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(54) **Active interference-noise cancellation device**

Aktive Störsignalunterdrückungsvorrichtung

Dispositif d'annulation de bruit d'interférence active

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- **METTINGVANRIJN A C ET AL: "AMPLIFIERS FOR BIOELECTRIC EVENTS: A DESIGN WITH A MINIMAL NUMBER OF PARTS", MEDICAL AND BIOLOGICAL ENGINEERING AND COMPUTING, SPRINGER, HEILDELBERG, DE, vol. 32, no. 3, 1 May 1994 (1994-05-01), pages 305-310, XP000451956, ISSN: 0140-0118**

EP 2 601 884 B1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an interference-noise cancellation device according to the preambles of the independent claims.

BACKGROUND

[0002] The present invention relates in particular to a device applicable to medical intra-body sensors.

[0003] In many medical procedures, various physiological conditions present within a body cavity need to be monitored. These physiological conditions are typically physical in nature - such as pressure, temperature, rate-of-fluid flow, and provide the physician or medical technician with critical information as to the status of a patient's condition.

[0004] One device that is widely used to monitor conditions is the blood pressure sensor. A blood pressure sensor senses the magnitude of a patient's blood pressure, and converts it into a representative electrical signal that is transmitted to the exterior of the patient.

[0005] In the prior art, it is known to mount a sensor at a distal portion of a so-called sensor wire and to position the sensor by using the sensor wire in a blood vessel in a living body to detect a physical parameter, such as pressure or temperature. The sensor includes elements that are directly or indirectly sensitive to the parameter.

[0006] One known sensor wire has a typical length of 1.5-2 meters, and comprises a hollow tubing running along a major part of the wire and having an outer diameter in the range of 0.25 - 0.5 mm, typically approximately 0.35 mm. A core wire is arranged within the tubing and extends along the tubing and often extends out from a distal opening of the tubing. The sensor or sensors is/are preferably arranged in connection with the distal portion of the core wire, e.g. at the distal end of the sensor wire.

[0007] The present invention is applicable, for example, in relation with a sensor wire of the type described above.

[0008] In one application the sensor wire of the type described above is used to measure pressure in blood vessels, and in particular in the coronary vessels of the heart, e.g. to identify constrictions in the coronary vessels. This may be performed by determining the so-called Fractional Flow Reserve related to the vessel. The sensor wire is typically inserted by use of an insertion catheter, which in turn is inserted via the femoral vein or the radial artery, and guided by the inserted catheter to the measurement site.

[0009] In order to power the sensor and to communicate signals representing the measured physiological variable to an external physiology monitor, one or more cables or leads, often denoted microcables, for transmitting the signals are connected to the sensor, and are routed along the sensor wire to be passed out from the vessel to the external physiology monitor, via physical cables or wirelessly.

[0010] The sensor element further comprises an electrical circuitry, which generally is connected in a Wheatstone bridge-type of arrangement to one or several piezoresistive elements provided on a membrane. As is well known in the art, a certain pressure exerted on the membrane from the surrounding medium will thereby correspond to a certain stretching or deflection of the membrane and thereby to a certain resistance of the piezoresistive elements mounted thereon and, in turn, to a certain output from the sensor element.

[0011] In U.S. 2006/0009817 A1, which is assigned to the present assignee, an example of such a sensor and guide wire assembly is disclosed. The system comprises a sensor arranged to be disposed in the body, a control unit arranged to be disposed outside the body and a wired connection between the sensor and the control unit, to provide a supply voltage from the control unit to the sensor and to communicate a signal there between. The control unit further has a modulator, for modulating the received sensor signal and a communication interface for wireless communication of the modulated signal.

[0012] In U.S. Patent No. 7,724,148 B2, which also is assigned to the present assignee, another example of such pressure measurement system is disclosed. The pressure sensor wire is adapted to be connected, at its proximal end, to a transceiver unit that is adapted to wirelessly communicate via a communication signal with a communication unit arranged in connection with an external device.

[0013] In U.S. Patent No. 6,112,598, which is assigned to the present assignee, and also in U.S. Patent No. 7,207,227 B2, further examples of such pressure sensors and guide wire assemblies are disclosed.

[0014] In U.S. Patent No. 7,326,088, which is assigned to the present assignee, a device adapted for reducing leaking current in a guide wire assembly is disclosed. In this known device a guard potential is applied to an insulator or to a conductive guide wire sheath of the guide wire assembly in order to thereby reduce current leakage.

[0015] The patient body acts as an electrically conductive volume with a large surface area exposed to surrounding electrical equipment (fluorescent lighting, X-ray power supplies, etc.) as well as a direct conduction path to intra-body electrical devices (pacemakers, neurostimulators, RF ablation devices, ultrasound catheters, etc.). The man-made electrical interference noise created by such equipment thus efficiently couples onto the patient body through capacitive coupling in the case of external equipment and directly through conduction and/or capacitive coupling in the case of intra-body equipment. This is problematic for precision electrical intra-body sensors since interference voltages many thousand times larger than the signals of interest may corrupt the measurements. A simplified illustration of the influence onto the patient body is illustrated in Figure 1. In Figure 1, different influencing capacitances are indicated. For example,

Cground (e.g., 300 pF) is the capacitance to ground, Cpow (e.g., 3 pF) is the capacitance in relation to the main power supply, and Csup, Ciso are capacitances in relation to a measuring device connected to the body via an intra-body sensor. Furthermore, the main supply Vmain is an alternating (50/60 Hz) voltage of 230 Volt, for example. Rbody is the resistance of the body and may be approximated to 100 Ω. This may result in a voltage Vbody across the body of about 2.3 VAC having a frequency of 50 Hz. This voltage Vbody may naturally influence the measurements performed, for example, by an intra-body sensor being a pressure sensor of the kind described above.

[0016] For devices placed outside the body, e.g. those adapted to measure bioelectric events such as EEG and ECG, different ways of reducing electrical interferences have been suggested. Examples are disclosed in US Patent Application 2008/139953, US Patent No. 4,890,630 and the article "Amplifiers for bioelectric events: A design with a minimal number of parts" in Medical and Biological Engineering and Computing, Springer, Heidelberg, DE, vol. 32, no. 3, 1 May 1994, pages 305-310, ISSN: 0140-0118.

[0017] In addition it is referred to US Patent Application 2007/178579 that discloses apparatus and methods that provide the ability to electrical stimulate a physical system, and actively eliminate interference with signal acquisition (artifacts) that arises from the stimulation.

