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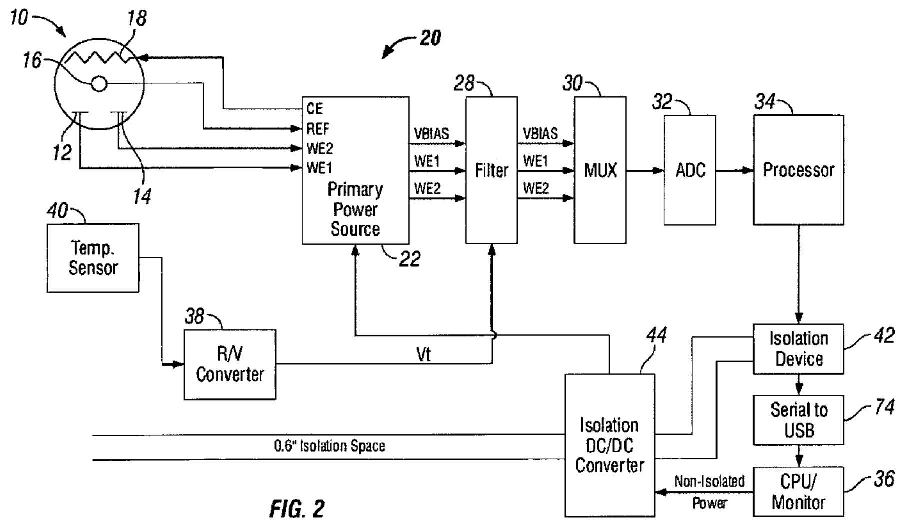

FIG. 2

(57) Abstract: An analyte monitoring system includes a biosensor for detecting an analyte concentration in blood. The monitoring system includes a sensor for sensing whether a tool or other piece of equipment is producing electrical noise that may affect operation of the biosensor. If such electrical noise is detected, the system isolates the biosensor during the period of detected operation of the other tool or equipment. In some embodiments, the system measures both signal noise in and temperature of the environment surrounding the biosensor to determine whether another tool or other piece of equipment is currently in operation. The system may also include an auxiliary power source to maintain the biosensor in a biased state during the period when the biosensor is placed in isolation.

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ANALYTE MONITORING SYSTEM CAPABLE OF DETECTING AND PROVIDING PROTECTION AGAINST SIGNAL NOISE GENERATED BY EXTERNAL SYSTEMS THAT MAY AFFECT THE MONITORING SYSTEM

BACKGROUND

Cross-Reference To Related Applications

[0001] This application claims priority from U.S. provisional patent application No. 60/985,068, filed on November 2, 2007, which is also hereby incorporated herein by reference.

Field of the Invention

[0002] The invention relates generally to an analyte monitoring systems and methods. More specifically, the invention relates to systems and methods for detecting and providing protection against signal noise generated by external systems that may affect an analyte monitoring system employing an electro-chemical biosensor, such as an amperometric, potentiometric, or similar type biosensor.

Description of Related Art.

[0003] Controlling blood glucose levels for diabetics and other patients can be a vital component in critical care, particularly in an intensive care unit (ICU), operating room (OR), or emergency room (ER) setting where time and accuracy are essential. Presently, the most reliable way to obtain a highly accurate blood glucose measurement from a patient is by a direct time-point method, which is an invasive method that involves drawing a blood sample and sending it off for laboratory analysis. This is a time-consuming method that is often incapable of producing needed results in a timely manner. Other minimally invasive methods such as subcutaneous methods involve the use of a lancet or pin to pierce the skin to obtain a small sample of blood, which is then smeared on a test strip and analyzed by a glucose meter. While these minimally invasive methods may be effective in determining trends in blood glucose concentration, they do not track glucose accurately enough to be used for intensive insulin therapy, for example, where inaccuracy at conditions of hypoglycemia could pose a very high risk to the patient.

[0004] Electro-chemical biosensors have been developed for measuring various analytes in a substance, such as glucose. An analyte is a substance or chemical constituent that is determined in an analytical procedure, such as a titration. For instance, in an immunoassay, the analyte may be the ligand or the binder, where in blood glucose testing, the analyte is glucose. Electro-chemical biosensors comprise eletrolytic cells including electrodes used to measure an analyte. Two types of electro-chemical biosensors are potentiometric and amperometric biosensors.

[0005] Amperometric biosensors, for example, are known in the medical industry for analyzing blood chemistry. These types of sensors contain enzyme electrodes, which typically include an oxidase enzyme, such as glucose oxidase, that is immobilized behind a membrane on the surface of an electrode. In the presence of blood, the membrane selectively passes an analyte of interest, *e.g.* glucose, to the oxidase enzyme where it undergoes oxidation or reduction, e.g. the reduction of oxygen to hydrogen peroxide. Amperometric biosensors function by producing an electric current when a potential sufficient to sustain the reaction is applied between two electrodes in the presence of the reactants. For example, in the reaction of glucose and glucose oxidase, the hydrogen peroxide reaction product may be subsequently oxidized by electron transfer to an electrode. The resulting flow of electrical current in the electrode is indicative of the concentration of the analyte of interest.

[0006] Figure 1 is a schematic diagram of an exemplary electro-chemical biosensor, and specifically a basic amperometric biosensor 10. The biosensor comprises two working electrodes: a first working electrode 12 and a second working electrode 14. The first working electrode 12 is typically an enzyme electrode either containing or immobilizing an enzyme layer. The second working electrode 14 is typically identical in all respects to the first working electrode 12, except that it may not contain an enzyme layer. The biosensor also includes a reference electrode 16 and a counter electrode 18. The reference electrode 16 establishes a fixed potential from which the potential of the counter electrode 18 and the working electrodes 12 and 14 are established. In order for the reference electrode 16 to function properly, no current must flow through it. The counter electrode 18 is used to conduct current in or out of the biosensor so as to balance the current generated by the working electrodes. The four electrodes together are typically referred to as a cell. During operation, outputs from the working electrodes are monitored to determine the amount of an analyte of interest that is in the blood. Potentiometric biosensors operate in a similar manner to detect the amount of an analyte in a substance.

[0007] As described in U.S. Patent Application No. 11/696,675, filed April 4, 2007, and titled ISOLATED INTRAVENOUS ANALYTE MONITORING SYSTEM, electro-chemical sensors have been designed for continuous monitoring of analytes such as blood glucose. Specifically, the system comprises placement of the electro-chemical sensor in a catheter, which is the inserted into the blood stream of a patient. Electrical signals from the sensor are routed via wires from the catheter to an external system for analysis. Use of the intravenous biosensor means that the patient does not suffer any discomfort from periodic blood drawing, or experience any blood loss whenever a measurement needs to be taken.

[0008] While electro-chemical biosensors containing eletrolytic cells, such as amperometric and potentiometric biosensors, are a marked improvement over more conventional analyte testing devices and methods, there are some potential drawbacks to their use. For example, electro-chemical biosensors typically require time for chemistry cell alignment after initial biasing and prior to calibration and use. The process beginning from a time when the bias signals are applied until the cell is in full alignment (i.e., steady state) can be anywhere from a few minutes to more than an hour (e.g., 15 minutes to 1.5 hours). The time for chemistry cell alignment is typically referred to as run-in time.

[0009] Significant delays in run-in time can be problematic, especially where the biosensor is in use and there is an unexpected loss of power to the cell. For example, if the electronics to the biosensor is unplugged during the transport of the patient or to reconfigure the various electric lines, IVs, tubes, etc. connected to a patient, the biometric sensor will experience disruption of steady state that may require significant time for the biosensor to again be operational. This may be a particular problem where the patient is entering surgery, where blood content monitoring is critical.

[0010] Additional issues relate to sensitivity to signal noise. Specifically, there are various instruments and equipment in the hospital room or operation room that can affect operation of the electro-chemical biosensor. For example, electrosurgerical procedures are common place in many surgical procedures. Electrosurgery is the application of a high-frequency electric current to human (or other animal) tissue as a means to remove lesions, staunch bleeding, or cut tissue. Its benefits include the ability to make precise cuts with limited blood loss. In electrosurgerical procedures, the tissue is burned by an alternating electrical current, which directly heats the tissue, while the probe tip remains relatively cool. Electrosurgery is performed using a device called a electrosurgical generator (ESG) or electrosurgical cautery (ESU), sometimes referred to as an RF knife or Bovie knife.

[0011] As an initial issue, the electrical noise from the ESU can interfere, disrupt, over-power or otherwise affect the signals transmitted from the biosensor. Further, the noise may harm the electrolytic cell of the biosensor. As described more fully below with referecne to Figure 5, a voltage converter is associated with both of the working electrodes 12 and 14. The voltage converter is referenced to ground. Where the ESU is operated near to the biosensor, the current generated by the ESU may pass through both the working electrodes 12 and 14 to ground. The current passing through the working electrodes may generate significant heat that may dehydrate the enzyme protein present in the first working electrode 12, thereby damaging and destroying one of both of the working electrodes.

[0012] In light of the above, systems and methods are needed to monitor electrical noise associated with the biosensor to determine if the biosensor is experiencing interference from other tools or equipment in its associated environment. Systems and methods are also needed to isolate the electro-chemical biosensor from such interference so as to maintain performance and operation of the biosensor.

BRIEF SUMMARY OF THE INVENTION

[0013] The present invention provides systems and methods that address many, if not all, of the above-referenced problems with conventional analyte monitoring systems. Specifically, the present invention provides systems and methods that monitor whether other tools or equipment in the vicinity of an analyte monitoring system are outputting electrical signal noise that may affect the performance of the monitoring system and selectively isolates the biosensor of the monitoring system.

[0014] For example, in one embodiment, the present invention provides a selector electrically connected between a biosensor and a monitoring system associated with the biosensor. The selector selectively connects or isolates the biosensor from the monitoring system. For example, in some embodiments, the selector could be a manual switch that is configured by a user to selectively isolate the biosensor or connect it to the monitoring system. This is applicable where the user knows that a tool or other equipment is going to be put in to operation that may interfere or harm the biosensor. By configuring the selector to isolate the biosensor, such issues are avoided.

[0015] In one embodiment, a system of the present invention may comprise a noise detector for detecting electrical signal noise in an environment associated with the biosensor. A processor or other type of comparator may be connected to the noise detector and the selector. The processor may compare noise signals received from the noise detector to a threshold value and control the selector to isolate the biosensor if the noise signals from the noise detector are at least as great as the threshold value.

[0016] In another embodiment, a system of the present invention may comprise a temperature sensor for detecting a temperature in an environment associated with the biosensor. A processor or other type of comparator may be connected to the temperature sensor and the selector. The processor may compare temperature readings received from the temperature sensor to a threshold value and control the selector to isolate the biosensor if the temperature is at least as great as the threshold value.

[0017] In some embodiments, a system of the present invention may include both a noise detector and a temperature sensor for respectively sensing electrical signal noise in and a temperature of an environment associated with the biosensor. A processor or other type of comparator may be connected to both the temperature sensor and noise detector and the selector. The processor may respectively compare the noise and the temperature received from the noise detector and temperature sensor to respective threshold values and control the selector to isolate the biosensor if either one or both of the noise or temperature is at least as great as the respective threshold values.

[0018] In one embodiment, the system of the present invention may comprise first and second power sources, each selectively couplable to the biosensor, wherein the first and second power sources are capable of providing one or more bias signals to the biosensor. In this embodiment, when the selector isolates the biosensor, it disconnects the biosensor from the first power source and connects it to the second power source to thereby maintain bias signals to the biosensor during isolation.

[0019] In one embodiment, the system of the present invention comprises a first selector for selectively connecting the biosensor either to an open circuit or to the monitoring system. The system of this embodiment further comprises a second selector connected between the first selector and the monitoring system. The second selector is capable of selecting either a first or second power source. In this embodiment, during isolation of the biosensor, the system can either select the first selector to connect the biosensor to an open circuit or select the second selector to connect the biosensor to the second power source.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Henceforth reference is made the accompanied drawings and its related text, whereby the present invention is described through given examples and provided embodiments for a better understanding of the invention, wherein:

[0021] Figure 1 is a schematic diagram of a four-electrode biosensor according to an embodiment of the invention;

[0022] Figure 2 is a block diagram of a monitoring system for monitoring the output of an electro-chemical sensor according to one embodiment of the present invention;

[0023] Figure 3 is a block diagram of a monitoring system for monitoring the output of an electro-chemical sensor according to one embodiment of the present invention, wherein an in-line filter is used to filter electrical noise;

[0024] Figure 4 is a block diagram depicting various embodiments of different monitoring systems according to the present invention for isolating a biosensor from electrical signal noise;

[0025] Figure 5 is partial schematic view of the monitoring system of Figure 4 depicting various components of the monitoring system according to one embodiment of the present invention;

[0026] Figure 6 is an operational block diagram illustrating methods steps for electrical noise in and/or temperature of an environment associated with a biosensor and selectively isolating the biosensor according to one embodiment of the present invention;

[0027] Figure 7 is a block diagram of an embodiment of the present invention which both monitors introduction of signal noise to an electro-chemical biosensor and also monitors bias signals sent to the biosensor so as to maintain the biosensor in a biased state and also isolate the biosensor from electrical signal noise;

[0028] Figure 8 is an illustration of an alternative embodiment of the four-electrode biosensor of Figure 1 with an added electrode used to dissipate or remove electrical signal noise from the electro-chemical sensor.

