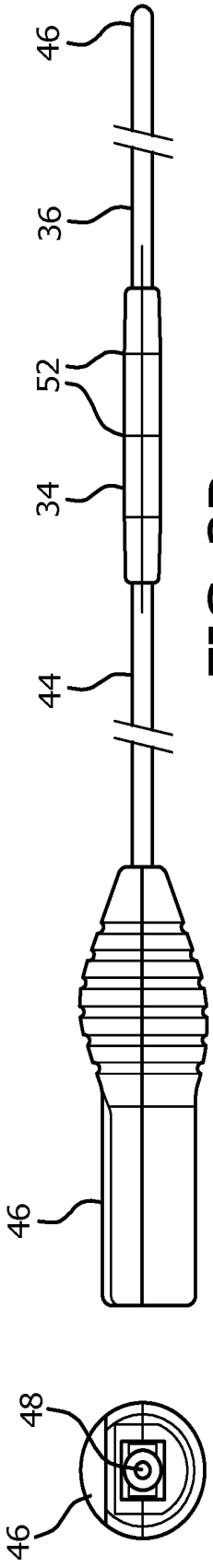


FIG. 3B

FIG. 3C

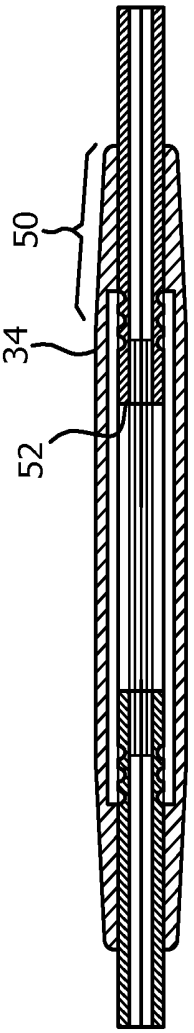


FIG. 3D

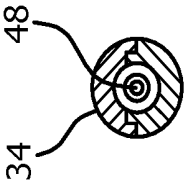
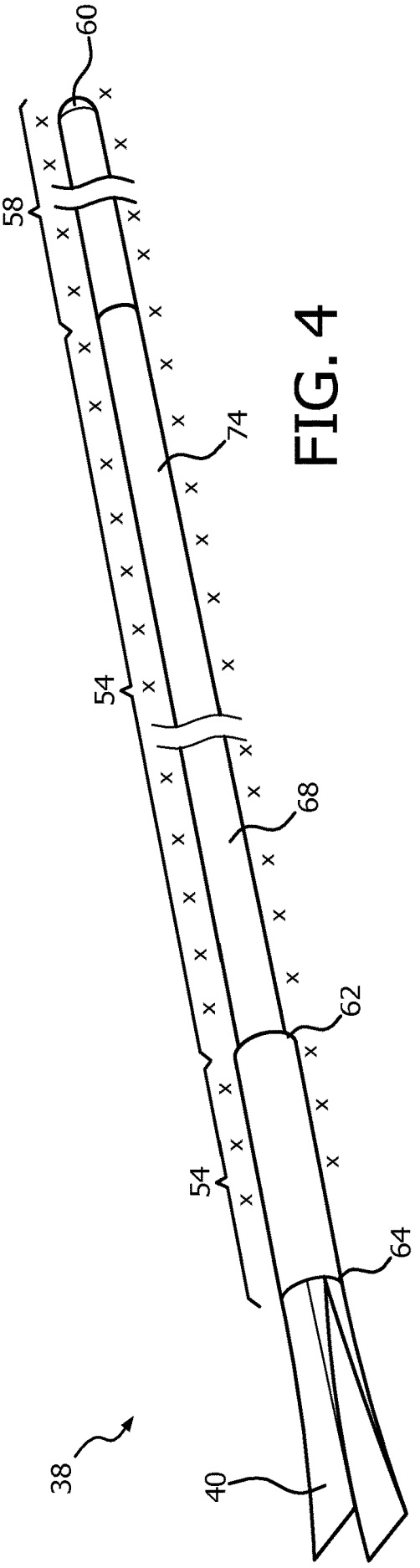


FIG. 3E



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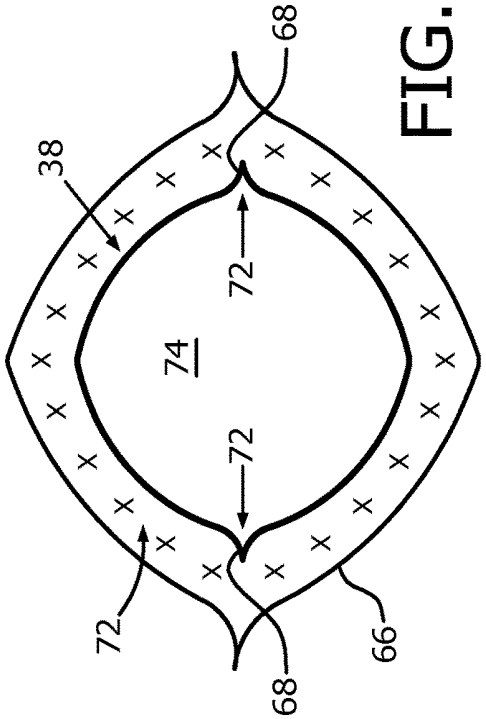