[0018] Direct electrical shielding of intra-body sensors is not always possible due to potentially life-threatening electrical leakage current situations that may develop due to sensor mechanical failure. Such a mechanical failure is considered a *single-mode fault condition (SFC).* In accordance with applicable safety standards for medical equipment no SFC event should be allowed to lead to such dangerous situations, i.e. at least two means of protection is required. One applicable safety standard is the IEC 60601 which is a series of technical standards for the safety and effectiveness of medical electrical equipment, published by the International Electrotechnical Commission.

[0019] A passive current-limited shielding that traditionally has been used provides the added means of protection for electrical safety essentially comprising an impedance (e.g., a resistor) connected to device ground. This type of shielding is schematically illustrated in Figure 2 in connection with a sensor guide wire. The shielding is achieved by a passive impedance connected between a shielded outer tubing of the guide wire and device ground. However the shielding provided is very modest, and at low frequencies (< 10 kHz) largely ineffective. This makes the sensor measurements highly vulnerable to 50/60 Hz line voltage interference.

[0020] Figure 3 is a schematic simplified circuit of the shielding in Figure 2 illustrating passive current-limited shielding provided with an impedance circuit having a resistance Rs of 100 kΩ and a capacitance of 3.3 nF resulting in an impedance of approximately 91 kΩ at 50 Hz. The sensor voltage is less than 5 Volt, which results in a leakage current of less than 50 μA in order to fulfil the type "CF" SFC requirement.

SUMMARY

[0021] One object of the present invention is to achieve an improved shielding of a medical device, and in particular of intra-body sensors, that in particular effectively shields the sensor from both external and intra-body interference sources.

[0022] The disclosed invention may significantly reduce electrical interference for precision intra-body sensor measurements (pressure, temperature, flow, pH, position, etc.) by driving the patient body through a low-impedance connection (i.e., a direct connection to the bloodstream) with an electrical signal that counters and nulls out impinging electrical noise, while still complying with the highest level of electrical safety (type CF) through limited patient currents during normal and single-mode fault (SFC) conditions.

[0023] By using a current-limited active feedback network, the shield, or parts of a medical sensor that come in direct connection with the bloodstream of a patient, is actively driven by a small current to balance and effectively null out any voltage potential induced on the body of the patient by other interfering electrical equipment, both external (50/60Hz line voltage, X-ray power supplies, ECG lead detection circuitry, etc.) and intra-body (pacemakers, implantable cardioverter-defibrillators (ICD), neurostimulators, RF ablation devices, ultrasound catheters, etc.), thus greatly reducing interference to precision measurements.

[0024] In further embodiments of the active noise cancellation device, internal sensor leakage currents, sensor settling times during switched operation, and motional artefacts due to cable capacitance variations of the sensor cables may also be reduced.

[0025] The embodiments disclosed herein may provide one or more of the following advantages:

1) Provides an active interference-noise cancellation through the use of feedback, by actively driving the patient body with a small correction current, thus using the patient body as a shield.
2) Fulfils patient leakage current requirements.
3) Allows the reference signal to be a fixed reference voltage or any sensor node signal. The reference signal may also be switched in time between different sensor signals.
4) When the reference signal is chosen as a sensor node signal it also suppresses motional artefacts due to cable capacitance variations (e.g., bending of sensor wire or catheter, organ movements, etc.) and errors due to sensor leakage currents.
5) Provides a means of detecting the interference frequency (e.g., 50/60 Hz) and detection and reduction of sensor leakage currents.

6) Provides an active shielding, supplied by an on-chip sensor active circuitry.
7) Provides an active shielding for multiple sensor nodes.
8) Speeds up sensor settling times when used in a switched or multiplexed technique.
9) Active noise cancellation may be performed by an external measurement device or directly on the sensor chip using active circuitry.

[0026] A further object is to provide a more reliable medical device by using the active noise cancellation device.

[0027] According to a first aspect of the present invention, there is provided a noise cancellation device comprising a low-impedance body connection electrode, arranged to actively apply a limited current to the patient's body, thereby using the patient's body as an active shield.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The disclosure will become more fully understood from the following detailed description, taken in conjunction with the accompanying Figures, wherein like reference numerals refer to like elements, in which:

Figure 1 is a simplified illustration of how external environmental voltages influence the patient body.
Figure 2 is a schematic illustration of a passive current-limited shielding in connection with a sensor guide wire.
Figure 3 is a schematic illustration of a passive type of shielding.
Figure 4 is a schematic illustration of an active noise cancellation device according to an exemplary embodiment of the present invention.
Figure 5 is a schematic illustration of one embodiment of an active noise cancellation device according to an exemplary embodiment of the present invention.
Figure 6 is a flow diagram that illustrates a method of active noise and interference cancellation according to an example.

DETAILED DESCRIPTION

[0029] Before turning to the Figures, which illustrate exemplary embodiments in detail, it should be understood that the application is not limited to the details or methodology set forth in the description or illustrated in the Figures. It should also be understood that the terminology is for the purpose of description only and should not be regarded as limiting.

[0030] According to the invention, an active noise cancellation device 2 for a medical device comprises an active circuit having a first input connection 8, a second input connection 10, and an output connection 12, a low-impedance body connection electrode 4 adapted to be in direct electrical contact with the bloodstream of a subject (e.g., a human or animal body), and a feedback branch 14 connecting said output connection 12 with said first input connection 8.

[0031] Referring to Figure 5, a basic principle of one embodiment of the active noise cancellation device is that a current limiting circuit 18, in the feedback branch 14, feedbacks an error correction current to the patient's body that counterbalances the influences from noise and interference voltage of the patient. In the embodiment of Figure 5, the active circuit includes an operational amplifier unit 6 having a very high amplification. The operation amplifier unit 6 may be connected as a transimpedance amplifier or current to voltage (I-V) converter. The operational amplifier outputs an error correction voltage, causing an error correction current to flow through the current limiting circuit 18. The error correction current precisely counterbalances the interfering voltage at the negative input 8, thus keeping this input at the same potential as the reference input 10. The resistor R_{LIM} both sets the I-V conversion factor and thus the output excursion of the operational amplifier for a given interference level, as well as limits the maximum DC correction current. Capacitor C_{LIM} limits the AC correction current and provides frequency stabilization of the control loop.

[0032] The active noise cancellation device 2 is electrically connected to the patient via a low-impedance body connection electrode 4. The body connection electrode 4 is adapted to be in direct connection to the blood of the human or animal. The body connection electrode 4 may be in contact with the patient's blood by being located on an external portion of a medical device that is inserted into the patient's bloodstream. For example, if the medical device is a sensor guide wire, direct contact with blood can be achieved by connecting the body connection electrode 4 to an outer non-insulated tubing of the sensor guide wire that is in direct connection to the blood. When the medical device is inserted into a patient's body, the body connection electrode 4 is able to provide an electrical connection between the patient's body and the circuitry of the active noise cancellation device 2. As described in more detail below, the active noise cancellation device 2 acts to drive the patient's body to a desired potential, thereby cancelling any interference voltage (or current) within the patient's body.