[0029] Figures 9A-9D are circuit diagrams of an analyte monitoring system according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0030] The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the inventions are shown. Indeed, these inventions may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like numbers refer to like elements throughout.

[0031] The present invention provides systems and methods that allow physicians or other health care workers to monitor a patient using a biosensor, such as an electro-chemical biosensor comprising an eletrolytic cell. The electro-chemical biosensor may contain an enzyme capable of reacting with a substance in a fluid, such as blood glucose, to generate electrical signals. These signals are sent to processor, which calculates the amount of substance in the fluid, for example, the blood glucose concentration in blood. The results can then be conveniently displayed for the attending physician. The device may also be specially designed to isolate the biosensor signals from interfering noise and electrical static, so that more accurate measurements can be taken and displayed. In some embodiments, the biosensor can operate continually when it is installed in the blood vessel, the results may be seen in real time whenever they are needed. This has the advantage of eliminating costly delays that occur using the old method of extracting blood samples and sending them off for laboratory analysis. In some instance, the biosensor is fitted to a catheter, such that it may be placed into the patient's blood stream. In this instance, use of the intravenous biosensor means that the patient does not suffer any discomfort from periodic blood drawing, or experience any blood loss whenever a measurement is needed.

[0032] It must be understood that the systems and methods of the present invention may be used with any biosensor that is sensitive to either electrical noise or voltage or current spikes that may disrupt and/or affect the biosensor. For example, the systems and methods may be used with electro-chemical biosensors having eletrolytic cells, such as amperometric and potentiometric biosensors containing one or more electrodes used to measure an analyte in a substance, such as glucose in blood, where the electrodes of the electrolytic cell are susceptible to electrical noise and current or voltage spikes.

[0033] For example, Figure 1 is a schematic diagram of an amperometric, four-electrode biosensor 10 which can be used in conjunction with the present invention. In the illustrated embodiment, the biosensor 10 includes two working electrodes: a first working electrode 12 and a second working electrode 14. The first working electrode 12 may be a platinum based enzyme electrode, i.e. an electrode containing or immobilizing an enzyme layer. In one embodiment, the first working electrode 12 may immobilize an oxidase enzyme, such as in the sensor disclosed in U.S. Patent No. 5,352,348, the contents of which are hereby incorporated by reference. In some embodiments, the biosensor is a glucose sensor, in which case the first working electrode 12 may immobilize a glucose oxidase enzyme. The first working electrode 12 may be formed using platinum, or a combination of platinum and graphite materials. The second working electrode 14 may be identical in all respects to the first working electrode 12, except that it may not contain an enzyme layer. The biosensor 10 further includes a reference electrode 16 and a counter electrode 18. The reference electrode 16 establishes a fixed potential from which the potential of the counter electrode 18 and the working electrodes 12 and 14 may be established. The counter electrode 18 provides a working area for conducting the majority of electrons produced from the oxidation chemistry back to the blood solution. During normal operation, the counter prevents excessive current from passing through the reference and working electrodes that may reduce their service life. However, the counter electrode may not typically have capacity to reduce current surges caused by spikes, which may affect the electrodes.

[0034] The amperometric biosensor 10 operates according to an amperometric measurement principle, where the working electrode 12 is held at a positive potential relative to the reference electrode 16. In one embodiment of a glucose monitoring system, the positive potential is sufficient to sustain an oxidation reaction of hydrogen peroxide, which is the result of glucose reaction with glucose oxidase. Thus, the working electrode 12 may function as an anode, collecting electrons produced at its surface that result from the oxidation reaction. The collected electrons flow into the working electrode 12 as an electrical current. In one embodiment with the working electrode 12 coated with glucose oxidase, the oxidation of glucose produces a hydrogen peroxide molecule for every molecule of glucose when the working electrode 12 is held at a potential between about +450 mV and about +650 mV. The hydrogen peroxide produced oxidizes at the surface of the working electrode 12 according to the equation:

$$H_2O_2 \rightarrow 2H^+ + O_2 + 2e^-$$

[0035] The equation indicates that two electrons are produced for every hydrogen peroxide molecule oxidized. Thus, under certain conditions, the amount of electrical current may be proportional to the hydrogen peroxide concentration. Since one hydrogen peroxide molecule is produced for every glucose molecule oxidized at the working electrode 12, a linear relationship exists between the blood glucose concentration and the resulting electrical current. The embodiment described above demonstrates how the working electrode 12 may operate by promoting anodic oxidation of hydrogen peroxide at its surface. Other embodiments are possible, however, wherein the working electrode 12 may be held at a negative potential. In this case, the electrical current produced at the working electrode 12 may result from the reduction of oxygen. The following article provides additional information on electronic sensing theory for amperometric glucose biosensors: J. Wang, "Glucose Biosensors: 40 Years of Advances and Challenges," Electroanaylsis, Vol. 13, No. 12, pp. 983-988 (2001).

[0036] Figure 2 illustrates a schematic block diagram of a system 20 for operating an electro-chemical biosensor such as an amperometric or potentiometric sensor, such as a glucose sensor. In particular, Figure 2 discloses a system comprising an amperometric biosensor. As more fully disclosed in U.S. Patent Application No. 11/696,675, filed April 4, 2007, and titled ISOLATED INTRAVENOUS ANALYTE MONITORING SYSTEM, a typical system for operating an amperometric sensor includes a potentiostat 22 in communication with the sensor 10. In normal operation, the potentiostat both biases the electrodes of the sensor and provides outputs regarding operation of the sensor. As illustrated in Figure 2, the potentiostat 22 receives signals WE1, WE2, and REF respectively from the first working electrode 12, second working electrode 14, and the reference electrode 16. The potentiostat further provides a bias voltage CE input to the counter electrode 18. The potentiostat 22, in turn, outputs the signals WE1, WE2 from the working electrodes 12 and 14 and a signal representing the voltage potential VBIAS between the counter electrode 18 and the reference electrode 16.

[0037] A potentiostat is a controller and measuring device that, in an electrolytic cell, keeps the potential of the working electrode 12 at a constant level with respect to the reference electrode 16. It consists of an electric circuit which controls the potential across the cell by sensing changes in its electrical resistance and varying accordingly the electric current supplied to the system: a higher resistance will result in a decreased current, while a lower resistance will result in an increased current, in order to keep the voltage constant.

[0038] Another function of the potentiostat is receiving electrical current signals from the working electrodes 12 and 14 for output to a controller. As the potentiostat 22 works to maintain a constant voltage for the working electrodes 12 and 14, current flow through the working electrodes 12 and 14 may change. The current signals indicate the presence of an analyte of interest in blood. In addition, the potentiostat 22 holds the counter electrode 18 at a voltage level with respect to the reference electrode 16 to provide a return path for the electrical current to the bloodstream, such that the returning current balances the sum of currents drawn in the working electrodes 12 and 14.

[0039] While a potentiostat is disclosed herein as the first or primary power source for the electrolytic cell and data acquisition device, it must be understood that other devices for performing the same functions may be employed in the system and a potentiostat is only one example. For example, an amperostat, sometimes referred to as a galvanostat, could be used.

[0040] As illustrated in Figure 2, the output of the potentiostat 22 is typically provided to a filter 28, which removes at least some of the spurious signal noise caused by either the electronics of the sensor or control circuit and/or external environmental noise. The filter 28 is typically a low pass filter, but can be any type of filter to achieve desired noise reduction.

[0041] In addition to electrical signal noise, the system may also correct analyte readings from the sensor based on operating temperature of the sensor. With reference to Figure 2, a temperature sensor 40 may be collocated with the biosensor 10. Since chemical reaction rates (including the rate of glucose oxidation) are typically affected by temperature, the temperature sensor 40 may be used to monitor the temperature in the same environment where the working electrodes 12 and 14 of the biosensor are located. In the illustrated embodiment, the temperature sensor may be a thermistor, resistance temperature detector (RTD), or similar device that changes resistance based on temperature. An R/V converter 38 may be provided to convert the change in resistance to a voltage signal Vt that can be read by a processor 34. The voltage signal Vt represents the approximate temperature of the biosensor 10. The voltage signal Vt may then be output to the filter 28 and used for temperature compensation.

[0042] As illustrated in Figure 2, a multiplexer may be employed to transfer the signals from the potentiostat 22, namely 1) the signals WE1, WE2 from the working electrodes 12 and 14; 2) the bias signal VBIAS representing the voltage potential between the counter electrode 18 and the reference electrode 16; and 3) the temperature signal Vt from the temperature sensor 40 to the processor 34. The signals are also provided to an analog to digital converter (ADC) 32 to digitize the signals prior to input to the processor.

[0043] The processor uses algorithms in the form of either computer program code where the processor is a microprocessor or transistor circuit networks where the processor is an ASIC or other specialized processing device to determine the amount of analyte in a substance, such as the amount of glucose in blood. The results determined by the processor may be provided to a monitor or other display device 36. As illustrated in Figure 2 and more fully described in U.S. Patent App 11/696,675, filed April 4, 2007, and titled ISOLATED INTRAVENOUS ANALYTE MONITORING SYSTEM, the system may employ various devices to isolate the biosensor 10 and associated electronics from environmental noise. For example, the system may include an isolation device 42, such as an optical transmitter for transmitting signals from the processor to the monitor to avoid backfeed of electrical noise from the monitor to the biosensor and its associated circuitry. Additionally, an isolated main power supply 44 for supplying power to the circuit, such as an isolation DC/DC converter.

[0044] While Figure 2 discloses a block diagram of a biosensor and circuit configuration, Figures 9A-9D discussed later below provide added details regarding circuit configuration.

[0045] While Figure 2 represents a general monitoring system 20 for an electro-chemical biosensor 10, the system 20 of Figure 2 may be susceptible to signal noise from other tools and equipment in the vicinity of the biosensor 10 or monitoring system 20 that may affect the performance of the biosensor or monitoring system 20 or in some cases may damage the biosensor or monitoring system. In light of this, the present invention provides various systems and methods for detecting potential operation of such tools and equipment, and isolating the effects of such external systems on the biosensor 10 and/or the analyte monitoring system 20.

[0046] For example, Figure 3 represents one embodiment of the systems and methods of the present invention for isolating the electro-chemical biosensor from signal noise generated external devices, such as other tools and equipment. For example, as illustrated, the system of the present invention may employ an in-line filter 80 to reduce signal noise. The in-line filter is designed to reduce the transient noise amplitude prior to input to the potentiostat. The in-line filter may either be of generic design or it may be specifically tailored to eliminate specific signal noise. For example, an ESU generates mainly AC signals. In this regard, the in-line filter 80 may comprise inductive elements 80a-80d (see Figure 5) to filter out the AC signal noise generated by the ESU. The in-line filter will reduce harmful signal noise from damaging the electrodes of the electrolytic cell of the biosensor. In some embodiments, the in-line filter 80 will effectively filter signal noise and allow for measurements from the biosensor to continue to be read even in times when such noise is in the environment.

[0047] Figure 4 discloses another embodiment of the systems and methods of the present invention that may be used either in conjunction with or without the in-line filter 80. In other words, the in-line filter 80, while depicted, may be optional in this embodiment. As illustrated, in this embodiment, the system 20 includes a noise detector 82. The noise detector is typically situated near the biosensor 10 and detects signal noise. For example, in one embodiment the noise detector 82 is coupled to the output of the temperature sensor. In this embodiment, the noise detector 82 essentially monitors the signals from the temperature sensor in order to detect signal noise in the vicinity of the biosensor. As illustrated, the noise detector 82 is connected to the processor 34 and provides indications regarding signal noise level to the processor. In some embodiments, the noise detector 82 may have an associated noise threshold input that dictates a noise threshold level for triggering output to the processor 34. While in other embodiments, the processor 34 may comprise one or more stored noise threshold values for use in determining when action should be taken to isolate the electrolytic cell of the biosensor 10 from such noise.

[0048] While the noise detector 82 is illustrated as connected to the temperature sensor 40, it must be understood that the detector could be electrically located at several different points in the system. For example, the noise detector could be electrically connected to the electrodes of the biosensor 10 itself or other electronics associated with the system 20. In some embodiments, the noise detector 82 may be a separate system from the analyte monitoring system for sensing signal noise in the vicinity of the biosensor 10. Importantly, regardless of the form and/or placement of the noise detector, such a detector provides signal noise input that can be monitored to determine when other tools or equipment, such as ESU, in the vicinity of the biosensor 10 is in operation and may affect the operation of the biosensor 10 and/or the monitoring system 20.