FIG. 5

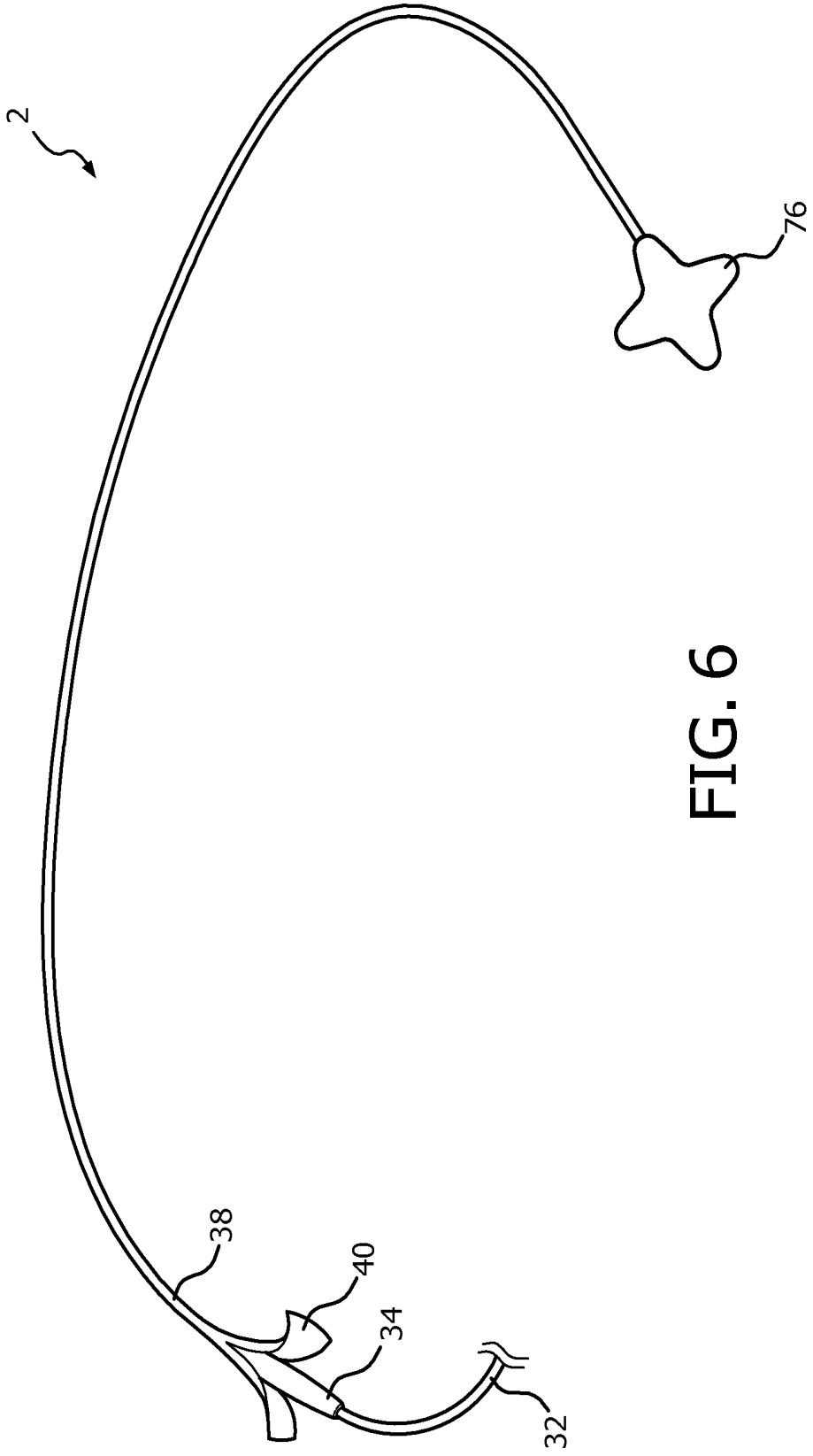


FIG. 6

FIG. 7A

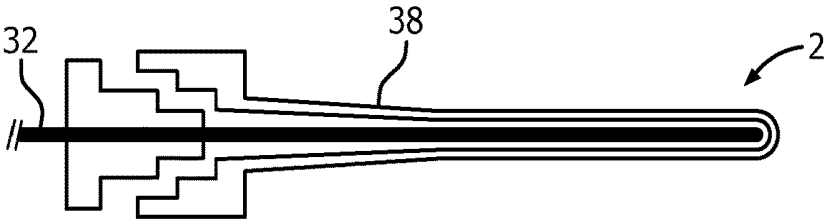


FIG. 7B

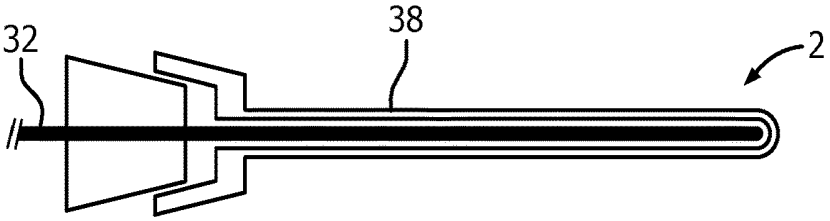


FIG. 7C

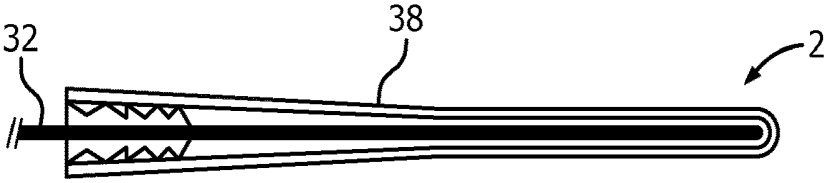


FIG. 7D

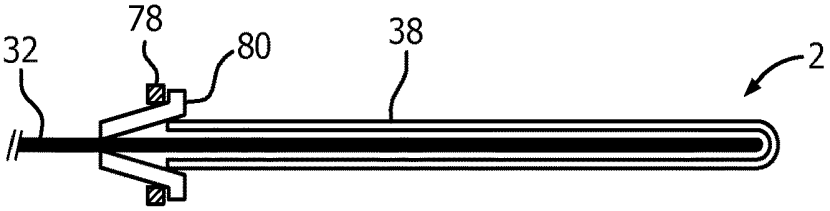


FIG. 7E

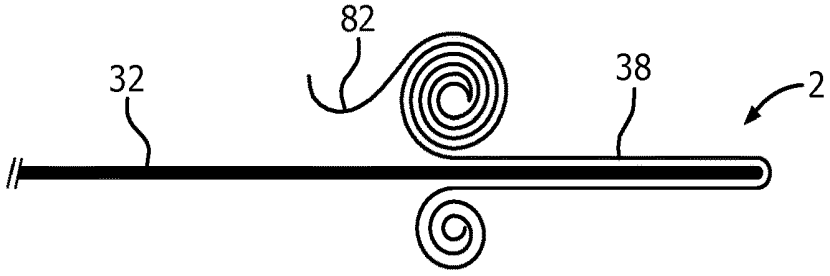


FIG. 7F

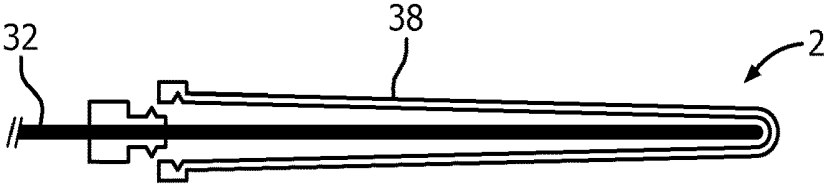


FIG. 7G

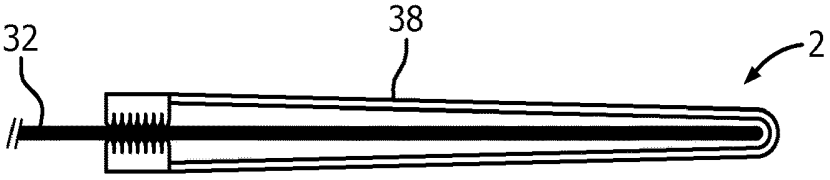


FIG. 7H

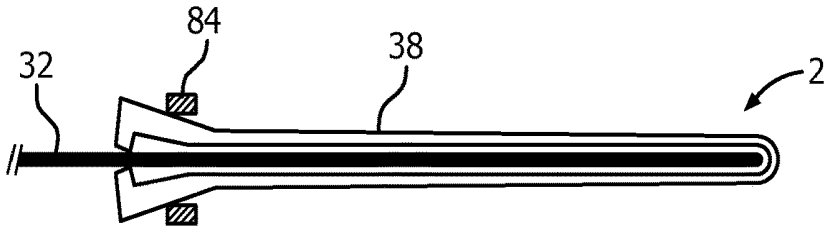


FIG. 7I

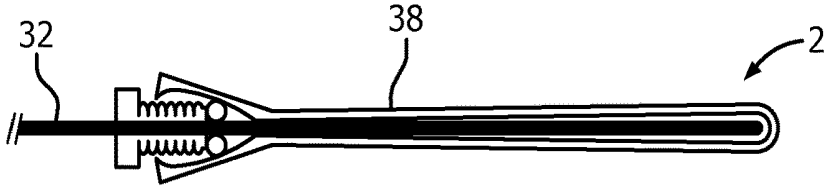