[0033] Herein, low-impedance is generally meant impedance values less than 1kΩ. The impedance value may be dependent on the material used in the body connection electrode 4. In various embodiments, the body connection electrode 4 has an impedance value of: less than 900 Ω, less than 800 Ω, less than 700 Ω, less than 600 Ω, less than 500 Ω, less than 400 Ω, less than 300 Ω, or less than 200 Ω. In another embodiment, the impedance value of the low-impedance body connection electrode 4 is in the interval of 10-100 Ω.

[0034] Referring to Figure 5, the body connection electrode 4 is connected to the first input connection 8 of an active circuit. The active circuit includes a first input con-

nection 8, a second input connection 10, and an output connection 12. The active circuit may include an operational amplifier unit 6. In this embodiment, the predetermined reference signal 16 is connected to the second input connection 10 of the operational amplifier unit 6. The operational amplifier unit 6 acts to maintain the same voltage at each input terminal 8, 10. The presence of the feedback branch 14, which connects the output connection 12 of the operational amplifier unit 6 to the input connection 8, causes the operational amplifier unit 6 to output the voltage necessary to maintain the input terminals 8, 10 at the same potential. Thus, the operational amplifier unit 6 outputs an error correction signal (i.e., voltage) that will operate to bring the first input terminal 8 to the same voltage as the second input terminal 10, which is determined based on the reference signal 16. The error correction signal can also be used for other advantageous purposes, such as to measure the level of electrical interference on a patient, the capacitance of a sensor wire, and leakage current flowing through the patient or sensor.

[0035] The feedback branch 14 comprises a current limiting circuit 18 adapted to limit the error correction current through the feedback branch 14 such that it is lower than a predetermined current. As illustrated schematically in Figure 4, the current limiting circuit 18 may generally have a designated transfer function H(s). The transfer function H(s) may be tailored to the specific medical device in which the active noise cancellation device 2 is applied. The transfer function H(s) may include any combination of circuit components that acts to limit the current flowing from the output connection 12 to the first input connection 8. Limiting the current flowing towards first input connection 8 also limits the current flowing to the body connection electrode 4 (i.e., to the patient's body). The ability of the current limiting circuit 18 to limit the current flowing to the patient's body is an important advantage of the active noise cancellation device 2. Conventional active shielding mechanisms pose risks to the patient because a leakage scenario could cause currents of a dangerous level to flow through the patient's body. However, the current limiting circuit 18 of the noise cancellation device 2 is configured to limit the current flowing through the patient's body, protecting the patient from dangerous current levels that might otherwise result from a mechanical failure of components during active shielding.

[0036] According to one embodiment, the error correction current (i.e., the current flowing from output connection 12 to input connection 8) is limited to be 50μA or lower (such as 30μA or 15μA). The highest level of the error correction current may be related to applicable safety standards, such as the safety standard that was briefly discussed in the Background section. Furthermore, the active noise cancellation device may be in particular adapted to reduce the influence of an interference frequency of 50-60 Hz. In one embodiment, the current limiting circuit 18 includes an impedance circuit that is matched in relation to the highest allowable error correction current, and also to the frequencies of the noise and interference voltage.

[0037] In one embodiment, the current limiting circuit includes a resistor unit and a capacitance unit, as shown in Figure 5. In this embodiment, I_{LIMIT} is set by configuring R_{LIM} and C_{LIM} to have the desired resistance and capacitance, respectively, necessary to achieve a current limiting circuit 18 having the desired impedance. The desired impedance can also be achieved by alternative combinations of resistors, capacitors, or other circuit components.

[0038] As illustrated in Figure 4 the reference signal 16 may generally have a designated transfer function G(s). The transfer function may be tailored for a particular frequency range and may also be chosen to ensure control loop stability to the specific medical device where the active noise cancellation device is applied. Maintaining control loop stability is important since the capacitive and/or resistive coupling from the patient body to the sensor signal may create a positive feedback path that could render the control loop unstable.

[0039] The predetermined reference signal 16 can be any stable voltage. Because the noise cancellation device 2 acts to bring the first input connection 8 to the same potential as the second input connection 10, it follows that the voltage at the body connection electrode 4 will be the same as the voltage at the second input connection 10. The noise cancellation device 2 therefore provides a mechanism to use the reference signal 16 to control the voltage at the body connection electrode 4, in effect cancelling out any interference voltage. According to one embodiment, the predetermined reference signal 16 is a fixed DC reference voltage related to a ground of the medical device.

[0040] According to another embodiment, the predetermined reference signal 16 is related to a sensor signal of said medical device. For example, the second input connection 10 may be connected to a microcable within the medical device (e.g., a microcable used for transmitting signals from a pressure sensor to the exterior of a patient). This embodiment provides an additional safety advantage of substantially preventing leakage currents from flowing from the medical device to the patient, even in the event of a mechanical failure of the medical device. This advantage occurs because when a sensor node is used as the reference signal 16, the noise cancellation device 2 causes the voltage of the patient (i.e., the voltage at the body connection electrode 4) to be the same as the voltage of the medical device (i.e., the voltage at the second input connection 10). Thus, even if the medical device were to experience mechanical failure, no leakage current would flow from the medical device to the patient. In this manner, the noise cancellation device 2 can be used to both: 1) limit the current flowing from the active noise cancellation device 2 to the patient (e.g., from output connection 12 to first input connection 8), and 2) prevent leakage current from flowing from the medical de-

vice to the patient in the event of a mechanical failure.

[0041] Using a sensor microcable as the reference signal 16 may speed up sensor settling times when a medical device is used in a switched or multiplexed technique. Each sensor microcable and tubing has associated distributed resistance, capacitance and inductance. The capacitance is typically around 100pF/m of sensor wire. This capacitance creates an RC filter time constant. In other words, after energizing a particular sensor node, a certain time must pass before the voltages and currents have settled to their new values. This poses a fundamental limit as to how fast various sensor nodes can be switched between (such as temperature/pressure readout, etc.). By applying active shield drive to the tube and/or patient body using the active noise cancellation device 2, the effects of capacitance between a sensor cable (that is used as the reference signal 16 to the active drive) and the tube/patient body are essentially eliminated. Because the sensor cable and the tube/patient body are at the same potential, no current can flow, and therefore no RC time constant can be generated. Active drive using the noise cancellation device 2 thus greatly speeds up settling times.

[0042] When the reference signal is chosen as a sensor node signal it also suppresses motional artefacts due to cable capacitance variations (i.e. bending of sensor wire or catheter, organ movements etc.) and errors due to sensor leakage currents.