[0049] With reference to Figure 4, in addition to providing isolation against signal noise in the form of an in-line filter, and/or sensing electrical signal noise that may affect either the analyte monitoring system 20 or the biosensor 10, the present invention may include either additively or alternatively a temperature sensor for detecting temperature increases or spikes which would indicate operation of another tool or equipment, such as an ESU, that may affect the system 20 and/or the biosensor 10. As discussed previously, an ESU or similar device typically generates heat during operation. By sensing changes in temperature, the system can determine that an ESU is in operation. Further, as discussed, if unchecked, the AC signal noise from the ESU may flow through the work electrodes 12 and 14 to ground. This current flow can cause heating of the sensor, which would also be an indication that an ESU or similar device is in operation.

[0050] As discussed above, the output of the temperature sensor 40 is already typically employed to monitor the temperature of the electrolytic cell of the biosensor 10. The processor 34, in some embodiments, may also monitor the output of the temperature sensor 40 for temperatures that exceed a threshold value or temperature spikes (i.e., rapid temperature increases over short time periods) that may indicate that an ESU or similar type device is in operation.

[0051] In the illustrated embodiment, either one or both the noise detector 82 and temperature sensor 40 indicates possible operation of an ESU or similar tool or equipment. The system should further include a mechanism for acting on such indications. For example, in some embodiments, the processor 34 may simply ignore inputs from the biosensor 10 when it is determined that other tools or equipment are in operation that may affect the output of the biosensors and/or detection of signals from the biosensor. For example, if the processor 34 determines from either one or both the noise detector 82 or the temperature sensor 40 that a tool or other equipment such as a ESU is in operation, the processor may simply disregard use of the input from the biosensor until such tool or equipment operation has ended.

[0052] While this embodiment ensures that error-prone readings from the biosensor are not used to assess the presence of analyte, such a system does not protect either the biosensor or monitoring system 20 from the effects of the signal noise. As such, in some embodiments, the monitoring system 22 may further comprise mechanisms for isolating the biosensor so as to protect the biosensor from deleterious effects of the signal noise.

[0053] For example, as illustrated in Figure 4, the system 20 may further include a first selector 84 located electrically between the biosensor 10 and the potentiostat 22 or other type of primary power source. The first selector 84 is configured so as to isolate the biosensor from the remainder of the system when it is determined that another tool or equipment is in operation that may affect the biosensor 10. For example, if the signal noise levels are greater than a selected threshold and/or the temperature sensor 40 indicates that the temperature has increased above or equal to a threshold or there is a sudden increase or spike in temperature. The first selector 84 essentially creates an open circuit between the biosensor 10 and the remainder of the circuitry. This is discussed more fully below with reference to Figure 5.

[0054] The first selector 84 may take many forms depending on the embodiment. For example, in some embodiments, the selector may be a relay, such as single throw double pole relay. By activating or deactivating the relay, either the potentiostat 22 is connected to the biosensor 10 or the biosensor is open circuited. Other embodiments may employ transistor networks that operate as a relay. A processor, multiplexer, or other type of device may be deployed for alternatively connecting either the potentiostat to the biosensor or open circuiting the biosensor. In short, any device capable of connecting either the potentiostat (or other primary power source) or providing an open circuit to the biosensor is contemplated.

[0055] In some embodiments, the first selector 84 may comprise a manual switch. In this embodiment, the patient's caretaker may toggle the selector to place to open circuit the biosensor 10 prior to operation of an ESU or other device that may affect the biosensor. In this way, the caretaker can ensure that the electrolytic cell of the biosensor is not affected by excessive signal noise associated with ESU's or similar devices.

[0056] Figure 4 is a block diagram illustration of the in-line filter 80, noise detector 82, temperature sensor 40, and first selector 84 according to an embodiment of the present invention. Figure 5 illustrates schematically an exemplary configuration of these devices according to one embodiment of the present invention. For example, Figure 5 illustrates an embodiment of the connection of the in-line filter 80 and the first selector 84 with the biosensor 10 and the potentiostat 22. Figure 5 is an illustration of a typical potentiostat 22 as it would be connected to the biosensor 10. As illustrated, the potentiostat comprises three operational amplifiers, 52, 54, and 56. Operational amplifiers 54 and 56 are respectively coupled to working electrodes 12 and 14 of the biosensor 10 are referenced to ground. The other operational amplifier 52 is connected to both the reference 16 and the counter 18 electrodes. In this configuration, the operational amplifier 52 provides a bias voltage to the counter electrode 18.

[0057] Figure 5 also illustrates an in-line filter 80 in the form of four inductors 80a-80d, which are placed in the current path of each output and/or input of the biosensor. This embodiment is directed to alleviate signal noise from an ESU or similar device. Specifically, an ESU outputs AC signal noise. The inductors 80a-80b filter the AC signal noise so that this signal noise does not affect the signals output by the biosensor. These filters may also isolate the biosensor from the AC signal noise. In one embodiment, these inductors are 10 μH and have an impedance of 2400 K at 10 Mhz. As an alternative to the inductors, an EMI filter could be used.

[0058] As further illustrated in Figure 5, in this embodiment, the selector 84 is located electrically between the electrodes of the biosensor 10 and the potentiostat 22 or other form of primary power source. The selector 84 is configured to either connect the potentiostat 22 to the electrodes or to open circuit the electrodes in the event that excessive signal noise is detected. Depending on the embodiment, the selector 84 may either be connected directly electrically connected to the output of the noise detector 82, to the processor 34, or as discussed previously may be a manual switch.

[0059] Figure 5 also illustrates schematically a circuit representing an embodiment of the noise detector 82. The noise detector of this embodiment is connected to the temperature sensor 40. The noise detector comprises operational amplifiers and an R-C network for proper amplification and filtering of the noise signals received from the temperature sensor 40. The dual operational amplifier may be a TLC2262. It is used as a buffer and voltage comparator for alerting that a Bovie Knife or like noise generator is present and to switch the sensor from the potentiostat to the batteries backup to prevent the excessive Bovie knife current spike from damaging the sensor.

[0060] Figure 5 also provides a representative circuit for the temperature sensing circuit for processing signals from the temperature sensor 40.

[0061] The above embodiments describe systems and methods that attempt to detect operation of another tool or equipment, such as an ESU, in the biosensor's environment by monitoring either the electrical or temperature environment of the biosensor. An embodiment has also been disclosed in which the selector 84 is a manually activated switch which can be operated by user prior to tools or equipment which may affect the biosensor 10. In another embodiment, the systems and methods of the present invention may use a direct or indirect connection to the other tools or equipment for assessing their operation. For example, a communication line may be established with the tool or equipment and the analyte monitoring system, where the communication line indicates operation of the equipment or tool to the analyte monitoring system 20, such that the analyte monitoring system can coordinate isolation of the biosensor 10 with operation of the tool or equipment. For example, when a user initiates operation of the tool or equipments, such as an ESU, the analyte monitoring 20 is notified and can isolate the biosensor 10.

[0062] In the above describe embodiments, the selector 84 is configured to present an open circuit to the electrodes of the biosensor in instances where the biosensor is be isolated from signal noise caused by operation of other tools or equipment such as a ESU. While this provides a simple solution for isolating the biosensor, such a solution may have some drawbacks. As discussed previously, for proper operation of an electro-chemical biosensor, the electrodes of it electrolytic cell should remain biased to maintain a steady state or chemistry cell alignment. Disruption of bias voltage to the electrodes will result in a loss of steady state for the cell. Realignment of the cell may require an unacceptable run-in time, typically ranging from 15 minutes to over one (1) hour.

[0063] In light of this issue, systems and methods have been developed to provide bias signals to the electrolytic cell of an electro-chemical biosensor to avoid loss of bias in the cell due to a primary power source outage. These systems and methods are more fully described in U.S. Patent Application No. "TBD", titled ANALYTE MONITORING SYSTEM HAVING BACK-UP POWER SOURCE FOR USE IN EITHER TRANSPORT OF THE SYSTEM OR PRIMARY POWER LOSS, and filed concurrently herewith. The contents of this patent application are herein incorporated by reference.

[0064] In particular, the systems and methods described in the above-referenced application are capable of sensing a loss of power to the electrolytic cell of the biosensor and application of auxiliary power to maintain bias voltages to the electrolytic cell of the biosensor, so as to prevent disruption of the operation of biosensor or at least minimize run-in time for realignment.

[0065] Again with regard to Figures 4 and 5, an auxiliary power source 26 may be associated with the selector 84. In this embodiment, if it is determined that another tool or equipment is operating and such operation may affect the biosensor and/or the monitoring system, the selector 80 may disconnect the primary power source, such as the potentiostat 22 from the electrodes of the biosensor 10 and instead connect the auxiliary power system to the electrodes of the biosensor 10. In this manner, the biosensor and monitoring system is isolated from signal noise generated by the tools or equipment, while at the same time bias is maintained within the electrolytic cell so as to negate or lessen run-in time required to reinitiate use of the biosensor 10 following a signal event.

[0066] While in some embodiments, the auxiliary power source 26 may be directly connected to the selector 80, in some embodiments, a separate selector 24 may be employed for connecting the auxiliary power source 26 to the biosensor 10. The use of two selectors 80 and 24 may allow flexibility such that in some instances the system may retain the option to open circuit the biosensor using the first selector 80.

[0067] For example, as illustrated in Figures 4 and 5, the system 20 may further include a second or auxiliary power source 26. The auxiliary power source 26 is adapted for connection to the electrolytic cell of the biosensor 10. In this embodiment, the system includes a second selector 24 located between the bio sensor 10 and the potentiostat 22 or other type of primary power source. The selector 24 is configured so as to connect either the potentiostat 22 or the auxiliary power source 26 to the electrolytic cell of the biosensor 10.

[0068] The selector 24 may take many forms depending on the embodiment. For example, in some embodiments, the selector may be a relay, such as single throw double pole relay. By activating or deactivating the relay, either the potentiostat 22 or the auxiliary power source 26 can be connected to the biosensor 10. Other embodiments may employ transistor networks that operate as a relay. A processor, multiplexer, or other type of device may be deployed for alternatively connecting either the potentiostat or auxiliary power source to the biosensor. In short, any device capable of connecting either the potentiostat (or other primary power source) or auxiliary power source to the biosensor is contemplated. In some embodiments, the selector may comprise a manual switch. In this embodiment, the patient's caretaker may toggle the selector to place the auxiliary power source in connection with the biosensor. In this way, the caretaker can ensure that the electrolytic cell of the biosensor is maintained in a steady state mode.

[0069] With reference to Figures 4 and 5, the inclusion of the auxiliary power source 26 and second selector 24 are further illustrated in combination with the in-line filter 80, second selector 82, temperature sensor circuit 38 and the noise detector 82. As illustrated, the potentiostat 22 comprises three operational amplifiers, 52, 54, and 56. Operational amplifiers 54 and 56 are respectively coupled to working electrodes 12 and 14 of the biosensor 10 are referenced to ground. The other operational amplifier 52 is connected to both the reference 16 and the counter 18 electrodes. The auxiliary power source is configured to replace the potentiostat in terms of providing bias signals to the electrodes of the sensor.

[0070] In this regard, Figures 4 and 5 illustrate an embodiment of the auxiliary power source 26 in combination with a selector 24. The auxiliary power source of this embodiment comprises a power source 58, such as a battery or uninterruptible power source. The auxiliary power source 26 further includes three separate circuit paths 60-64 for connecting respectively to the reference electrode 16 and the first and second work electrodes 12 and 14. The circuit paths provide bias voltage or current to the electrodes. They each employ resistor/capacitor networks to tailor the voltage or current applied to the electrodes. For example, in one embodiment, bias voltages levels are provided to the electrodes so as to maintain a voltage level for each working electrode 12 and 14 of between about +450 mV and about +650 mV with respect to the reference electrode 16. In some embodiments, the auxiliary power source provides the same voltage to one or more electrodes and in other embodiments, different voltages are provided to some of the electrodes. The Alkaline 3.0VDC battery is used as backup for the sensor voltage potential of 0.700VDC. The Battery voltage is divided by two ratiometric resistor 2.49Meg, and 750 K to provide voltage potential approximate 695mv. Capacitor 1uf is used as a energy holder voltage potential switch from internal voltage to battery bias. Additional three resistors of 20 Meg act as a current limit to sensor for patient safety limit.

[0071] In the embodiment of Figures 4 and 5, the selector 24 is a relay switch. In the disabled mode, the selector connects the potentiostat 22, not shown, to the biosensor 10 electrodes. When enabled, the selector disconnects the potentiostat 22 from the biosensor 10 and connects the outputs of the auxiliary power source 26 thereto. By toggling the relay, either the potentiostat or the auxiliary power source can be connected to the biosensor 10.

[0072] Operation of the different embodiments illustrated in Figures 4 and 5 based on the premise of sensing or otherwise determining that a tool or other equipment is in operation and producing electrical noise that may affect operation of the biosensor. The systems and methods then isolate the biosensor from such electrical noise. Depending on the embodiment, the biosensor may be either open circuited or connected to an auxiliary power source so as to maintain a steady state mode of the sensor. Figure 6 illustrates an operational flow chart detailing operation of at least one embodiment of a system of the present invention in which both a noise detection device 82 and temperature sensor 40 are employed, along with an auxiliary power source 26.