FIG. 7J

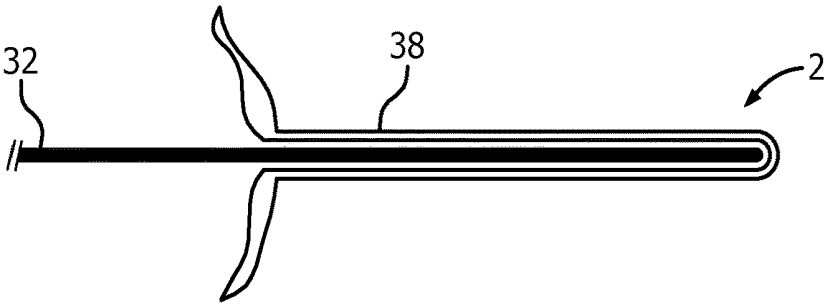


FIG. 7K

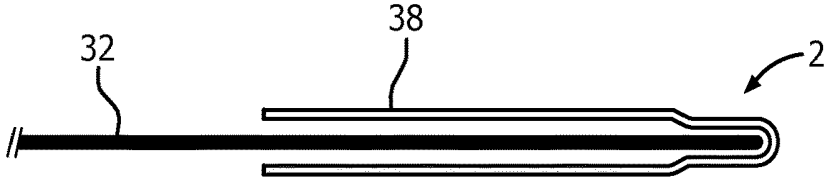
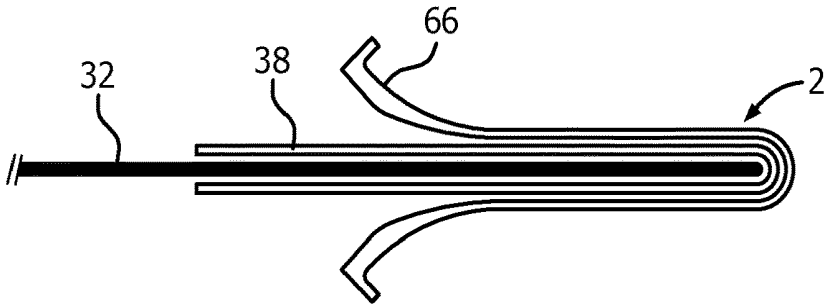


FIG. 7L

FIG. 7M



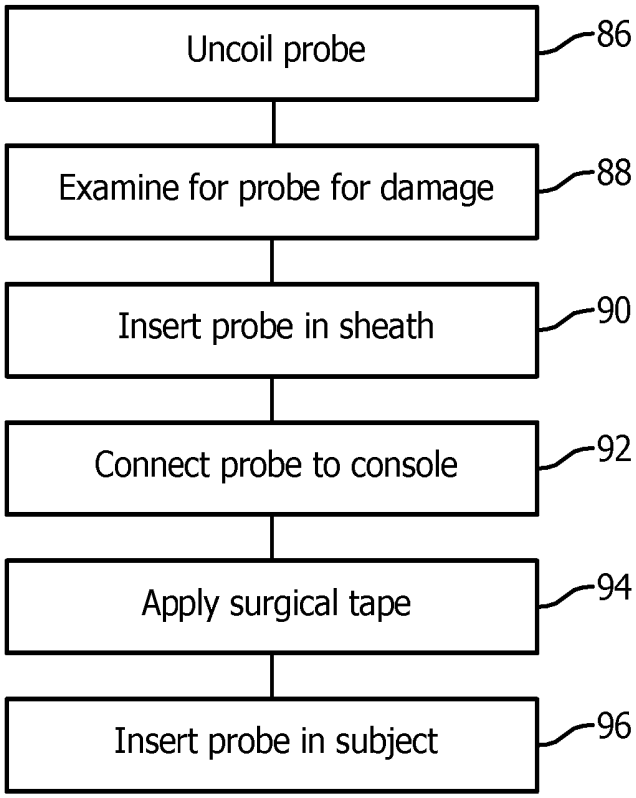

Uncoil probe
86
Examine for probe for damage
88
Insert probe in sheath
90
Connect probe to console
92
Apply surgical tape
94
Insert probe in subject
96

FIG. 8

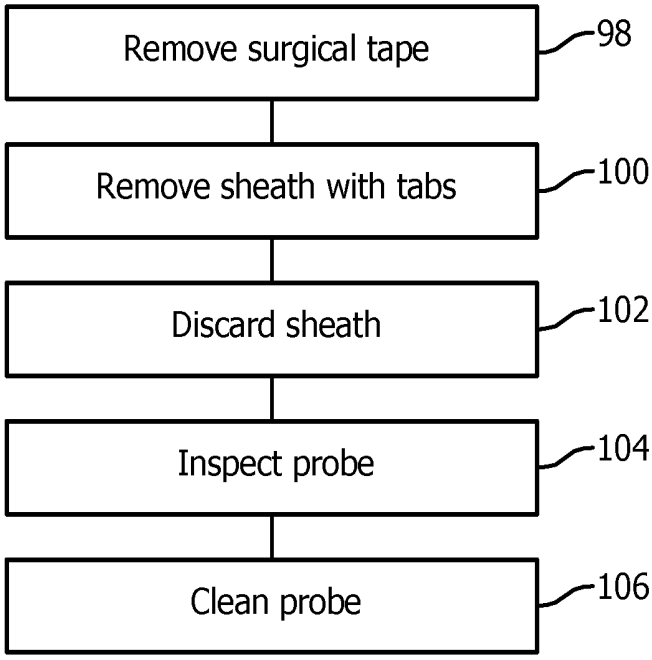

Remove surgical tape
98
Remove sheath with tabs
100
Discard sheath
102
Inspect probe
104
Clean probe
106