[0043] According to still another embodiment, the predetermined reference signal 16 is obtained by switching between different sensor signals of said medical device. This embodiment provides several advantages. First, the interference levels may be different on different sensor signals due to different associated impedances. Using the sensor signal that is to be measured at a given time as the reference signal 16 thus reduces interference particularly for that signal. Simply put, using a sensor signal as the reference signal 16 "protects" the signal that is to be measured at a given time. Second, using a certain sensor signal as a reference signal 16 reduces leakage current from that specific sensor signal when it is measured, allowing for a more stable and robust signal (the various sensor signals are typically at different voltages). Again, this embodiment provides the ability to "protect" the signal currently of interest. Third, the ability to switch between different sensor signals to obtain the reference signal 16 can be used to measure the leakage current from a specific sensor signal. For example, if a sensor has three signal leads, any leakage current can be pinpointed to a particular sensor lead.

[0044] According to one embodiment, the active noise cancellation device 2 is arranged at a distal end of a medical device. The medical device may be an elongated medical tube adapted to be inserted into a patient, such as a sensor guide wire provided with a pressure sensor at its distal end portion. The active noise cancellation device 2 may be arranged in connection with the pressure sensor by being integrated on the same chip. Similarly, if the medical device is a sensor guide wire provided with another type of sensor (e.g., temperature, flow, pH, etc.), the noise cancellation device 2 may be integrated on an alternative chip.

[0045] The present invention is thus applicable to any type of medical device provided with one or many intrabody sensor(s) arranged to measure, for example, one or many of pressure, temperature, flow, pH, or position of the sensor when the sensor is positioned at a distal tip portion of the medical device (so-called mGPS-sensors). The present invention can also be used in medical devices that are semi-permanently or permanently implanted into a subject.

[0046] A method of active noise and interference cancellation in a medical device will now be described with reference to the schematic flow diagram shown in Figure 6.

[0047] In one example, the method comprises providing an active circuit having a first input connection 8, a second input connection 10, and an output connection 12, wherein said second input connection is connected to a predetermined reference signal, arranging a low-impedance body connection electrode 4 in electrical contact with the bloodstream of a human or animal body, wherein said body connection electrode 4 is connected to said first input connection 8, and providing a feedback branch 14 connecting said output connection 12 with said first input connection 8. The method further comprises limiting an error correction current through said feedback branch 14 by providing a current limiting circuit 18 such that said error correction current is lower than a predetermined current. In the embodiment shown in Figure 6, the step of providing an active circuit includes providing an operational amplifier unit having a feedback branch. The body connection electrode may be connected to an input of the operational amplifier unit.

[0048] The error correction current may be limited to be 50μA or lower. The active cancellation may be in particular adapted to reduce the influence of an interference frequency of 50-60 Hz. As described above, the predetermined reference signal 16 may be a fixed reference voltage related to a ground of the medical device. Alternatively, the predetermined reference signal 16 may be related to a sensor signal of the medical device. In one embodiment, the reference signal 16 is obtained by switching between different sensor signals of the medical device.

[0049] The low-impedance body connection electrode 4 is adapted to be in direct connection to the blood of the human or animal. This is achieved in accordance with the different embodiments disclosed above in connection with the noise cancellation device 2.

[0050] In one embodiment, the current limiting circuit 18 includes an impedance circuit, including, for example, a resistor unit and/or a capacitance unit.

[0051] The construction and arrangement of the systems and methods as shown in the various exemplary embodiments and examples are illustrative only. Al-

though only a few embodiments
have been described in detail in this disclosure, many modifications are possible (e.g., variations in sizes, components, and structures of the various elements, values of parameters, use of materials, etc.). For example, the position of elements may be varied and the nature or number of discrete elements or positions may be altered or varied. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative examples.

[0052] Other substitutions, modifications, changes, and omissions may be made in the design, operating conditions and arrangement of the exemplary embodiments without departing from the scope of the present disclosure, which is defined by the appended claims.

Claims

1. An active noise cancellation device (2) for a medical device, comprising:

an active circuit (6) having a first input connection (8), a second input connection (10), and an output connection (12), wherein said second input connection is connected to at least one predetermined reference signal (16);
a low-impedance body connection electrode (4) adapted to be in direct electrical contact with a bloodstream of a subject, wherein the low-impedance body connection electrode (4) is connected to said first input connection (8); and
a feedback branch (14) connecting the output connection (12) with the first input connection (8);
wherein said feedback branch (14) comprises a current limiting circuit (18) adapted to limit a current through said feedback branch to be lower than a predetermined current.

2. The active noise cancellation device (2) according to claim 1, wherein said current is limited to be 50μA or lower.

3. The active noise cancellation device (2) according to claim 1 or 2, wherein said active noise cancellation device (2) is adapted to reduce the influence of an interference frequency of 50-60 Hz.

4. The active noise cancellation device (2) according to any of claims 1-3, wherein said at least one predetermined reference signal (16) is a fixed reference voltage related to a ground of the medical device.

5. The active noise cancellation device (2) according to any of claims 1-3, wherein said at least one predetermined reference signal (16) is related to a sensor signal of said medical device.

6. The active noise cancellation device (2) according to any of claims 1-3, wherein said at least one predetermined reference signal (16) is obtained by switching between different sensor signals of said medical device.

7. The active noise cancellation device (2) according to any of claims 1-6, wherein said current limiting circuit (18) includes an impedance circuit.

8. The active noise cancellation device (2) according to any of claims 1-7, wherein said current limiting circuit (18) includes a resistor unit.

9. The active noise cancellation device (2) according to any of claims 1-8, wherein said current limiting circuit (18) includes a capacitance unit.

10. A sensor guide wire comprising the active noise cancellation device (2) according to any of claims 1-9.

11. The sensor guide wire according to claim 10, wherein said body connection electrode (4) is adapted to be in direct connection to the bloodstream of the subject by being connected to an outer non-insulated tubing of said sensor guide wire that is adapted to be in direct connection to the blood.

12. An elongated medical tube adapted to be inserted into the subject, comprising the active noise cancellation device (2) according to any of claims 1-9, wherein said noise cancellation device (2) is arranged on a sensor chip at a distal end portion of said elongated medical tube.

13. The elongated medical tube according to claim 12, wherein said elongated medical tube is a sensor guide wire provided with a pressure sensor at the distal end portion.