[0073] In particular, with reference to Figure 6, the monitoring system 20 initially detects whether either the noise detector 82 and/or the temperature sensor 40 are providing readings that indicate that another tool or equipment, such as an ESU, is operating in the vicinity of the biosensor 10 and either is or may general electric signal noise that would disrupt either the biosensor or the monitoring system. See block 100. In this embodiment, the output of the noise detector 82 and the temperature sensor 40 are provided to the processor 34. The processor 34 may include stored noise and temperature threshold values, which it may compare to respective received noise and temperature signals. See blocks 110a and 110b. If one of the noise and temperature signals is greater than the threshold (or in some embodiments, equal to the threshold), the processor 34 will initially store the current bias levels of the electrodes of the biosensor in memory, not shown. See block 120. The processor 34 will then activate the second selector 24 to connect the auxiliary power source 26 to the electrodes of the biosensor to thereby maintain a substantially steady state bias for the electrolytic cell. (See block 130).

[0074] The processor 34 will continue to monitor the outputs of the noise detector 82 and the temperature sensor 40. Once it is determined that both noise signal and temperature signal are below respective thresholds, (see block 140), the processor 34 will operate the second selector 24 to connect the electrodes of the biosensor 10 to the potentiostat 22. See block 150. The processor 34 may monitor the outputs of the electrodes to ensure that the electrolytic cell is at steady state. See block 160. The processor 34 will then resume monitoring and using the signals output by the biosensor to measure the amount of an analyte in a substance. See block 170.

[0075] U.S. Patent Application No. "TBD", titled ANALYTE MONITORING SYSTEM HAVING BACK-UP POWER SOURCE FOR USE IN EITHER TRANSPORT OF THE SYSTEM OR PRIMARY POWER LOSS describes a system for determining whether bias signals are being supplied by a primary power source such as the potentiostat 22. If there is a power outage, the system connects the auxiliary power source to the biosensor to maintain steady state operation of the biosensor. While the above embodiments are directed to isolation of the biosensor from disruptive signal noise and the use of an auxiliary power source 26 to maintain a steady state bias mode for the biosensor during isolation, an integrated system is envisioned in which the system is both capable of isolating the biosensor in instance where unwanted signal noise may affect sensor operation, while also detecting possible primary power source outage. An illustrative embodiment of such a system is provided in Figure 6.

[0076] Specifically, as illustrated, the system 22 may further include a sensor 50 for determining operation of either the potentiostat 22 or the main power supply 44. The sensor can be any type sensor. For example, it can be a voltage, current, inductive, capacitance, Hall Effect or similar type sensor connected to the outputs of either the potentiostat 22 or the main power supply 44. The sensor is either directly connected to the selector 24 or alternatively to the processor 34. In the embodiment illustrated in Figure 6, the sensor is connected to the bias voltage output of the potentiostat, which is provided to the electrolytic cell of the biosensor 10. The sensor 50 is also connected to the processor 34. If the sensor 50 fails to detect a bias signal from the potentiostat, the processor 34 controls the selector 24 to connect the auxiliary power source 26 to the biosensor. When the sensor 50 indicates that potentiostat has a bias output, the processor controls the selector to disconnect the auxiliary power source 26 from the biosensor 10 and connect the potentiostat 22 to the biosensor.

[0077] As discussed previously, the type and placement of the sensor can vary and Figure 6 is only one exemplary embodiment of the present invention. The sensor can be connected to either the output of the potentiostat or the main power supply or it could be a simple push button operated manually by a caretaker or in some instances, the selector may act as the sensor by allowing a caretaker to manually toggle the switch.

[0078] Figures 3-6 disclose systems and methods of the present invention that use a selector switch and or in-line filtering to isolate a biosensor from electrical noise. The present invention contemplates other systems and methods for protecting the electrolytic cell of an electro-chemical sensor from the effect of electrical noise. For example, as illustrated in Figure 8, an added electrode 90 could be added to the electrolytic cell of the biosensor 10. The electrode 90 could then be connected via a low resistance path to ground. The added electrode 90 would thus be used to discharge any excessive electrical energy from high source build up by Bovie knife, or defribulating procedure that is input to the bias sensor 10.

[0079] The above discussion describes the addition of an auxiliary power source, selector, and power outage sensor to an analyte monitoring system. It also provides exemplary circuit diagrams for these added elements to the system. Following is a discussion of exemplary circuit diagrams for a basic analyte monitoring system that includes added signal isolation.

[0080] With reference to Figure 9A, the biosensor 10 is shown in the upper left, coupled to the potentiostat 22 via inputs EM11 through EM16. The signal lines to inputs EM11, EM12, EM13 and EM14 connect to the counter electrode 18, the reference electrode 16, the working electrode 12, and the working electrode 14, respectively as shown. The signal line to input EM15 connects to a first output from a thermistor 40, and the signal line to input EM16 connects to a second output from the thermistor 40. For convenience, the thermistor 40 outputs are shown originating from a sensor block 10, which in this figure represents a local connection point. For example, the thermistor 40 may be integrated with or installed adjacent to the biosensor 10 in an intravenous catheter, in which case it may be convenient to terminate the thermistor 40 and sensor leads at the same connector. In another embodiment, the thermistor 40 and sensor leads may be terminated at separate locations.

[0081] The potentiostat 22 may include a control amplifier U2, such as an OPA129 by Texas Instruments, Inc., for sensing voltage at reference electrode 16 through input EM12. The control amplifier U2 may have low noise (about 15nV/sqrt(Hz) at 10kHz), an offset (about 5μV max), an offset drift (about 0.04μV max) and a low input bias current (about 20 fA max). The control amplifier U2 may provide electrical current to the counter electrode 18 to balance the current drawn by the working electrodes 12 and 14. The inverting input of the control amplifier U2 may be connected to the reference electrode 16 and preferably may not draw any significant current from the reference electrode 16. In one embodiment, the counter electrode 18 may be held at a potential of between about -600mV and about -800mV with respect to the reference electrode 16. The control amplifier U2 should preferably output enough voltage swing to drive the counter electrode 18 to the desired potential and pass current demanded by the biosensor 10. The potentiostat 22 may rely on R2, R3 and C4 for circuit stability and noise reduction, although for certain operational amplifiers, the capacitor C4 may not be needed. A resistor RMOD1 may be coupled between the counter electrode 18 and the output of the control amplifier U2 for division of return current through the counter electrode 18.

[0082] The potentiostat 22 may further include two current-to-voltage (I/V) measuring circuits for transmission and control of the output signals from the working electrode 12 and the working electrode 14, through inputs EM12 and EM13, respectively. Each I/V measuring circuit operates similarly, and may include a single stage operational amplifier U3C or U6C, such as a type TLC2264. The operational amplifier U3C or U6C may be employed in a transimpedance configuration. In the U3C measuring circuit, the current sensed by the working electrode 12 is reflected across the feedback resistors R11, R52 and R53. In the U6C measuring circuit, the current sensed in the working electrode 14 is reflected across the feedback resistors R20, R54 and R55. The operational amplifier U3C or U6C may generate an output voltage relative to virtual ground. The input offset voltage of the operational amplifier U3C or U6C adds to the sensor bias voltage, such that the input offset of the operational amplifier U3C or U6C may be kept to a minimum.

[0083] The I/V measuring circuits for the working electrode 12 and the working electrode 14 may also use load resistors R10 and R19 in series with the inverting inputs of operational amplifiers U3C and U6C, respectively. The resistance of the load resistors R10 and R19 may be selected to achieve a compromise between response time and noise rejection. Since the I/V measuring circuit affects both the RMS noise and the response time, the response time increases linearly with an increasing value of the load resistors R10 and R19, while noise decreases rapidly with increasing resistance. In one embodiment, each of load resistors R10 and R19 may have a resistance of about 100 ohms. In addition to the load resistors R10 and R19, the I/V amplifiers may also include capacitors C10 and C19 to reduce high frequency noise.

[0084] In addition, the I/V amplifiers of the potentiostat 22 may each include a Dual In-line Package (DIP) switch S1 or S2. Each DIP switch S1 and S2 may have hardware programmable gain selection. Switches S1 and S2 may be used to scale the input current from the working electrode 12 and the working electrode 14, respectively. For operational amplifier U3C, the gain is a function of RMOD2 and a selected parallel combination of one or more resistors R11, R52 and R53. For operational amplifier U6C, the gain is a function of RMOD3 and a selected parallel combination of one or more resistors R20, R54 and R55. Table 1 below illustrates exemplary voltage gains achievable using different configurations of switches S1 and S2.

Switch Position (S1 and S2)			**I/V Output (U3C, U6C) V per nA**	**Voltage at A/D Input**
OPEN	OPEN	OPEN	+4.9 V	+4.9 V
OPEN	OPEN	CLOSED	10 mV (1-20 nA Scale)	200 mV
OPEN	CLOSED	OPEN	6.65 mV (1-30 nA Scale)	133 mV
CLOSED	OPEN	OPEN	5 mV (1-40 nA Scale)	100 mV

Table 1: Exemplary Voltage Gain

[0085] As shown from Table 1, three gain scale settings may be achieved, in addition to the full scale setting. These settings may be selected to correspond to input ratings at the ADC 32.

[0086] The potentiostat 22, or a circuit coupled to the potentiostat 22, may further include a digital-to-analog converter (DAC) 66 that enables a programmer to select, via digital input, a bias voltage V_{BIAS} between the reference electrode 16 and the counter electrode 18. The analog output from the DAC 66 may be cascaded through a buffering amplifier U5B and provided to the non-inverting input of the amplifier U5A. In one embodiment, the amplifier

U5A may be a type TLC2264 operational amplifier. The output of the amplifier U5A may be bipolar, between ± 5 VDC, to establish the programmable bias voltage V_{BIAS} for the biosensor 10. The bias voltage V_{BIAS} is the voltage between the counter electrode 18 and the reference electrode 16. Resistors R13 and R14 may be selected to establish a desired gain for the amplifier U5A and the capacitors C13, C17 and C20 may be selected for noise filtration.

[0087] The potentiostat 22, or a circuit coupled to the potentiostat 22, may also establish a reference voltage 68 (VREF) for use elsewhere in the control circuits of the continuous glucose monitoring system 20. In one embodiment, the VREF 68 may be established using a voltage reference device U15, which may be an integrated circuit such as an Analog Devices type AD580M. In another embodiment, the reference voltage 68 may be established at about +2.5 VDC. The reference voltage 68 may be buffered and filtered by an amplifier U5D in combination with resistors and capacitors R32, C29, C30 and C31. In one embodiment, the amplifier U5D may be a type TLC2264 device.

[0088] With reference now to Figure 9B, the low-pass filter 28 is now described. The low-pass filter 28 may provide a two-stage amplifier circuit for each signal CE-REF, WE1 and WE2 received from the potentiostat 22. In one embodiment, a 1Hz Bessel multi-pole low-pass filter may be provided for each signal. For example, the output signal CE_REF of amplifier U2 may be cascaded with a first stage amplifier U1A and a second stage amplifier U1B. The amplifier U1A, in combination with resistor R6 and capacitor C5, may provide one or more poles. One or more additional poles may be formed using an amplifier U1B in combination with R1, R4, R5, C1 and C6. Capacitors such as C3 and C9 may be added, as necessary, for filtering noise from the +/- 5VDC power supply. Similar low-pass filters may be provided for signals WE1 and WE2. For example, the amplifier U3B may be cascaded with an amplifier U3A to filter WE1. The amplifier U3B in combination with components such as R8, R9, R15, R16, C14 and C15 may provide one or more poles, and the amplifier U3A in combination with components such as R17, R18, C11, C12, C16 and C18 may provide one or more additional poles. Similarly, the amplifier U6B may be cascaded with an amplifier U6A to filter WE2. The amplifier U6B in combination with components such as R22, R23, R30, R31, C24 and C25 may provide a first pole, and the amplifier U6A in combination with components such as R24, R25, C21, C22 and C23 may provide one or more additional poles. Additional similar filters (not shown) may be added for filtering signal Vt received from the R/V converter 38. After the low-pass filter 28 filters out high-frequency noise, it may pass signals CE_REF, WE1 and WE2 to a multiplexer 30.

[0089] With reference to Figure 9C, a temperature sensing circuit including the temperature sensor 40 and the R/V converter 38 is now described. The R/V converter 38 receives input from the temperature sensor 40 at terminals THER_IN1 and THER_IN2. These two terminals correspond respectively to the inputs EM15 and EM16 of Figure 9A that are connected across the temperature sensor 40. In one embodiment, the temperature sensor 40 may be a thermocouple. In another embodiment, the temperature sensor 40 may be a device such as a thermistor or a resistance temperature detector (RTD), which has a temperature dependent resistance. Hereinafter, for purposes of illustration only, the monitoring system 20 will be described that employs a thermistor as the temperature sensor 40.