FIG. 9

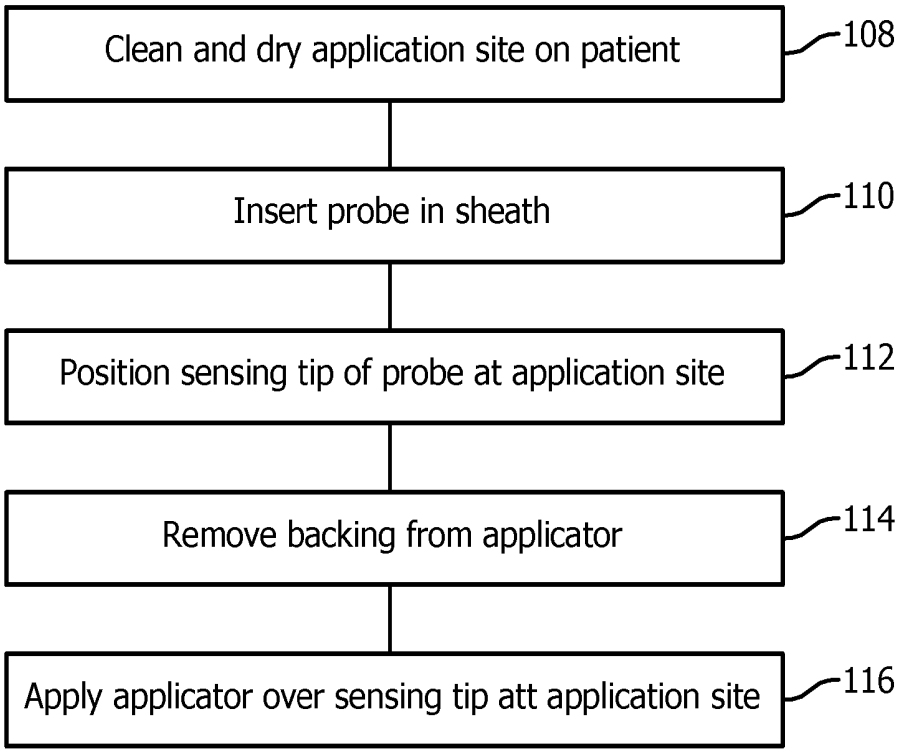

Clean and dry application site on patient
108
Insert probe in sheath
110
Position sensing tip of probe at application site
112
Remove backing from applicator
114
Apply applicator over sensing tip att application site
116

FIG. 10

REUSABLE MR SAFE TEMPERATURE PROBE FOR SURFACE AND BODY TEMPERATURE MEASUREMENT

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a national filing of PCT application Serial No. PCT/IB2013/060765, filed Dec. 10, 2013, published as WO 2014/097049 A2 on Jun. 26, 2014, which claims the benefit of U.S. provisional application Ser. No. 61/738,460 filed Dec. 18, 2012, which is incorporated herein by reference.

The following relates generally to magnetic resonance imaging and temperature sensing. It finds particular application in conjunction with non-ferrous sterile temperature sensing, and will be described with particular reference thereto. However, it will be understood that it also finds application in other usage scenarios and is not necessarily limited to the aforementioned application.

During magnetic resonance (MR) imaging, patient vital signs are frequently monitored such as the temperature of a patient. Monitoring can include a surface temperature with a probe placed against the skin of the patient or internally in the gut such as through the esophagus or the rectum. Temperature can also be used as part of an imaging protocol where temperature can affect quantitative measurement such as diffusion rates in angiograms.

Safe temperature probes in magnetic resonance imaging ideally use non-conductive, non-ferrous materials. Magnetic resonance uses strong radio frequency (RF) and gradient magnetic fields which can induce currents in conductive materials. Ferrous materials can cause aberrations in magnetic fields. Conductive materials with induced currents can cause unsafe conditions for the patient such as the potential for patient burns.

The material used during magnetic resonance imaging should not affect the imaging. That is, the material should be invisible to the magnetic resonance imaging and not emit proton resonance. Improper selection of materials can cause distortions or gaps in the MR signals which cause distortions or gaps in the MR images.

The protocols and procedures used before, during, and after magnetic resonance imaging vary and accommodate a wide variety of situations that call for flexibility of the temperature probe. For example, a surface temperature may be all that is called for by one situation, while a different patient protocol may call for an internal temperature. In order to provide an efficient and effective workflow, the workflow and tools used for MR imaging should accommodate the variety of situations with minimal change in tools such as the temperature probe. The time to measure the temperature is called the response time and includes the time from the application of the probe to the body surface or internally to the time of temperature measurement. The response time is based on the material properties including thickness used to measure the temperature. The response time affects the clinical workflow. Too long a response time is undesirable in measuring patient vital signs and/or measuring changes for a clinical protocol and may pose a risk to the patient.

For internal usage, the probe is sterile and biocompatible. Typically, MR probes used internally are disposable because of the difficulty of sterilization for reuse. For example, a fiber optic probe such as a single piece Fabry-Perot optical sensor can be used in MR imaging, but the materials in the probe are not easily sterilized. Heat is one method of sterilization which is not compatible with fiber optics. Alternatively, chemicals and/or abrasives can be used, but can also damage the fiber optics. Typically, fiber optic temperature probes, although expensive, are used as disposable probes.

Probe materials of an internal probe are often bent to pass through the nasal passage into the esophagus. The probe needs to accommodate the size and bending within the small nasal passage during insertion and removal. A stiff probe can damage the cavity and harm the patient. The probe during insertion and removal should be strong enough not to break or leave components in the patient. The sterile portion of a probe which is inserted into the patient can be as long as 50 cm.

The following discloses a new and improved reusable MR safe probe which addresses the above referenced issues, and others.

In accordance with one aspect, a magnetic resonance probe includes a fiber optic sensor probe and a sheath. The fiber optic sensor probe includes a non-ferrous sensor on a distal portion configured for insertion into a subject, a locking element connected to the distal portion, and a proximal portion connected to the locking element and in light communication via an optical fiber with the non-ferrous sensor and includes a connector. The sheath covers the distal portion of the fiber optic sensor probe, engages the locking element, and provides a sterile outer surface.

In accordance with another aspect, a sterile sheath includes a tube of a material which produces no magnetic resonance signal and configured with a cavity open at one end and to receive and enclose at least one non-ferrous sensor located at an end of a fiber optic sensor probe, closed at an other end, and which provides a sterile outer surface.