Patentansprüche

1. Aktive Rauschunterdrückungsvorrichtung (2) für ein medizinisches Gerät, umfassend:

eine aktive Schaltung (6) mit einem ersten Eingangsanschluss (8), einem zweiten Eingangsanschluss (10) und einem Ausgangsanschluss (12); wobei besagte zweite Eingangsverbindung mit mindestens einem vorbestimmten Referenzsignal (16) verbunden ist;
eine Niederimpedanz-Körperverbindungselektrode (4), die dazu geeignet ist, in direktem elektrischem Kontakt mit einem Blutkreislauf eines Probanden zu stehen, wobei die Niederimpedanz-Körperverbindungselektrode (4) mit der ersten Eingangsverbindung (8) verbunden ist;

und einen den Ausgangsanschluss (12) mit dem ersten Eingangsanschluss (8) verbindenden Rückkopplungszweig (14); wobei der Rückkopplungszweig (14) eine Strombegrenzungsschaltung (18) aufweist, die geeignet ist, einen Strom durch besagten Rückkopplungszweig zu begrenzen, um niedriger als ein vorbestimmter Strom zu sein.

2. Aktive Rauschunterdrückungsvorrichtung (2) nach Anspruch 1, wobei besagter Strom auf 50 μA oder weniger begrenzt ist.

3. Aktive Rauschunterdrückungsvorrichtung (2) nach Anspruch 1 oder 2, wobei besagte aktive Rauschunterdrückungsvorrichtung (2) geeignet ist, den Einfluss einer Störfrequenz von 50 bis 60 Hz zu verringern.

4. Aktive Rauschunterdrückungsvorrichtung (2) nach einem der Ansprüche 1-3, wobei besagtes zumindest eine vorbestimmte Referenzsignal (16) eine feste Referenzspannung ist, die sich auf eine Masse der medizinischen Vorrichtung bezieht.

5. Aktive Rauschunterdrückungsvorrichtung (2) nach einem der Ansprüche 1-3, wobei besagtes zumindest eine vorbestimmte Referenzsignal (16) sich auf ein Sensorsignal besagter medizinischer Vorrichtung bezieht.

6. Aktive Rauschunterdrückungsvorrichtung (2) nach einem der Ansprüche 1-3, wobei besagtes zumindest eine vorbestimmte Referenzsignal (16) durch Umschalten zwischen verschiedenen Sensorsignalen besagter medizinischen Vorrichtung erhalten wird.

7. Aktive Rauschunterdrückungsvorrichtung (2) nach einem der Ansprüche 1-6,
wobei besagte Strombegrenzungsschaltung (18) eine Impedanzschaltung aufweist.

8. Aktive Rauschunterdrückungsvorrichtung (2) nach einem der Ansprüche 1-7,
wobei besagte Strombegrenzungsschaltung (18) eine Widerstandseinheit aufweist.

9. Aktive Rauschunterdrückungsvorrichtung (2) nach einem der Ansprüche 1-8, wobei besagte Strombegrenzungsschaltung (18) eine kapazitive Einheit aufweist.

10. Sensorführungsdraht, umfassend die aktive Rauschunterdrückungsvorrichtung (2) nach einem der Ansprüche 1-9.

11. Sensorführungsdraht nach Anspruch 10, wobei besagte Körperverbindungselektrode (4) geeignet ist, in direkter Verbindung mit dem Blutstrom des Probanden zu stehen, indem sie mit einem äußeren, nicht isolierten Schlauch besagten Sensorführungsdrahtes verbunden ist, der geeignet ist, in direkter Verbindung mit dem Blut zu stehen.

12. Langgestreckter medizinischer Schlauch, welcher in den Probanden einführbar ist und eine aktive Rauschunterdrückungsvorrichtung (2) nach einem der Ansprüche 1-9 aufweist, wobei besagte Rauschunterdrückungsvorrichtung (2) auf einem Sensorchip an einem distalen Endabschnitt besagten länglichen medizinischen Schlauchs angeordnet ist.

13. Langgestreckter medizinischer Schlauch nach Anspruch 12, wobei besagter langgestreckter medizinischer Schlauch ein Sensorführungsdraht ist, der mit einem Drucksensor am distalen Endabschnitt versehen ist.

Revendications

1. Dispositif (2) d'annulation active du bruit pour un dispositif médical, comprenant :

un circuit actif (6) possédant une première connexion (8) d'entrée, une seconde connexion (10) d'entrée et une connexion (12) de sortie, ladite seconde connexion d'entrée étant connectée à au moins un signal (16) de référence prédéterminé ;
une électrode (4) basse impédance de connexion corporelle conçue pour entrer en contact électrique direct avec un courant sanguin d'un sujet, l'électrode (4) basse impédance de connexion corporelle étant connectée à ladite première connexion (8) d'entrée ; et
une branche (14) de rétroaction connectant la connexion (12) de sortie à la première connexion (8) d'entrée ;
dans lequel ladite branche (14) de rétroaction comprend un circuit (18) de limitation de courant conçu pour limiter un courant circulant à travers ladite branche de rétroaction à une valeur inférieure à celle d'un courant prédéterminé.

2. Dispositif (2) d'annulation active du bruit selon la revendication 1, dans lequel ledit courant est limité à 50 μA ou moins.

3. Dispositif (2) d'annulation active du bruit selon la revendication 1 ou 2, dans lequel ledit dispositif (2) d'annulation active du bruit est conçu pour réduire l'influence d'une fréquence d'interférence de 50-60 Hz.

4. Dispositif (2) d'annulation active du bruit selon l'une quelconque des revendications 1 à 3, dans lequel ledit au moins un signal (16) de référence prédéterminé est une tension de référence fixe mise à la terre du dispositif médical.

5. Dispositif (2) d'annulation active du bruit selon l'une quelconque des revendications 1 à 3, dans lequel ledit au moins un signal (16) de référence prédéterminé est lié à un signal de détection dudit dispositif médical.

6. Dispositif (2) d'annulation active du bruit selon l'une quelconque des revendications 1 à 3, dans lequel ledit au moins un signal (16) de référence prédéterminé est obtenu par commutation entre différents signaux de détection dudit dispositif médical.

7. Dispositif (2) d'annulation active du bruit selon l'une quelconque des revendications 1 à 6, dans lequel ledit circuit (18) de limitation de courant comprend un circuit à impédance.

8. Dispositif (2) d'annulation active du bruit selon l'une quelconque des revendications 1 à 7, dans lequel ledit circuit (18) de limitation de courant comprend une unité faisant office de résistance.

9. Dispositif (2) d'annulation active du bruit selon l'une quelconque des revendications 1 à 8, dans lequel ledit circuit (18) de limitation de courant comprend une unité faisant office de capacité.

10. Fil-guide de détecteur comprenant le dispositif (2) d'annulation active du bruit selon l'une quelconque des revendications 1 à 9.

11. Fil-guide de détecteur selon la revendication 10, dans lequel ladite électrode (4) de connexion corporelle est conçue pour une mise en connexion directe avec le courant sanguin du sujet en étant connectée à une tubulure externe non isolée dudit fil-guide de détecteur, qui est conçue pour une mise en connexion directe avec le sang.