[0090] Since chemical reaction rates (including the rate of glucose oxidation) are typically affected by temperature, the temperature sensor 40 may be used to monitor the temperature in the same environment where the working electrodes 12 and 14 are located. In one embodiment, the monitoring system 20 may operate over a temperature range of between about 15°C and about 45°C. For continuous monitoring in an intravenous application, the operating temperature range is expected to be within a few degrees of normal body temperature. A thermistor 40 should therefore be selected that may operate within such a desired range, and that may be sized for installation in close proximity to the biosensor 10. In one embodiment, the thermistor 40 may be installed in the same probe or catheter bearing the biosensor 10.

[0091] The thermistor 40 may be isolated to prevent interference from other sensors or devices that can affect its temperature reading. As shown in Figure 9C, the isolation of the thermistor 40 may be accomplished by including in the

R/V converter 38 a low-pass filter 70 at input THER_IN2. In one embodiment, the low-pass filter 78 may include a simple R-C circuit coupling input THER_IN2 to signal ground. For example, the filter 78 may be formed by a resistor R51 in parallel with a capacitance, *e.g.* capacitors C67 and C68.

[0092] With the thermistor 40 installed in an intravenous location, its resistance changes as the body temperature of the patient changes. The R/V converter 38 may be provided to convert this change in resistance to the voltage signal Vt. Thus, the voltage signal Vt represents the temperature of the biosensor 10. The voltage signal Vt may then be output to the low-pass filter 28 and used for temperature compensation elsewhere in the monitoring system 20.

[0093] In one embodiment, the thermistor 40 may be selected having the following specifications:

$$R_{th} = R_o e^{\beta[\frac{1}{T} - \frac{1}{T_o}]}$$

(1)

where,

R_{th} is the thermistor resistance at a temperature T;

R_o is the thermistor resistance at temperature T_o;

β = 3500°K +/- 5%;

T_o = 310.15°K; and

T is the blood temperature in K.

[0094] The reference resistance R_s is selected to yield:

$$\frac{R_{th}}{R_s} = 1.4308 + / - 0.010507$$

(2)

[0095] To determine the blood temperature of a patient, equation (1) may be rewritten as:

[0096]

$$T = T_o \frac{\beta}{T_o \ln(\frac{R_{th}}{R_o}) + \beta}$$

(3)

[0097] To compensate the output from the biosensor 10 according to temperature, the resistance R_0 of the thermistor 40 may be converted into a voltage signal Vt. To accomplish this, the R/V converter 38 may provide a current source 72 for running a fixed current through the thermistor 40. One embodiment of a circuit for the current source 72 is shown at the top of Figure 9C, and includes device Q1 and all components to the right of Q1.

[0098] In one embodiment, the current source 72 may provide a desired current through Q1. In one embodiment, the source current through Q1 may be between about 5μA and about 15 μA. Q1 may be a JFET such as a type SST201. To control the JFET, the output of an operational amplifier U7A may be provided to drive the gate of Q1. The voltage VREF may be divided, as necessary, to place a voltage of about +2VDC at the non-inverting input of the amplifier U7A. For example, a voltage divider may be formed by the resistors R37 and R38 between VREF and the amplifier U7A. The amplifier U7A may be configured as an integrator, as shown, by including a capacitor C45 in a feedback path between the output and the non-inverting input, and the resistor R34 in a feedback path from the drain of Q1 to the inverting input, to maintain the drain voltage of Q1 at about +2V. Components such as R36, C34, C42, C43 and C44 may be included, as desired, for filtration and stability.

[0099] The resistor R33 placed between the drain of Q1 and the +2.5V VREF may be selected to establish the source current of Q1 at a desired value. In one embodiment, the source current may be maintained at about 9.8μA for compliance with a medical device standard such as IEC 60601-1. In one embodiment, the thermistor 40 is classified under that standard as a Type CF device (*i.e.* a device that comes into physical contact with the human heart), and has limits for electrical current leakage that are set at 10μA for normal operating conditions, and that are set at 50μA for a single fault condition. The selection of resistor R33 and other components that make up the current source 72 may therefore depend on the desired end use application of the monitoring system 20.

[00100] One or more voltage signals Vt may be derived from the thermistor 40 by placing one or more reference resistors R39 and R43 in series with the thermistor 40 to carry the source current of Q1. The voltage signals created by the flow of the source current of Q1 through this series resistance may be filtered for electromagnetic interference (EMI) using capacitors C54 and C63. The voltage signals may be further filtered with passive signal poles formed by R40 and C55, and by R46 and C64. In one embodiment, these poles may be established to provide a crossover frequency at approximately 30 Hz. These passive filters protect amplifiers U11A, U11B and U11C from electrostatic discharge (ESD).

[00101] In one embodiment, the amplifiers U11A, U11B and U11C may be type TLC2264 devices selected for low noise (12nV/sqrtHz at frequency = 1 Hz), an offset of about 5uV max, an offset drift of about 0.04μV max, and an input bias current of about 1pA max. The amplifier U11A may form a low-pass filter, and transmit a thermistor reference voltage Vt1 at resistor R43. The amplifier U11B may also form a low-pass filter, and transmit a thermistor input voltage Vt2 at the thermistor 40 that represents a sensed temperature. In one embodiment, the amplifier U11A or U11B may function as a two-pole Butterworth filter having a -3dB point at about 5.0 Hz +/- 0.6Hz for anti-aliasing. Components such as R41, R42, R44, R45, C49, C56, C57 and C58 may be configured for this purpose. The amplifier U11C may be provided as a buffer amplifier at the input of the amplifier U11B.

[00102] The first and second voltage signals Vt output from the R/V converter 38 may then be received by the low-pass filter 72 for additional conditioning. In one embodiment, the low-pass filter 70 may provide a four-pole 5Hz Butterworth filter for signals Vt. The Butterworth filters may double as anti-aliasing filters to create the four-pole response with a -3dB point at about 5.0 Hz, and have a gain of about 20 (*i.e.* 26 dB) to provide an output from about 100 mV to about 200 mV per 1.0 nA.

[00103] The signals from the biosensor 10 and the thermistor 40 filtered by the low-pass filter 70 may then be output to the multiplexer 30. As shown in Figure 9D, the multiplexer 30 may receive the signals CE_REF, WE1, WE2, VREF, and the two Vt signals (Vt1 and Vt2), and provide them to the analog to digital converter 32. A buffer amplifier U11 may be provided in this transmission path, along with filtering components such as R47 and C50.

[00104] In one embodiment, the multiplexer 30 may be an 8-channel analog multiplexer, such as a Maxim monolithic CMOS type DG508A. The channel selection may be controlled by the processor 34 via the output bits P0, P1 and P2 of the ADC 32. Table 2 illustrates an exemplary channel selection for the multiplexer 30.

[00105] The ADC 32 converts analog signals to discrete digital data. The ADC 32 may have *n* output bits (*e.g.* P0 - P2) used for selecting analog input signals at a 2^n-channel multiplexer 30. In one embodiment, the ADC 32 may be a Maxim type MAX1133BCAP device having a bipolar input with 16 bits successive approximation, single +5V DC power supply and low power rating of about 40 mW at 200 kSPS. The ADC 32 may have an internal 4.096 V_{REF}, which can be used as a buffer. The ADC 32 may be compatible with Serial Peripheral Interface (SPI), Queued Serial Peripheral Interface (QSPI), Microwire or other serial data link. In one embodiment, the ADC 32 may have the following input channels: bias voltage output (CE_REF), working electrode 12 (WE1), working electrode 14 (WE2), DAC converter voltage (DAC_BIAS), thermistor reference voltage (Vt1), thermistor input voltage (Vt2), reference voltage (2.5VREF), and analog ground (ISOGND).

P2	P1	P0	Mux. Channel	Analog Inputs Description
0	0	0	0	Reference electrode 16 control voltage
0	0	1	1	Working Electrode 12 current to voltage
0	1	0	2	Working electrode 14 current to voltage
0	1	1	3	Control & Reference bias voltage

1	0	0	4	Thermistor Reference voltage Vt1
1	0	1	5	Thermistor Input voltage Vt2
1	1	0	6	2.5 V_{REF} voltage
1	1	1	7	ISOGND voltage

Table 2: Exemplary Channel Selection for the Multiplexer

[00106] The digital data from the ADC 32 may be transmitted to the processor 34. The processor 34 may be a programmable microprocessor or microcontroller capable of downloading and executing the software for accurate calculation of analyte levels sensed by the biosensor 10. The processor 34 may be configured to receive the digital data and, by running one or more algorithms contained in integral memory, may compute the analyte (*e.g.* glucose) level in the blood based on one or more digital signals representing CE_REF, WE1, WE2, DAC_BIAS and 2.5VREF. The processor 34 may also run a temperature correction algorithm based on one or more of the foregoing digital signals and/or digital signal Vt1 and/or Vt2. The processor 34 may derive a temperature-corrected value for the analyte level based on the results of the temperature correction algorithm. In one embodiment, the processor 34 may be a Microchip Technology type PIC18F2520 28-pin enhanced flash microcontroller, with 10-bit A/D and nano-Watt technology, 32k x 8 flash memory, 1536 bytes of SRAM data memory, and 256 bytes of EEPROM.

[00107] The input clock to the processor 34 may be provided by a crystal oscillator Y1 coupled to the clock input pins. In one embodiment, the oscillator Y1 may be a CTS Corp. oscillator rated at 4 MHz, 0.005% or +/- 50 ppm. Y1 may be filtered using the capacitors C65 and C66. The processor 34 may further include an open drain output U14, for example, a Maxim type MAX6328UR device configured with a pull-up resistor R50 that provides system power up RESET input to the processor 34. In one embodiment, the pull-up resistor R50 may have a value of about 10 kΩ. The capacitors C69 and C70 may be sized appropriately for noise reduction.

[00108] In one embodiment, data transfer between the processor 34 and the ADC 32 may be enabled via pins SHDN, RST, ECONV, SDI, SDO, SCLK and CS, as shown. An electrical connector J2, such as an ICP model 5-pin connector, may be used to couple pins PGD and PGC of the processor 34 to drain output U14. The connector J2 may provide a path for downloading desired software into the integral memory, e.g. flash memory, of the processor 34.

[00109] The processor 34 may output its results to a monitor, such as a CPU 36 via an optical isolator 42 and the serial-to-USB port 74. The optical isolator 42 may use a short optical transmission path to transfer data signals between the processor 34 and the serial-to-USB converter 74, while keeping them electrically isolated. In one embodiment, the optical isolator 42 may be an Analog Devices model ADuM1201 dual channel digital isolator. The optical isolator 42 may include high speed CMOS and monolithic transformer technology for providing enhanced performance characteristics. The optical isolator 42 may provide an isolation of up to 6000 VDC for serial communication between the processor 34 and the serial-to-USB converter 74. The filter capacitors C61 and C62 may be added for additional noise reduction at the +5VDC inputs. At the capacitor C61, the +5VDC power may be provided by an isolated output from the DC/DC converter 44. At the capacitor C62, the +5VDC power may be provided from a USB interface via the CPU 36. In addition to these features, an isolation space 51 may be established (*e.g.*, on a circuit board containing the isolated electrical components) between about 0.3 inches and about 1.0 inches to provide physical separation to electrically and magnetically isolate circuit components on the "isolated" side of the optical isolator 46 from circuit components on the "non-isolated" side. The components segregated onto "isolated" and "non-isolated" sides are indicated by the dashed line on Figure 9D. In one embodiment, the isolation space may be 0.6 inches.

[00110] Generally, an isolation device or isolation means prevents noise from outside the isolated side of the circuit from interfering with signals sensed or processed within the isolated side of the circuit. The noise may include any type of electrical, magnetic, radio frequency, or ground noise that may be induced or transmitted in the isolated side of the circuit. In one embodiment, the isolation device provides EMI isolation between the isolated sensing circuit used for sensing and signal processing, and the non-isolated computer circuit used for power supply and display. The isolation device may include one or more optical isolators 42, DC/DC converters 44, isolation spaces 51, and one or more of the many electronic filters or grounding schemes used throughout the monitoring system 20.

[00111] The serial-to-USB converter 74 may convert serial output received through the optical isolator 42 to a USB communication interface to facilitate coupling of output from the processor 34 to the CPU 36. In one embodiment, the serial-to-USB converter 74 may be an FTDI model DLP-USB232M UART interface module. The converted USB signals may then be transmitted to the CPU 36 via a USB port for storage, printing, or display. The serial-to-USB converter 74 may also provide a +5VDC source that may be isolated by isolation DC/DC converter 44 for use by potentiostat 22 and other electronic components on the isolated side of the circuit.

[00112] The CPU 36 may be configured with software for displaying an analyte level in a desired graphical format on a display unit 36. The CPU 36 may be any commercial computer, such as a PC or other laptop or desktop computer running on a platform such as Windows, Unix or Linux. In one embodiment, the CPU 36 may be a ruggedized laptop computer. In another embodiment, the graphics displayed by the CPU 36 on the display unit 36 may show a numerical value representing real-time measurements, and also a historical trend, of the analyte of interest to best inform attendant health care professionals. The real-time measurements may be continuously or periodically updated. The historical trend may show changing analyte levels over time, for example, over one or more hours or days, for an analyte level such as blood glucose concentration.