In accordance with another aspect, a method for configuring a magnetic resonance temperature probe includes inserting a non-ferrous temperature sensor on a distal portion of a fiber optic sensor probe into a sterile sheath which produces no magnetic resonance signal and covers the distal portion of the fiber optic sensor probe, and the proximal end of the sheath frictionally engages a locking element connected to the distal portion of the probe.

One advantage is a sterile temperature probe which is MR safe and reusable.

Another advantage resides in accommodating surface and internal uses with a single probe.

Another advantage resides in the material size, flexibility, and strength for internal usage.

Another advantage resides in ease of use in an MR clinical workflow.

Another advantage resides in the disposable sterile sheath.

Another advantage resides in the coupling of the disposable sterile sheath and the fiber optic temperature probe.

Still further advantages will be appreciated to those of ordinary skill in the art upon reading and understanding the following detailed description.

The invention may take form in various components and arrangements of components, and in various steps and arrangement of steps. The drawings are only for purposes of illustrating the preferred embodiments and are not to be construed as limiting the invention.

FIG. **1** schematically illustrates an embodiment of a magnetic resonance system with a reusable MR safe probe.

FIG. **2** schematically illustrates one embodiment of a reusable MR safe probe.

FIGS. **3**A-**3**E schematically illustrate an embodiment of a fiber optic sensor probe.

FIG. **4** illustrates an embodiment of a sheath in perspective.

FIG. **5** illustrates an embodiment of a sheath with a cover in a cross section view.

FIG. **6** illustrates an embodiment of the reusable MR safe probe with a surface application.

FIGS. **7**A-**7**M diagrammatically illustrate various embodiments of the reusable MR safe probe and sheath.

FIG. **8** flowcharts one method of configuring the reusable MR safe probe for insertion into a subject.

FIG. **9** flowcharts one method of removing the sheath from the reusable MR safe probe.

FIG. **10** flowcharts one method of configuring the reusable MR safe probe for a surface application.

With reference to FIG. **1**, an embodiment of a magnetic resonance system **1** with a reusable MR safe probe **2** is schematically illustrated. The system **1** includes a MR scanner **4** such as an open system or c-type scanner, a horizontal bore scanner, and the like shown in a cross section view. The scanner includes an opening or bore that defines an examination region in which a subject **6** is placed for a spectroscopic and/or imaging examination. The MR scanner **4** includes one or more main magnets **8** with a C-shape ferrous flux return path, one or more radio frequency (RF) coils **10**, and one or more gradient coils **12**.

The system **1** includes a sequence controller **14** which controls the operation of the imaging sequence, a RF transmitter unit **16** controlling the operation of the RF coils **10**, and a gradient controller **18** controlling the operation of the gradient coils **12**. The communication between the controlling unit and the corresponding coils can be wireless or wired. The RF coils **10** generate radio frequency pulses which excite and manipulate resonance in tissue of the subject **6**. The RF coils **10** can include a whole body coil and/or a local coil such as a torso coil, hand coil, shoulder coil, knee coil, etc. The one or more gradient coils **12** generate gradient magnetic fields across the static magnetic field to spatially encode the induced resonance, induced gradient echoes, and the like. The sequence controller **14** configures the RF coils and the gradient coils to excite and manipulate resonance in tissues of the subject.

The system **10** includes a RF receiver unit **20**, which receives MR signals. As the resonance decays in the tissue of the subject, weak radio frequency signals or MR signals are received by a radio frequency antenna such as the RF coils **10** and transmitted to the RF receiver unit **20**. A reconstruction unit, such as a processor, receives RF data or MR signals from the RF receiver **20** and reconstructs one or more images from the received MR data such as image slices, a volume, etc.

The reusable MR safe probe **2** can be used during a MR imaging procedure or in the presence of the MR scanner **4** at any time. The reusable MR safe probe can be used internally by insertion into the gut of the subject **6** such as either through the nasal passage into the esophagus or the rectum. The reusable MR safe probe has flexibility and size to bend around and pass through the nasal passages of the subject. The reusable MR safe probe **2** includes material which produces no or a minimal MR signal, e.g. emits no proton resonance during excitation or in the presence of the magnetic fields generated by the main magnet coils **8** or the gradient coils **12**. The portion of the probe **2** which is inserted into the subject includes an outer surface which is sterile and non-permeable, and includes at least one non-ferrous sensor such as a temperature sensor. The reusable MR safe probe connects to a console **22** which receives the light signal from the temperature sensor and converts the signal to a human readable quantified measurement which is displayed on a display device **24** and/or used in conjunction with analysis of the received MR signals.

The display device **24** can be a separate device such as an LED display or incorporated into a workstation **26**. The workstation **26** includes an electronic processor or electronic processing device **28**, the display device **24**, and at least one input device **30**. The workstation **26** can be a desktop computer, a laptop, a tablet, a mobile computing device, a smartphone, and the like. The display device **24** can include a computer monitor, a touch screen, Cathode ray tube (CRT), Storage tube, Flat panel display, Light-emitting diode (LED) displays, Electroluminescent display (ELD), Plasma display panels (PDP), Liquid crystal display (LCD), Organic light-emitting diode displays (OLED), a projector, and the like. The input device **30** can be a keyboard, a mouse, a microphone, and the like.

The reusable MR safe probe **2** can be configured to receive and display light signals which correspond to a sensed value such as temperature as soon as connected to the console **22**. The sensed value such as temperature can include a continuous measurement and the display on the display device **24** updated with the continuous measured values. The processor **28** can be configured with maximum or minimum values for the sensed values which sound an alarm such as an audible sound or visual display.

With reference to FIG. **2**, one embodiment of a reusable MR safe probe **2** is schematically illustrated. The reusable MR safe probe **2** includes a fiber optic sensor probe **32** and a sheath **38**. The fiber optic sensor probe **32** is shown with a distal portion **36** and a locking element **34** which engages the sheath **38** when the probe is inserted and indicates the proper depth in the sheath. The probe **32** is shown without the entire proximal portion and a connector. The probe **32** with the sheath **38** includes a maximum diameter which passes through a nasal passage of the subject such as 4.9 mm. The fiber optic sensor probe is reusable. The sheath is disposable. The sheath **38** covers and encloses the distal end of the probe and provides a non-permeable sterile surface.

The sheath in one embodiment includes tabs **40** at the proximal end of the sheath for pulling the sheath onto the probe **32** or holding the sheath while inserting the probe **32** to the indicated depth, and engaging the locking element **34**. The tabs can be two opposing tabs which allow a healthcare practitioner to grasp the sheath and handle in a manner which maintains the sterile outer surface. Gripping the tabs and gripping the locking mechanism, opposing forces exerted by the healthcare practitioner can bring the proximal end of the sheath to the locking element and engage the sheath to the locking element, e.g. tightly couple the sheath to the locking element forming a pressure seal. The tabs **40** when pulled toward the distal end of the probe **32** and away from the locking element, assist the healthcare practitioner in removal of the sheath **38** from the probe **32**. The sheath during removal can be pulled along the distal portion of the probe **32** by the tabs and fold the outer contaminated surface inside out. The removed sheath turned inside out can be safely handled and properly disposed.