12. Tube médical allongé conçu pour être inséré dans le sujet, comprenant le dispositif (2) d'annulation active du bruit selon l'une quelconque des revendications 1 à 9, dans lequel ledit dispositif (2) d'annulation active du bruit est disposé sur une puce de détection à une portion terminale distale dudit tube médical allongé.

13. Tube médical allongé selon la revendication 12, dans lequel ledit tube médical allongé est un fil-guide de détecteur équipé d'un capteur de pression à la portion terminale distale.

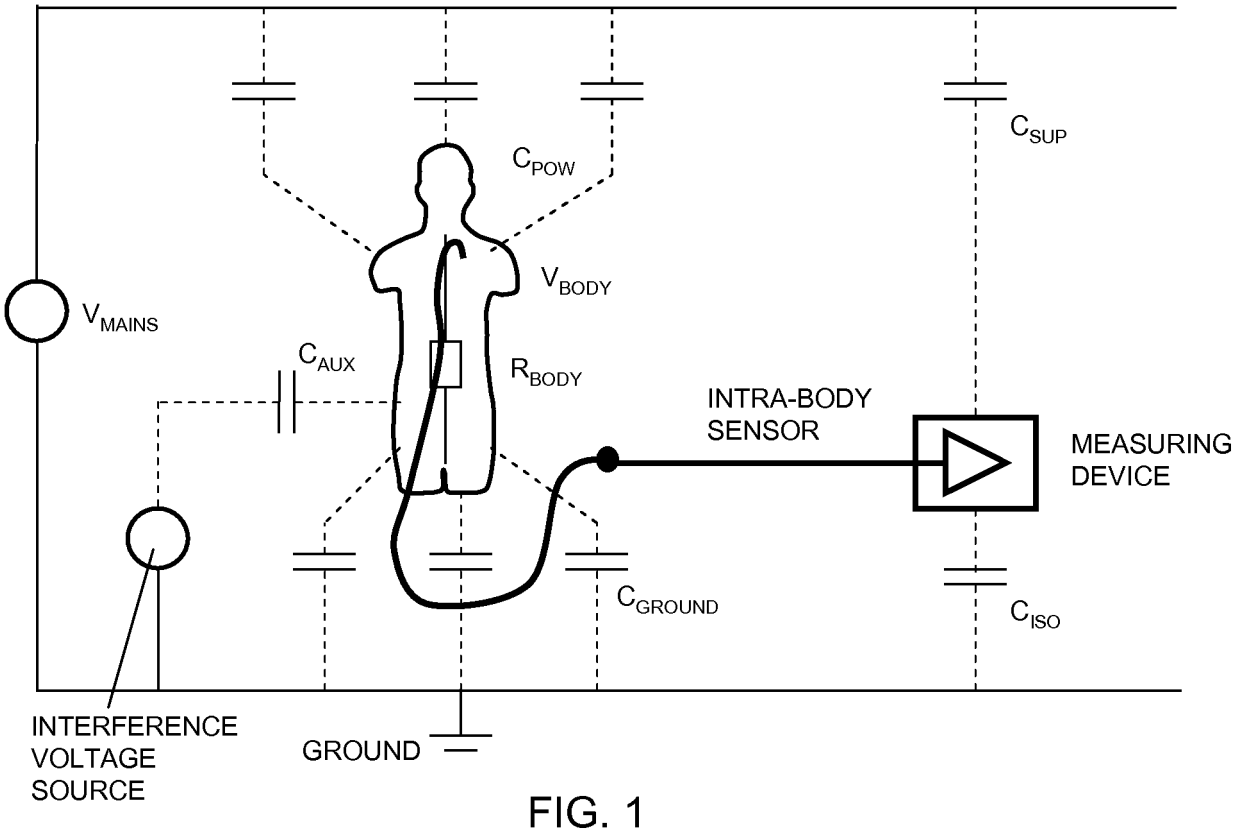
C_SUP
C_POW
V_BODY
V_MAINS
C_AUX
R_BODY
INTRA-BODY
SENSOR
MEASURING
DEVICE
C_GROUND
C_ISO
INTERFERENCE
VOLTAGE
SOURCE
GROUND

FIG. 1

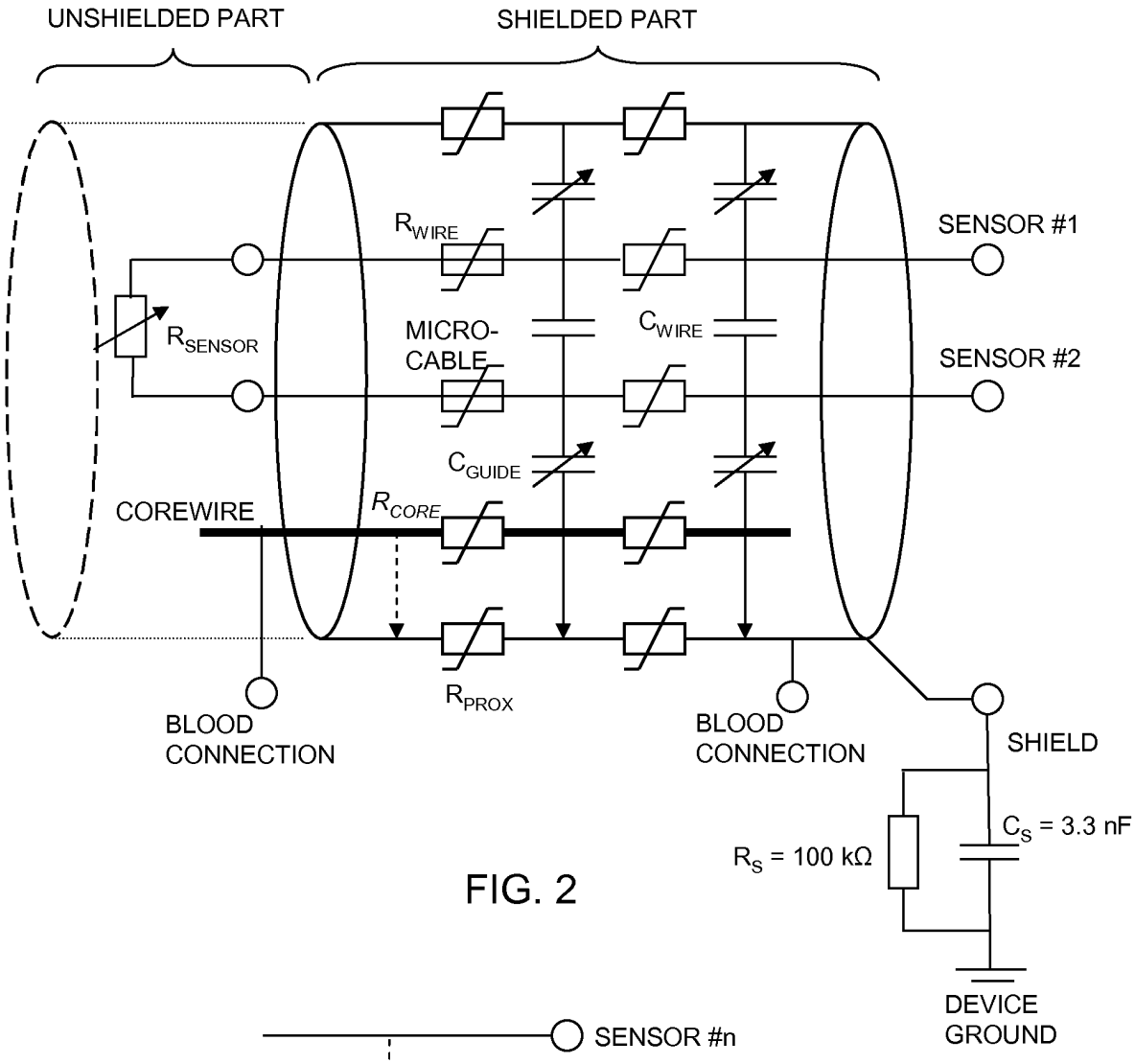
UNSHIELDED PART
SHIELDED PART
R_{WIRE}
SENSOR #1
R_{SENSOR}
MICRO-
CABLE
C_{WIRE}
SENSOR #2
C_{GUIDE}
COREWIRE
R_{CORE}
R_{PROX}
BLOOD
CONNECTION
BLOOD
CONNECTION
SHIELD
C_S = 3.3 nF
R_S = 100 kΩ
DEVICE
GROUND