[00113] The CPU 36 may provide power to the isolation DC/DC converter 44 and may also provide power to the display unit 36. The CPU 36 may receive power from a battery pack or a standard wall outlet (e.g. 120 VAC), and may include an internal AC/DC converter, battery charger, and similar power supply circuits. The isolation DC/DC converter 44 may receive DC power from the CPU 36 via a bus. In one embodiment, this DC power may be a +5VDC, 500 mA, +/- 5% source provided, for example, via an RS232/USB converter (not shown). The +5VDC supply may be filtered at the non-isolated side of isolation DC/DC converter 44 using capacitors such as C37 and C38.

[00114] The isolation DC/DC converter 44 converts non-isolated +5VDC power to an isolated +5VDC source for output onto the bus labeled ISOLATED PWS OUT. In addition, the isolation DC/DC converter 44 may provide a physical isolation space for added immunity from electrical and magnetic noise. In one embodiment, the isolation space may be between about 0.3 inches and about 1.0 inches. In another embodiment, the isolation space may be 8 mm. The isolation DC/DC converter 44 may be a Transitronix model TVF05D05K3 dual +/-5V output, 600 mA, regulated DC/DC converter with 6000 VDC isolation. The dual outputs +5V and -5V may be separated by a common terminal, and filtered using capacitors C33 and C36 between +5V and common, and capacitors C40 and C41 between -5V and common. Additional higher-order filtering may be provided to create multiple analog and digital 5V outputs, and to reduce any noise that may be generated on the isolated side of the circuit by digital switching of the components such as the ADC 32 and the processor 34. For example, the +5V and -5V outputs may be filtered by inductors L1, L2, L3 and L4 configured with the capacitors C32, C35 and C39. In the configuration shown, these components provide a +5V isolated supply (+5VD) for digital components, a +/- 5V isolated supply (+5VISO and -5VISO) for analog components, and an isolated signal ground for analog components.

[00115] In one embodiment, components of an analyte monitoring system may be mounted on one or more printed circuit boards contained within a box or Faraday cage. The components contained therein may include one or more potentiostats 22, R/V converters 38, low-pass filters 28, multiplexers 30, ADCs 32, processors 34, optical isolators 42, DC/DC converters 44, and associated isolated circuits and connectors. In another embodiment, the same board-mounted components may be housed within a chassis that may also contain serial-to-USB converter 74 and the CPU 36.

[00116] While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that this invention not be limited to the specific constructions and arrangements shown and described, since various other changes, combinations, omissions, modifications and substitutions, in addition to those set forth in the above paragraphs, are possible. Those skilled in the art will appreciate that various adaptations and modifications of the just described embodiments can be configured without departing from the scope and spirit of the invention. Therefore, it is to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described herein.

THAT WHICH IS CLAIMED:

1. An analyte monitoring system, comprising:

a biosensor capable of sensing an analyte concentration and outputting a signal indicative of the analyte concentration;

a monitoring system for at least monitoring an output of said biosensor; and

a first selector in electrical communication with said biosensor and said monitoring system for selectively connecting said biosensor to said monitoring system or isolating said biosensor from said monitoring system.

2. A system according to claim 1, wherein said first selector is a switch capable of being manipulated by an operator.

3. A system according to claim 1 further comprising a noise detector capable of sensing electrical signal noise in an environment associated with said biosensor, wherein said monitoring system comprises a processor in communication with said noise detector and said first selector, wherein said processor controls configuration of said first selector based on an output of said noise detector.

4. A system according to claim 4, wherein said processor compares an output of said noise detector to a threshold value, wherein if the output is at least as great as the threshold value, said processor controls said first selector to isolate said biosensor.

5. A system according to claim 1 further comprising a temperature sensor capable of sensing a temperature of an environment associated with said biosensor, herein said monitoring system comprises a processor in communication with said temperature sensor and said first selector, wherein said processor controls configuration of said first selector based on an output of said temperature sensor.

6. A system according to claim 5, wherein said processor compares an output of said temperature sensor to a threshold value, wherein if the output is at least as great as the threshold value, said processor controls said first selector to isolate said biosensor.

7. A system according to claim 1 further comprising a filter connected between said biosensor and said monitoring system, wherein said filter removes signal noise from signals input to said biosensor and signal noise output from said biosensor.

8. A system according to claim 1 further comprising first and second power sources, each selectively couplable to said biosensor, wherein said first and second power sources are capable of providing one or more bias signals to said biosensor, wherein said first selector selectively couples one of said first and second power sources to said biosensor.

9. A system according to claim 8 further comprising a noise detector capable of sensing electrical signal noise in an environment associated with said biosensor, wherein said monitoring system comprises a processor in communication with said noise detector and said first selector, wherein said processor compares an output of said noise detector to a threshold value, wherein if the output is at least as great as the threshold value, said processor controls said first selector to place said biosensor in communication with said second power source.

10. A system according to claim 8 further comprising a temperature sensor capable of sensing a temperature of an environment associated with said biosensor, herein said monitoring system comprises a processor in communication with said temperature sensor and said first selector, wherein said processor compares an output of said temperature sensor to a threshold value, wherein if the output is at least as great as the threshold value, said processor controls said first selector to place said biosensor in communication with said second power source.

11. A system according to claim 1 further comprising:

first and second power sources, each selectively couplable to said biosensor, wherein said first and second power sources are capable of providing one or more bias signals to said biosensor; and

a second selector connected to said first and second power sources and said first selector,

wherein said first selector is capable of selectively connecting said biosensor to said second selector or isolating said biosensor from said monitoring system, and

said selector capable of connecting said first or second power sources to said first selector.

12. A method for isolating an analyte monitoring system from electrical noise comprising:

providing a biosensor capable of sensing an analyte concentration and outputting a signal indicative of the analyte concentration;

providing a monitoring system for at least monitoring an output of said biosensor; and

selectively connecting the biosensor to the monitoring system or isolating the biosensor from the monitoring system.

13. A method according to claim 12 further comprising:

sensing electrical signal noise in an environment associated with said biosensor; and

comparing the electrical signal noise to a threshold value,

wherein said connecting step comprises isolating the biosensor if the electrical signal noise is at least as great as the threshold value.

14. A method according to claim 12 further comprising:

sensing electrical a temperature in an environment associated with said biosensor; and

comparing the temperature to a threshold value, wherein said connecting step comprises isolating the biosensor if the temperature is at least as great as the threshold value.

15. A method according to claim 12 further comprising filtering signal noise from signals input to the biosensor and signal noise output from the biosensor.

16. A method according to claim 1 further comprising:

providing first and second power sources, each selectively couplable to the biosensor, wherein the first and second power sources are capable of providing one or more bias signals to the biosensor, wherein said selectively connecting step comprises selectively connecting one of the first and second power sources to the biosensor.

17. A method according to claim 16 further comprising:

sensing electrical signal noise in an environment associated with said biosensor;

comparing the electrical signal noise to a threshold value,

wherein if the output is at least as great as the threshold value, said selectively connecting step connects the biosensor with the second power source.

18. A method according to claim 16 further comprising:

sensing a temperature in an environment associated with said biosensor;

comparing the temperature to a threshold value,

wherein if the output is at least as great as the threshold value, said selectively connecting step connects the biosensor with the second power source.

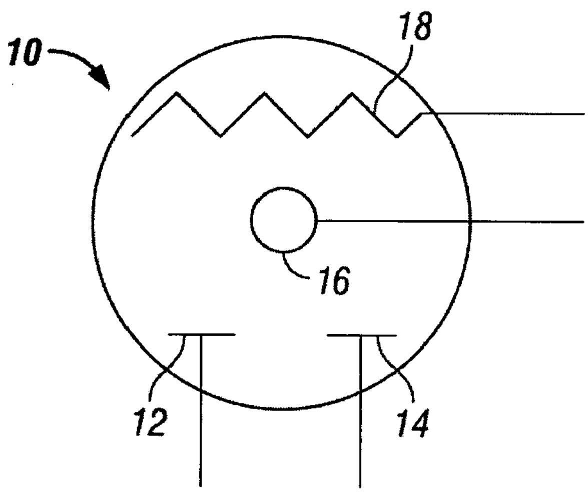


FIG. 1

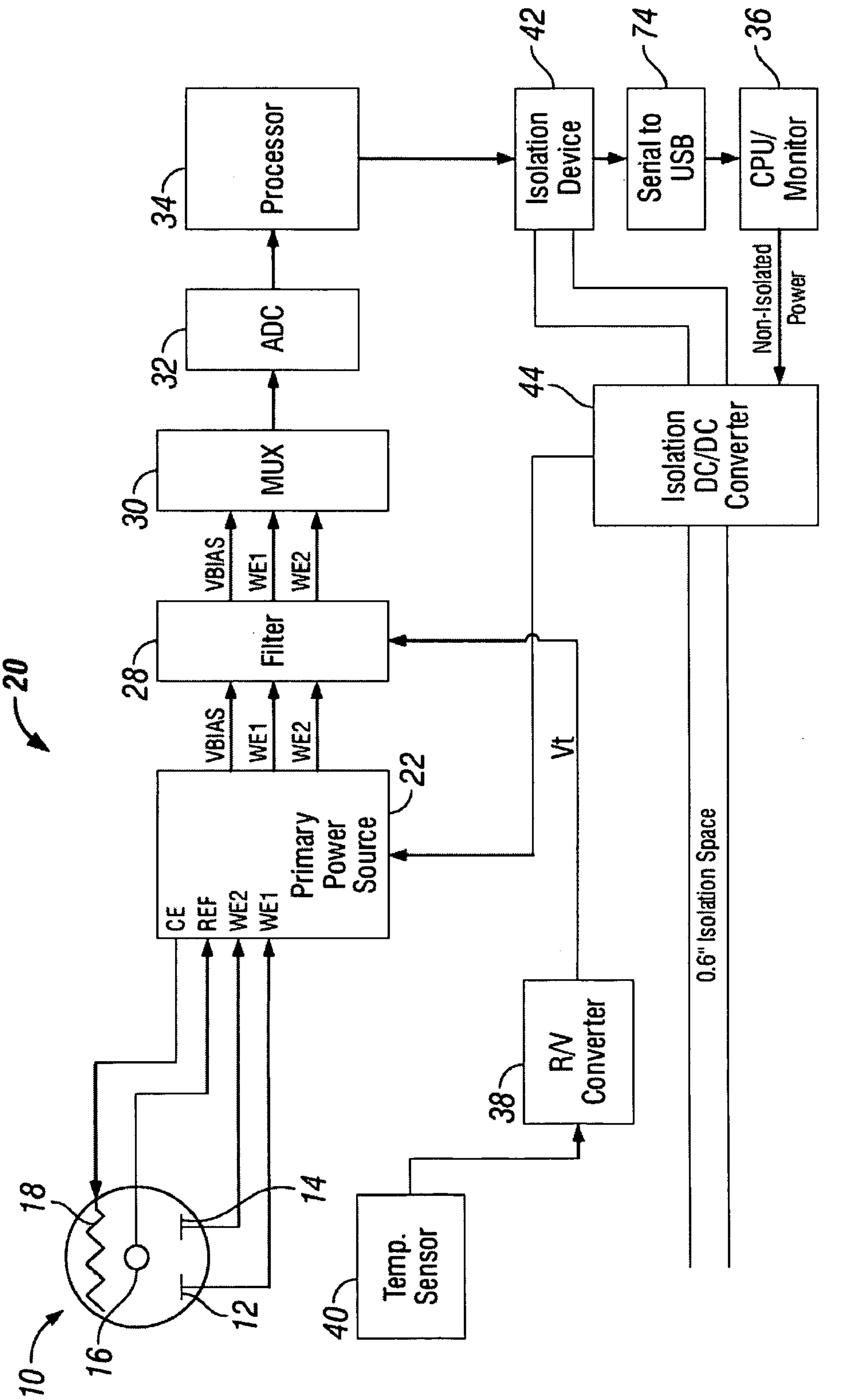

20
Processor
34
ADC
32
MUX
30
VBIAS
WE1
WE2
Filter
28
Primary Power Source
22
CE
REF
WE2
WE1
Vt
Isolation Device
42
Serial to USB
74
CPU/ Monitor
36
Non-Isolated Power
Isolation DC/DC Converter
44
R/V Converter
38
Temp. Sensor
40
0.6" Isolation Space
18
14
16
12
10