The reusable MR safe probe **2**, with the sheath **38** properly engaged with and enclosing distal end of probe **32** that includes the temperature sensor, is inserted into the esophagus or rectum of the subject. The reusable MR safe probe **2** with the sheath **38** and the probe **32** are inserted and removed from the subject as one unit. The sheath provides a sterile non-permeable barrier between the temperature sensing probe **32** and the subject.

In one embodiment, portions of the fiber optic sensor probe **32** and/or the sheath **38** can be manufactured with MR visible material, e.g. emits proton resonance for internal visual monitoring of the probe by the MR system. For example, a thin line in the sheath **38** can indicate the location and/or direction of the reusable MR safe probe **2** in an image reconstruction. The line can be a thin line, dotted line, include arrows, etc. The image reconstruction can show where the reusable MR safe probe **2** is internally in the subject. The portion of the MR visible material can be limited so that the material does not interfere with the image of the subject.

With reference to FIG. **3**A, an embodiment of a fiber optic sensor probe **32** is shown in a perspective view. The locking element **34** divides the probe **32** into the distal portion **36** which includes a temperature sensor **42** and a proximal portion **44** which connects to console via a connector **46**. The distal portion **36** has a length of sterile surface such as 50.8-55.8 cm. The proximal portion **44** includes a length from the subject to the console such as 3-5.5 meters.

FIG. **3**B shows an enlarged side view of fiber optic sensor probe **32**. The distal portion **36** includes a temperature sensor **42** and can include a rounded tip. The sensor operates from +20° C. to +44° C.±0.5° C. The proximal portion **44** can include a polyvinyl-chloride (PVC) covered single optical fiber. The proximal portion can be colored blue for visibility. The proximal portion includes a connector **46** which can operate reliably after multiple insertion cycles and in one embodiment meets an IEC 61754 standard e.g. IEC 61754-4. The PVC material, such as DEHP free 85A grey PVC from Sunlight Corporation, produces no visible MR signal, e.g. invisible to MR imaging. The connector **46** connects to the system **1** via a fiber optic connector in the console **22** and can include standard fiber optic connector interfaces. FIG. **3**C shows an end view of the connector **46**. The single optical fiber **48** is enclosed with the connector and optically connects to the console such that light communication is provided between the temperature sensor **42** and the console **22**.

With reference to FIG. **3**D, a side view of the locking element **34** is shown in a central slice. The locking element includes a rigid tapered surface **50**. The locking element can include marks **52** in the surface and/or lines which indicate the proper distance for insertion of the probe **32** into the sheath **38**. The locking element includes a maximum outer diameter which is large the maximum inner diameter of the sheath **38**. The length of the locking element can include a length easily gripped by the healthcare practitioner such as 5 cm. The size can be limited by the bulk and weight in handling of the probe by the healthcare practitioner. FIG. **3**E shows a cross section view of the locking element **34** with the enclosed single optical fiber **48**. Although a single optical fiber for both transmitted and returned light is illustrated, separate transmit and return optical fiber are also contemplated. Further, additional optical fibers may transmit light to and from other biological sensors.

FIG. **4** illustrates an embodiment of the sheath **38** in perspective. The sheath **38** includes a material which produces no MR signal such as TSP 1051-85A polyurethane made by Polyzen. The material emits no proton resonance, e.g. invisible to MR imaging. The material encloses the distal portion **36** of the probe **32**, as shown in reference to FIG. **2**, in a cavity with one opening and carries the probe **32** within the cavity or opening of the sheath **38**. The sheath can be further divided into a proximal portion **54**, a central portion **56**, and a distal portion **58**. The central portion and distal portion provides flexibility and sufficient strength with a thickness such as 0.0381 mm.

The distal portion **58** can include a rounded tip **60**. The rounded tip can ease the insertion into the subject as the probe bends and moves through the narrow nasal passage of the subject. The rounded tip can conform to a rounded tip of the probe **32** or provide a rounded tip to the probe **32**. The distal portion **58** can include a length such as 20.3 cm with a smaller outer diameter such as 3.9 mm.

The central portion **56** can include a slightly larger outer diameter such as 4.9 mm for a length such as 30.5 cm. The central portion **56** and the distal portion **58** provide an overall length of a sterile outer surface such as 50.8 cm.

The proximal portion **54** includes a rigid or thickened tubular connection **62** to the central portion. The proximal portion includes an outer diameter with firmness and tear resistance to engage the tapered locking element **34** of the fiber optic sensor probe **32** such as 6.04 mm. The proximal portion extends for a length such as 25.4 mm which provides sufficient area to engage the locking element **34**.

Two opposing flaps or tabs **40** connect to the proximal end **64** of the proximal portion **54**. The tabs extend for a length such as 2.5 cm with a flare such as 9.4 mm for easy gripping by the healthcare practitioner. For example, the healthcare practitioner can grip the proximal end of the locking element **34** of the probe **32** in one hand and grip a tab either side of the sheath in the other. Using opposing forces the sheath can be drawn onto the distal end of the probe **32** or the sheath can be held stationary while the distal end of probe **32** is pushed into the sheath. The proximal portion **54** is pulled by the tabs onto the tapered surface **50** of the locking element **34** to be stretched in a friction locking interaction.

FIG. **5** illustrates an embodiment of the sheath **38** with an optional cover **66** in a cross section view. The sheath includes at least one perimeter seam **68**. The perimeter seam is formed to the outside surface. In one embodiment, two perimeter seams are formed opposite. The perimeter seams seal the material of the sheath to provide a sterile outer surface **70**. The optional cover **66** such as a peel away introducer with a sterile inner surface can be for an individual sheath. The perimeter seam formed to the outside includes an air channel **72** on the inside which allows air to escape during insertion. By allowing the air to escape, a potential thermal barrier of trapped air is eliminated. A thermal barrier of trapped air can affect the temperature reading by the sensor **42**. The at least one perimeter seam also forms the cavity **74** which carries the distal portion of the probe **32** and includes the central **56** and distal **58** portions of sheath **38**.

With reference to FIG. **6** an embodiment of the reusable MR safe probe **2** with a surface application is illustrated. The distal portion of the probe **32** is fully inserted into the sheath **38** and the locking element **34** engages the proximal portion **54** of the sheath **38**. The tabs **40** extend over the locking element. An applicator **76** such as an adhesive backed biocompatible material is applied over the tip of the reusable MR safe probe **2** and affixed to the skin surface of the subject **6**. During removal, the applicator **76** and the sheath **38** can be disposed of as a unit. By using the sheath, any adhesive adheres to the sheath **38** and not the surface of the probe **32**, which avoids potential damage with the removal of any adhesive from the reusable probe **32**.