FIG. 2

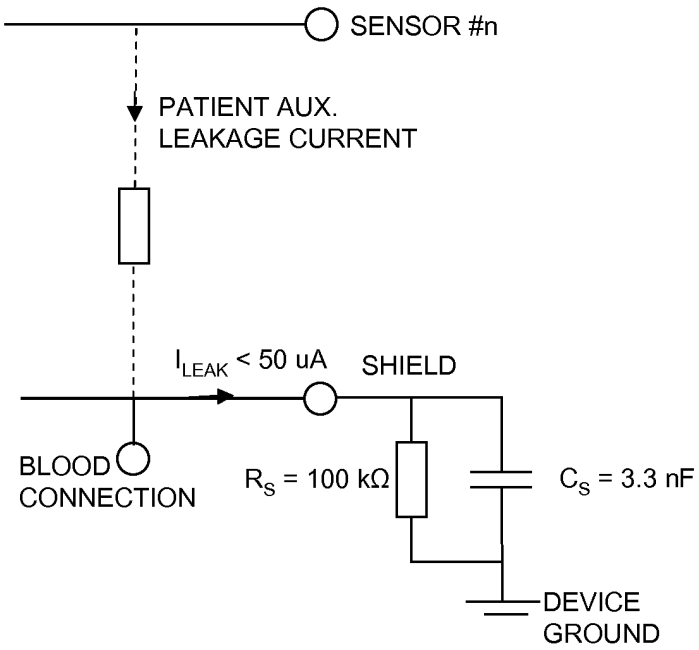
SENSOR #n
PATIENT AUX.
LEAKAGE CURRENT
I_{LEAK} < 50 uA
SHIELD
BLOOD
CONNECTION
R_S = 100 kΩ
C_S = 3.3 nF
DEVICE
GROUND

FIG. 3

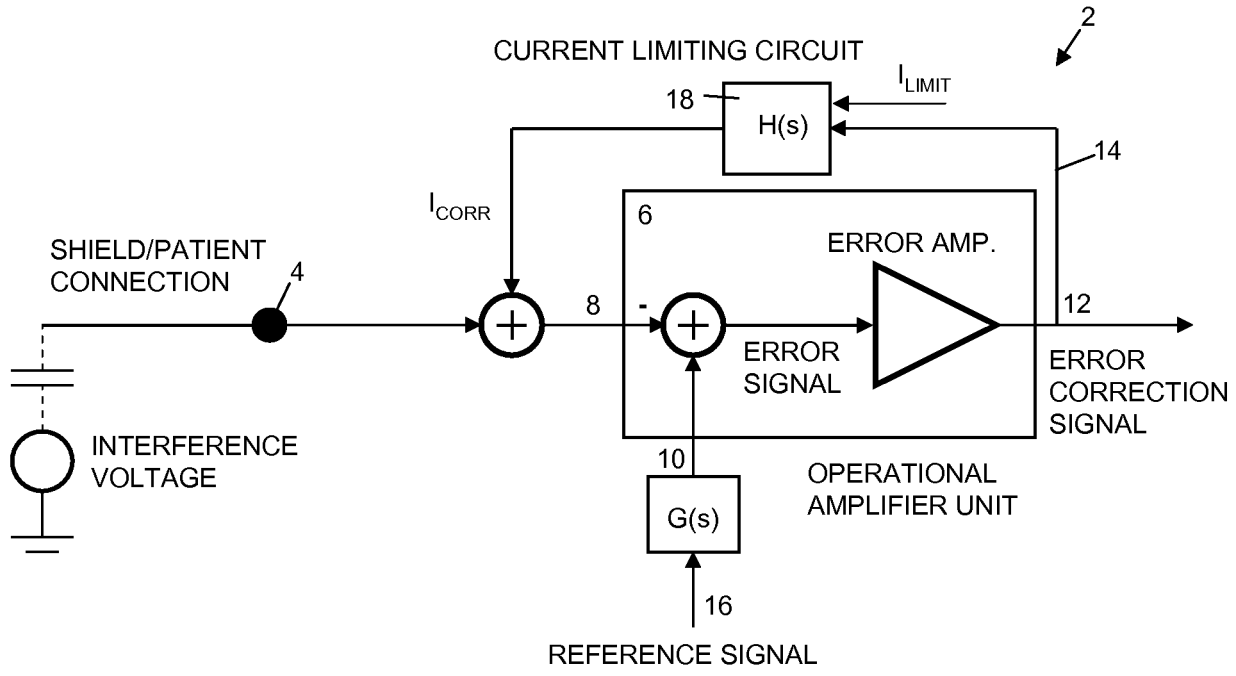
2
CURRENT LIMITING CIRCUIT
I_{LIMIT}
18
H(s)
14
I_{CORR}
6
ERROR AMP.
SHIELD/PATIENT CONNECTION
4
8
-
12
ERROR SIGNAL
ERROR CORRECTION SIGNAL
INTERFERENCE VOLTAGE
10
OPERATIONAL AMPLIFIER UNIT
G(s)
16
REFERENCE SIGNAL