FIG. 2

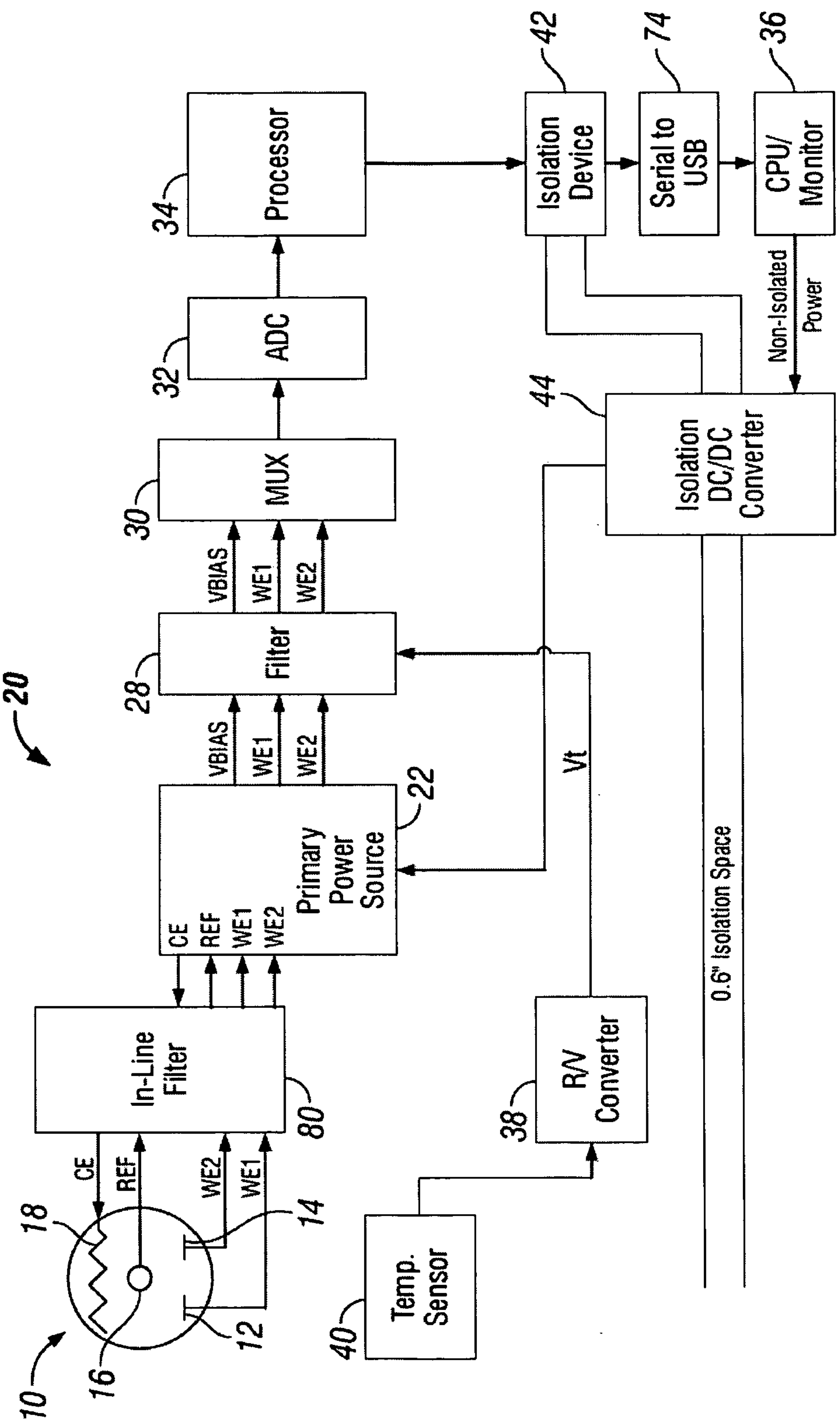
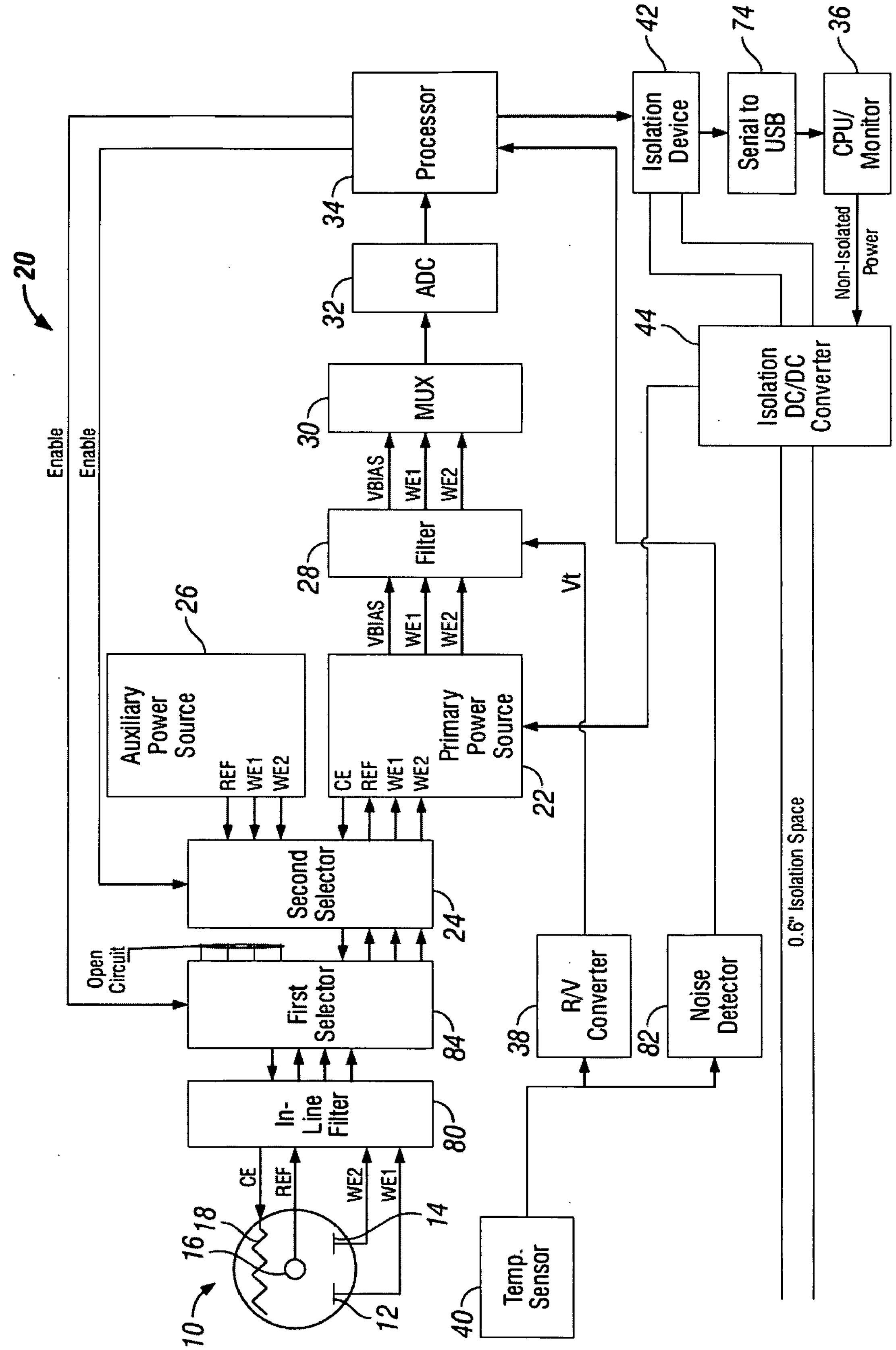

20
10
16
18
12
14
CE
REF
WE2
WE1
In-Line Filter
80
CE
REF
WE1
WE2
Primary Power Source
22
VBIAS
WE1
WE2
Filter
28
VBIAS
WE1
WE2
MUX
30
ADC
32
Processor
34
Isolation Device
42
Serial to USB
74
CPU/ Monitor
36
Non-Isolated Power
Isolation DC/DC Converter
44
Vt
R/V Converter
38
Temp. Sensor
40
0.6" Isolation Space

FIG. 3



20
Processor
34
ADC
32
MUX
30
VBIAS
WE1
WE2
Filter
28
Vt
Auxiliary Power Source
26
REF
WE1
WE2
Primary Power Source
22
CE
REF
WE1
WE2
Second Selector
24
First Selector
84
Open Circuit
Enable
Enable
In-Line Filter
80
CE
REF
WE2
WE1
10
12
14
16
18
Temp. Sensor
40
R/V Converter
38
Noise Detector
82
Isolation Device
42
Serial to USB
74
CPU/ Monitor
36
Non-Isolated Power
Isolation DC/DC Converter
44
0.6" Isolation Space

FIG. 4

5/12

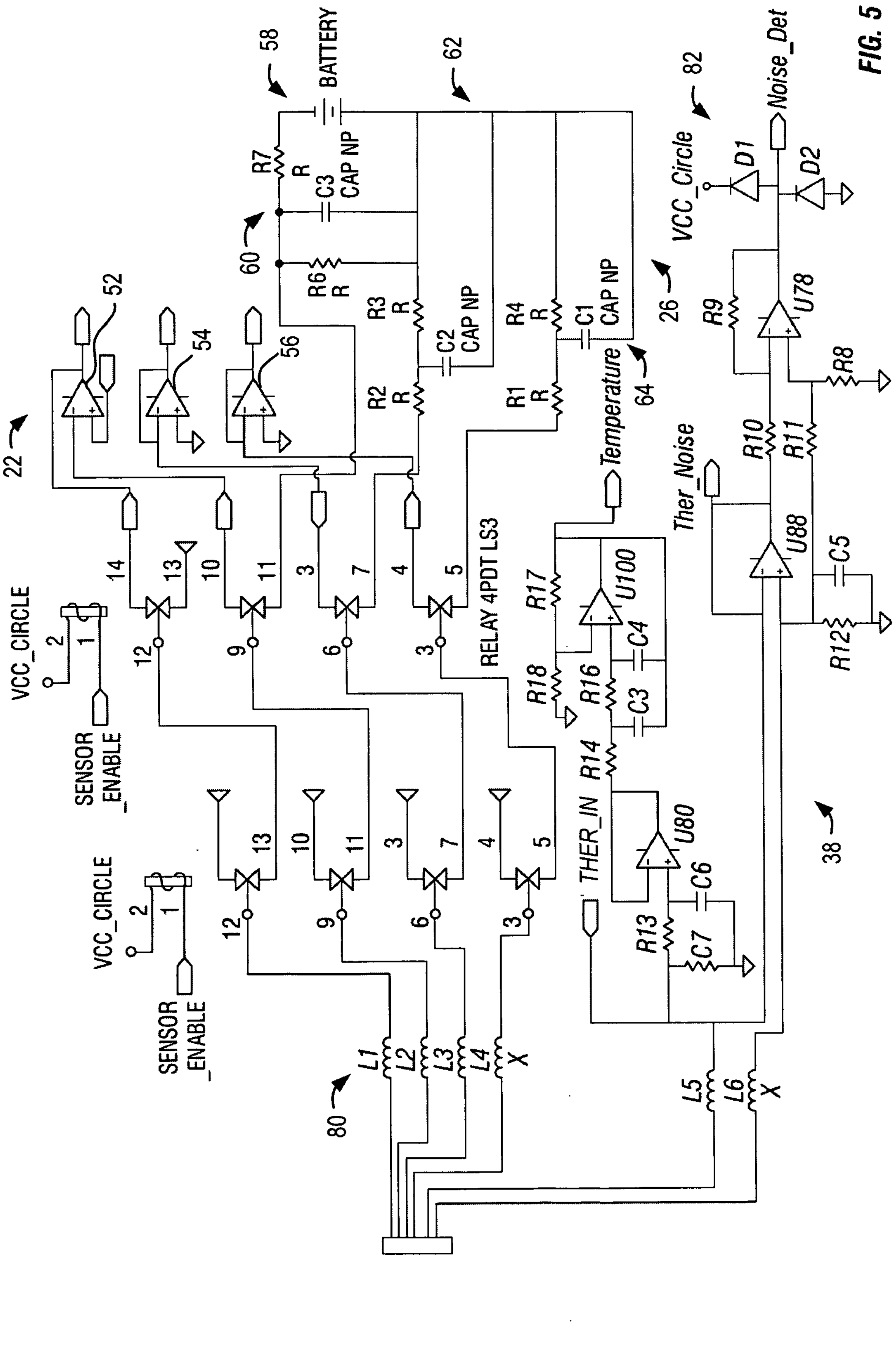

BATTERY
58
62
60
R7
R
C3
CAP NP
R6
R
R3
R
C2
CAP NP
R2
R
R4
R
C1
CAP NP
R1
R
26
64
Temperature
52
54
56
22
VCC_CIRCLE
SENSOR
_ENABLE
RELAY 4PDT LS3
R17
U100
C4
R18
R16
C3
R14
THER_IN
U80
C6
R13
C7
VCC_Circle
D1
Noise_Det
D2
82
R9
U78
R8
R10
R11
Ther_Noise
U88
C5
R12
38
L1
L2
L3
L4
X
L5
L6
80