FIGS. **7**A-**7**M diagrammatically illustrate various embodiments of the reusable MR safe probe **2**. In FIG. **7**A, the probe **32** and the sheath **38** include a stepped locking element. The distal end of the sheath has mating steps which frictionally engage the steps of the locking element. FIG. **7**B

shows a tapered locking element of both the probe **32** and the sheath **38**. The tapered locking element on the probe **32** expands to a larger diameter than the tapered locking element located on the proximal end of the sheath **38**. The tapered locking element located on the proximal end of the sheath engages frictionally the tapered locking element of the probe. A barbed locking element on the probe **32** is shown in FIG. **7**C. The straight or flared sheath **38** slides over the barbed locking element on the probe and engages with the barbed locking element with friction. A plastic collet **78** on the probe **32** in FIG. **7**D engages and holds the sheath **38**. A locking ring **80** clamps the collet tight around the proximal edge of the sheath. The locking ring slides from the proximal towards the distal end to lock the collet. The sheath **38** is rolled onto the probe **32** using a draw string **82** in FIG. **7**E. The sheath is rolled by pulling the draw string towards the proximal end of the probe and unrolls the sheath with a tight fit onto the probe. A locking element is threaded on the probe **32** and the sheath **38** in FIG. **7**F. The probe is inserted into the sheath and with a twisting motion such as with a screw, the female portion located on the sheath engages the male portion locking element of the probe. In FIG. **7**G, a barbed locking element is included in the sheath **38**. The probe is inserted into the sheath and pulled with the locking element of the sheath frictionally engaging the straight surface of the probe. The sheath **38** includes the plastic collet in FIG. **7**H. A locking ring **84** slides over the plastic collet incorporated into the proximal end of the sheath. The ring slides from the distal to the proximal end. The sheath **38** includes a crushable band in FIG. **7**I. The probe includes a rough surface which frictionally engages the sheath after crushing. The sheath **38** includes one or more tails in FIG. **7**J which are tied around the probe **32**. The sheath is pulled over the probe and the tails are tried around the probe to hold the sheath in position. The sheath **38** includes a length of decreased diameter near the tip which prevents the sensor **42** on the distal portion of the probe **32** from slipping out in FIG. **7**K. The sheath is pulled onto the probe and the remainder of the sheath can be increased in thickness which increases the rigidity of the remaining portion. The sheath **38** in FIG. **7**L includes a flange to assist gripping by the healthcare practitioner during insertion of the probe **32** into the sheath. The flange provides a rigid surface which extends radially from the proximal end of the sheath. The sheath **38** in FIG. **7**M includes a cover **66** such as a peel away introducer. The introducer includes tabs which provide a gripping surface. The healthcare practitioner grasps the tabs and pulls the sheath onto the probe. After the probe is fully inserted into the sheath, the introducer is peeled away leaving the sheath covering the distal end of the probe.

With reference to FIG. **8** one method of configuring the reusable MR safe probe **2** for insertion into a subject **6** is flowcharted. In a step **86**, the probe **32** is uncoiled. The uncoiling avoids knotting or kinking the probe **32**. In a step **88**, the healthcare practitioner examines the probe **32** for damage, adhesives or residue.

In a step **90**, the healthcare practitioner inserts the probe **32** into the sheath **38**. The healthcare practitioner holds the tabs **40** of the sheath **38** and pulls the sheath completely over the distal portion **36** of the probe **32** until the locking element **34** of the probe **32** is fully seated into or engaged with the proximal end **64** of the sheath **38** and the two opposing tabs **40** rest over the locking element **34**. In embodiments with an additional locking element, the locking element is engaged when the sheath is properly seated, the distal portion of the probe **32** fills the sheath completely to the tip, e.g. no open cavity with air at the end of the sheath. The step can include removal of an optional cover **66** such as a peel away introducer. The reusable MR safe probe **2** is connected to the system **1** via the console **22** with the connector **46** in a step **92**. Connecting to the console **22** can initiate sensor or specifically temperature readings. In an optional step **94**, surgical tape can be applied to the tabs **40** and around the locking element **34**.

The reusable MR safe probe **2** with a sterile outer surface is inserted into the subject **6**, e.g. through a nasal passage or rectum in a step **96**. The probe **2** provides sensor readings with light communications via an optical fiber **48** using a non-ferrous sensor **42** and does not include conductive elements such as ferrous sensors or conductive wires. The absence of conductive elements such as ferrous sensors or conductive wires eliminates the potential hazard of burns to the subject. The material of the probe **2** produces no MR signal, e.g. invisible to MR imaging, which eliminates potential distortions or gaps in imaging. The biocompatible sterile outer surface of the probe **2** allows usage internally to a subject **6**.

FIG. **9** flowcharts one method of removing the sheath **38** from the reusable MR safe probe **2**. In a step **98**, surgical tape is removed from around the tabs **40** if surgical tape was previously applied. The sheath is removed in a step **100**. The healthcare practitioner grips the tab or tabs **40** of the sheath **38**, and the proximal end of the locking element **34** of the probe **32**. With opposing force the sheath **38** is pulled from the probe **32** while turning the contaminated outer surface of the sheath **38** inside out. In a step **102**, the sheath is properly discarded according to a facility's biohazard procedures.

In a step **104**, the probe **32** is inspected by the healthcare practitioner, which ensures that the sheath was completely removed from the probe **32**. The probe **32** is cleaned and/or disinfected in a step **106**.

With reference to FIG. **10** one method of configuring the reusable MR safe probe **2** for a surface application is flowcharted. In a step **108**, the healthcare practitioner cleans and dries the application site on the subject **6**. In a step **110**, the healthcare practitioner inserts the fiber optic sensor probe **32** into the cavity of the sheath **38** by gripping the tabs **40** and pulling the sheath onto the distal portion of probe **32** until fully engaged by the locking element **34** of the probe **32**.

The healthcare practitioner positions the sensing tip of the reusable MR safe probe **2** at application site of the subject **6** in a step **112**. The backing is removed from an applicator **76** in a step **114**. The applicator **76** with the backing removed is applied over the sensing tip of the reusable MR safe probe **2** at application site of the subject **6** in a step **116**.

It is to be appreciated that in connection with the particular illustrative embodiments presented herein certain structural and/or function features are described as being incorporated in defined elements and/or components. However, it is contemplated that these features may, to the same or similar benefit, also likewise be incorporated in other elements and/or components where appropriate. It is also to be appreciated that different aspects of the exemplary embodiments may be selectively employed as appropriate to achieve other alternate embodiments suited for desired applications, the other alternate embodiments thereby realizing the respective advantages of the aspects incorporated therein.