FIG. 4

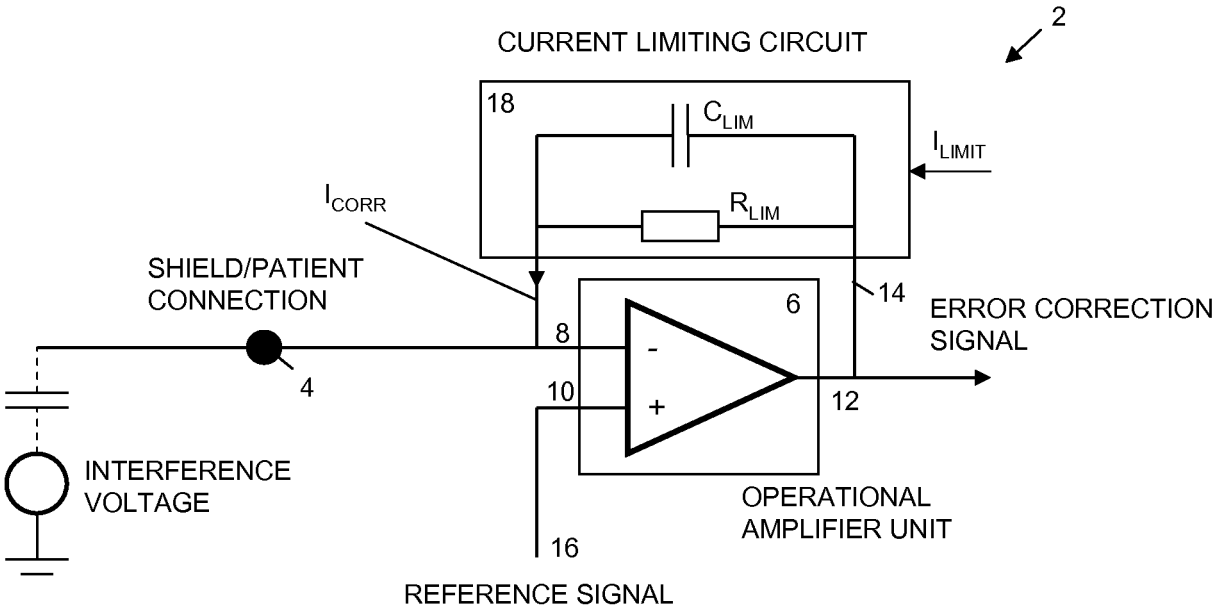
2
CURRENT LIMITING CIRCUIT
18
C_{LIM}
I_{LIMIT}
I_{CORR}
R_{LIM}
SHIELD/PATIENT CONNECTION
6
14
ERROR CORRECTION SIGNAL
8
-
4
10
+
12
INTERFERENCE VOLTAGE
OPERATIONAL AMPLIFIER UNIT
16
REFERENCE SIGNAL

FIG. 5

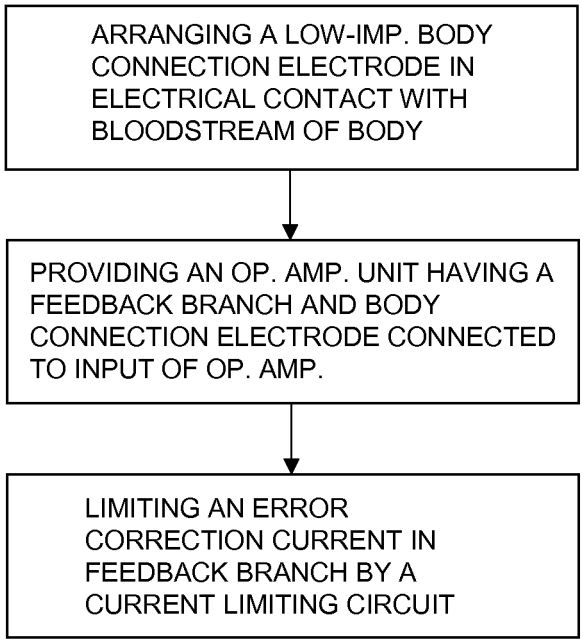
ARRANGING A LOW-IMP. BODY CONNECTION ELECTRODE IN ELECTRICAL CONTACT WITH BLOODSTREAM OF BODY
PROVIDING AN OP. AMP. UNIT HAVING A FEEDBACK BRANCH AND BODY CONNECTION ELECTRODE CONNECTED TO INPUT OF OP. AMP.
LIMITING AN ERROR CORRECTION CURRENT IN FEEDBACK BRANCH BY A CURRENT LIMITING CIRCUIT

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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- Amplifiers for bioelectric events: A design with a minimal number of parts. Medical and Biological Engineering and Computing. Springer, Heidelberg, DE, 01 May 1994, vol. 32, 305-310 **[0016]**

专利名称(译)	有源干扰噪声消除设备		
公开(公告)号	EP2601884B1	公开(公告)日	2017-03-08
申请号	EP2012195215	申请日	2012-12-03
[标]申请(专利权)人(译)	ST犹达医疗SYST		
申请(专利权)人(译)	ST.犹达医疗系统公司		
当前申请(专利权)人(译)	ST.犹达医疗协调中心BVBA		
[标]发明人	SAMUELSSON MAGNUS		
发明人	SAMUELSSON, MAGNUS		
IPC分类号	A61B5/00 A61B5/0215 H03H11/12 A61B5/01 A61B5/026 A61B5/06 A61B5/145		
CPC分类号	A61B5/01 A61B5/0215 A61B5/026 A61B5/065 A61B5/14539 A61B5/6851 A61B5/7203 A61M25/09 H03H11/12		
优先权	1151152 2011-12-05 SE		
其他公开文献	EP2601884A1		
外部链接	Espacenet		

摘要(译)

一种用于医疗设备的有源噪声消除设备（2）包括具有第一输入连接（8），第二输入连接（10）和输出连接（12）的有源电路。第二输入连接（10）连接到至少一个预定参考信号。有源噪声消除设备（2）还包括适于与对象的血流电接触的低阻抗体连接电极（4），其中低阻抗体连接电极（4）连接到所述第一输入连接（8）和将输出连接（12）与第一输入连接（8）连接的反馈支路（14）。反馈支路（14）包括限流电路（18），用于限制通过所述反馈支路（14）的电流低于预定电流。


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(11) EP 2 601 884 B1

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(54) Active interference-noise cancellation device

Aktive Störsignalunterdrückungsvorrichtung

Dispositif d'annulation de bruit d'interférence active

(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

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EP 2 601 884 B1

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