It is also to be appreciated that particular elements or components described herein may have their functionality suitably implemented via hardware, software, firmware or a combination thereof. Additionally, it is to be appreciated that

certain elements described herein as incorporated together may under suitable circumstances be stand-alone elements or otherwise divided. Similarly, a plurality of particular functions described as being carried out by one particular element may be carried out by a plurality of distinct elements acting independently to carry out individual functions, or certain individual functions may be split-up and carried out by a plurality of distinct elements acting in concert. Alternately, some elements or components otherwise described and/or shown herein as distinct from one another may be physically or functionally combined where appropriate.

In short, the present specification has been set forth with reference to preferred embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding the present specification. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof. That is to say, it will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications, and also that various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art which are similarly intended to be encompassed by the following claims.

What is claimed is:

1. A magnetic resonance probe configured for both insertion into and application to a surface of a subject, the magnetic resonance probe comprising:

a reusable fiber optic sensor probe comprising:

a distal portion having a sensor end and a locking element end opposite from the sensor end;

a proximal portion;

a locking element connecting the locking element end of the distal portion to the proximal portion, wherein the locking element comprises a tapered rigid surface and an indicator that indicates a proper distance for sheath insertion;

a non-ferrous sensor on the sensor end of the distal portion; and

an optical fiber connected with the non-ferrous sensor, the optical fiber extending from the proximal portion to the non-ferrous sensor;

a disposable sheath having a non-permeable sterile outer surface, a closed end and an open end opposite from the closed end, wherein the closed end covers the sensor end of the fiber optic sensor probe so that the distal portion of the fiber optic sensor probe fills the sheath, wherein the open end of the sheath comprises pull tabs, and wherein a portion of the open end of the sheath engages with the locking element at or near the indicator; and

a removable applicator configured to affix the closed end of the sheath to a surface of a subject.

2. The magnetic resonance probe according to claim **1**, wherein the closed end of the sheath comprises a rounded tip.

3. The magnetic resonance probe according to claim **1**, wherein the sheath further comprises:

at least one perimeter seam located on the outside of the sheath which provides enclosure of a central portion and a distal portion of the sheath about a cavity which carries the distal portion of the fiber optic sensor probe.

4. The magnetic resonance probe according to claim **1**, wherein the pull tabs are configured to allow a healthcare practitioner to remove the sheath from the fiber optic sensor probe while turning a central portion and a distal portion of the sheath inside out.

5. The magnetic resonance probe according to claim **1**, wherein the material of the fiber optic sensor probe and the sheath produce minimal magnetic resonance signal.

6. The magnetic resonance probe according to claim **1**, wherein the non-ferrous sensor includes a temperature sensor configured to measure a temperature change from 20 C-37 C in 20 seconds or less.

7. The magnetic resonance probe according to claim **1**, wherein

the sheath includes a tube of a material which produces no magnetic resonance signal.

8. The magnetic resonance probe according to claim **7**, wherein the tube comprises:

a tubular proximal portion connected to the open end of the material which engages and connects with a locking element of the sensor probe.

9. The magnetic resonance probe according to claim **7**, wherein the material comprises at least one perimeter seam which runs the length of the cavity on the outside of the cavity and provides an air channel on the inside of the at least one perimeter seam.

10. The magnetic resonance probe according to claim **7**, wherein the sheath is at least 50.8 cm long and less than 4.9 mm in diameter.

11. The magnetic resonance probe according to claim **7**, further comprising:

a removable cover which covers and maintains the sterile outer surface of the material.

12. The magnetic resonance probe according to claim **7**, wherein the sheath engages the probe with a tapered friction fit.

13. The magnetic resonance probe of claim **7**, wherein:

the fiber optic sensor probe comprises a fiber optic temperature sensing catheter including a temperature sensing probe and an elongated shaft carrying at least one optical fiber.

14. The magnetic resonance probe of claim **13**, wherein the elongated shaft has one or more magnetic resonance visible markings.

* * * * *

专利名称(译)	可重复使用的MR安全温度探头，用于表面和体温测量		
公开(公告)号	US10631736	公开(公告)日	2020-04-28
申请号	US14/649583	申请日	2013-12-10
[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
申请(专利权)人(译)	皇家飞利浦N.V.		
当前申请(专利权)人(译)	皇家飞利浦N.V.		
[标]发明人	ONEILL FRANCIS PATRICK KOVALSKY LEONARD JOHN IVANOV IVARS KASPICK STEVEN ANDREW GEMMATI MICHAEL JIRKA KEVIN WEINACHT JOHN BORNE FREDERIC EMMANUEL VACHON SAVARY MAXIM		
发明人	O'NEILL, FRANCIS PATRICK KOVALSKY, LEONARD JOHN IVANOV, IVARS KASPICK, STEVEN ANDREW GEMMATI, MICHAEL JIRKA, KEVIN WEINACHT, JOHN BORNE, FREDERIC EMMANUEL VACHON-SAVARY, MAXIM		
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CPC分类号	A61B5/01 A61B5/055 A61B90/39 A61B2090/3954 G01K11/3206 G01K13/002 G01R33/285 G01R33/28		
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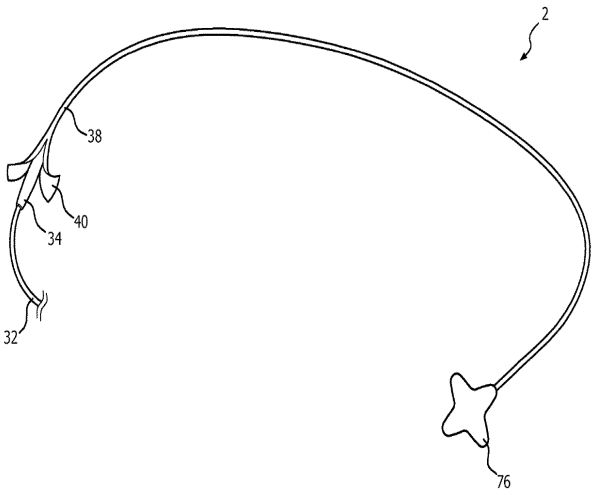
其他公开文献	US20150313473A1		
外部链接	Espacenet		

摘要(译)

磁共振探头2包括光纤传感器探头32和护套38。 光纤传感器探头32包括在配置为插入对象中的远端部分36上的非铁质传感器42，连接到远端部分的锁定元件34。 36和连接到锁定元件34并通过光纤48与有色金属传感器42光连通的近端部分44和 包括一个连接器（46）。 护套38覆盖光纤传感器探头32的远端部分36，与锁定元件34接合，并提供无菌的外表面70。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