FIG. 5

6/12

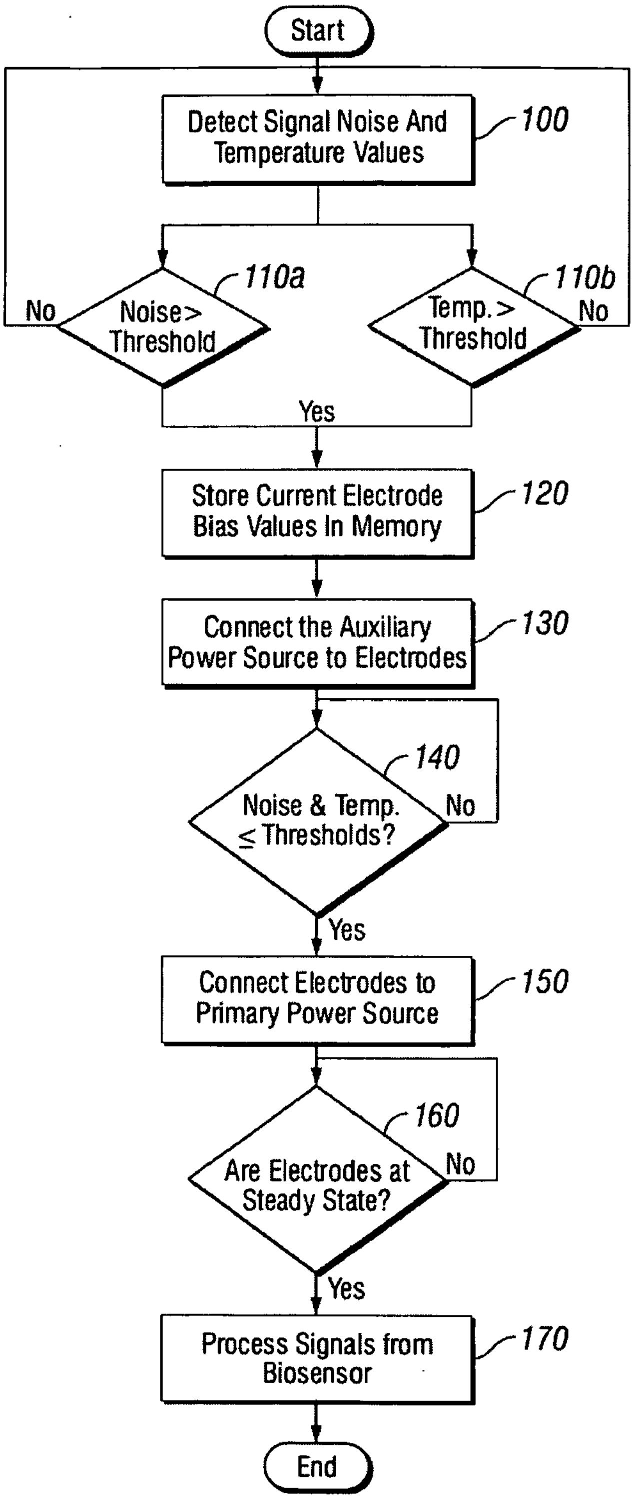

Start
Detect Signal Noise And Temperature Values
100
Noise> Threshold
110a
No
Temp.> Threshold
110b
No
Yes
Store Current Electrode Bias Values In Memory
120
Connect the Auxiliary Power Source to Electrodes
130
Noise & Temp. ≤ Thresholds?
140
No
Yes
Connect Electrodes to Primary Power Source
150
Are Electrodes at Steady State?
160
No
Yes
Process Signals from Biosensor
170
End

FIG. 6

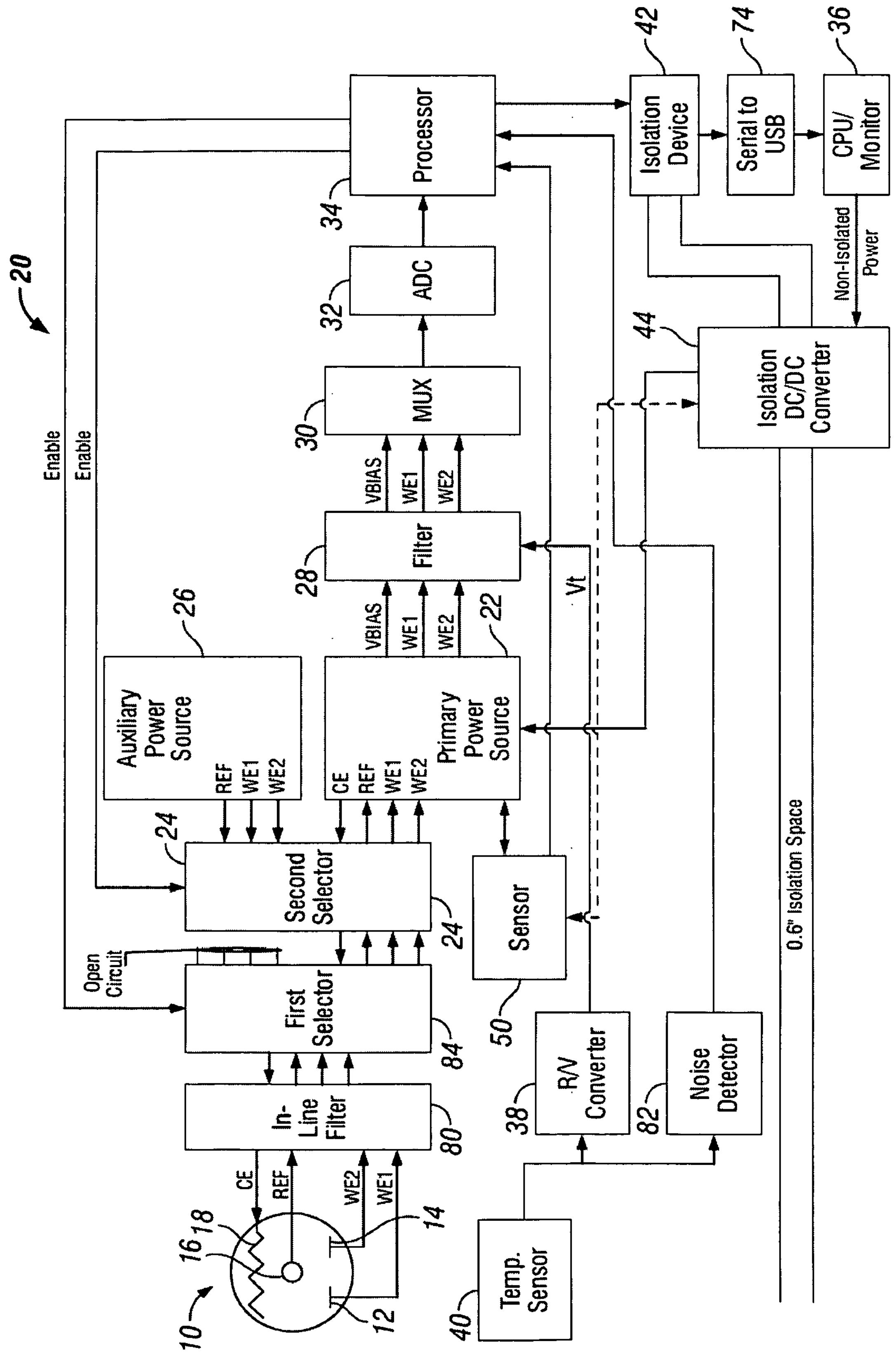

20
Processor
34
ADC
32
MUX
30
Filter
28
VBIAS
WE1
WE2
Primary Power Source
22
CE
REF
WE1
WE2
Auxiliary Power Source
26
Second Selector
24
First Selector
84
Open Circuit
Enable
Enable
In-Line Filter
80
CE
REF
WE2
WE1
10
12
14
16
18
Sensor
50
Vt
R/V Converter
38
Noise Detector
82
Temp. Sensor
40
Isolation Device
42
Serial to USB
74
CPU/ Monitor
36
Non-Isolated Power
Isolation DC/DC Converter
44
0.6" Isolation Space

FIG. 7

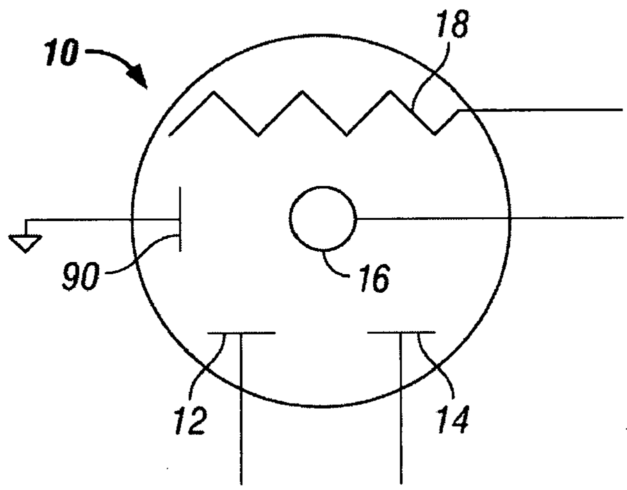


FIG. 8

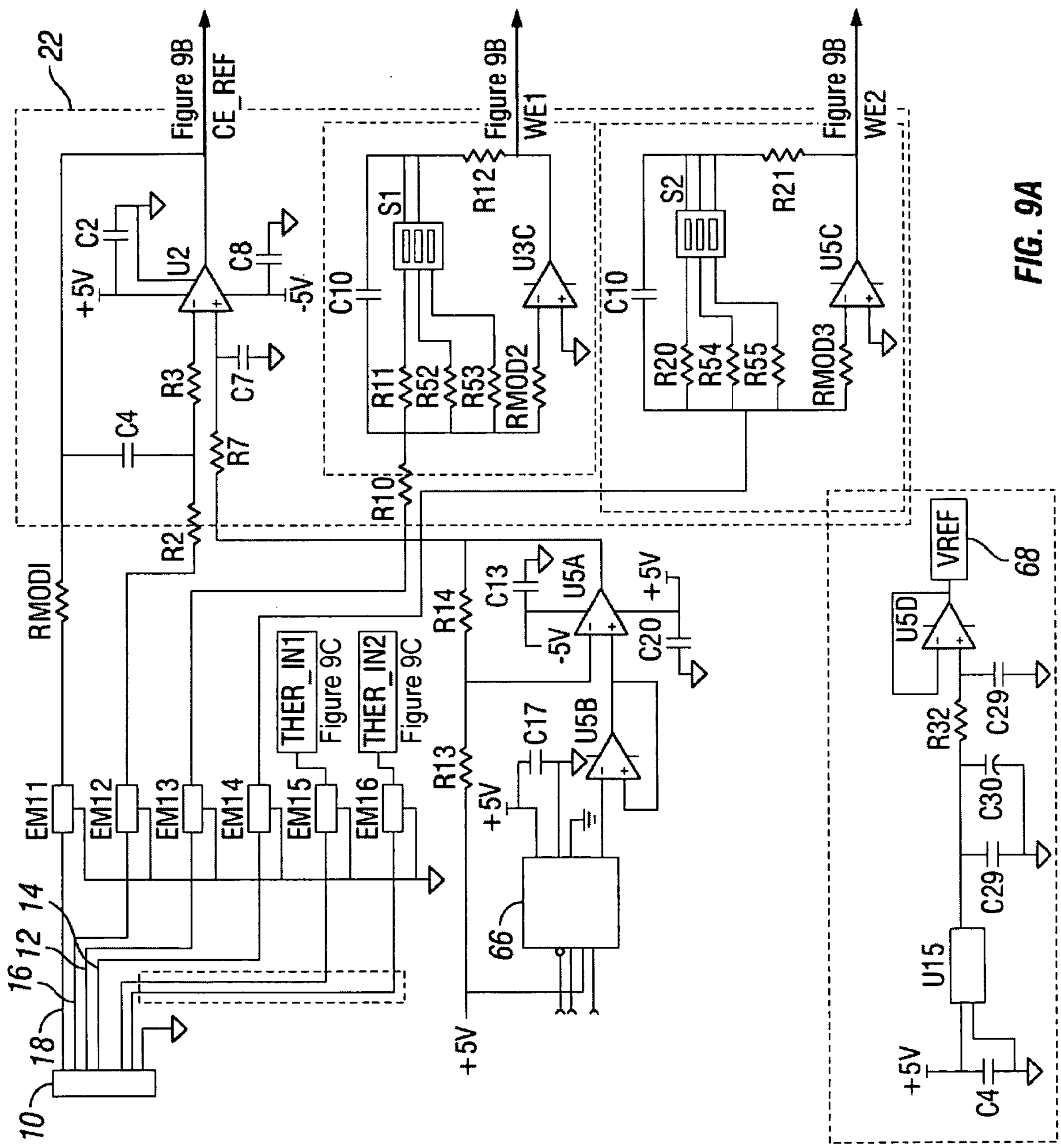

22
Figure 9B
CE_REF
Figure 9B
WE1
Figure 9B
WE2
+5V
C2
U2
C8
-5V
C10
S1
R12
U3C
C10
S2
R21
U5C
R3
C7
C4
R7
R11
R52
R53
RMOD2
R20
R54
R55
RMOD3
R10
R2
RMODI
R14
C13
U5A
+5V
-5V
C20
VREF
68
U5D
THER_IN1
Figure 9C
THER_IN2
Figure 9C
R13
C17
U5B
R32
C29
+5V
EM11
EM12
EM13
EM14
EM15
EM16
C30
14
12
16
18
10
66
+5V
C29
U15
+5V
C4

FIG. 9A

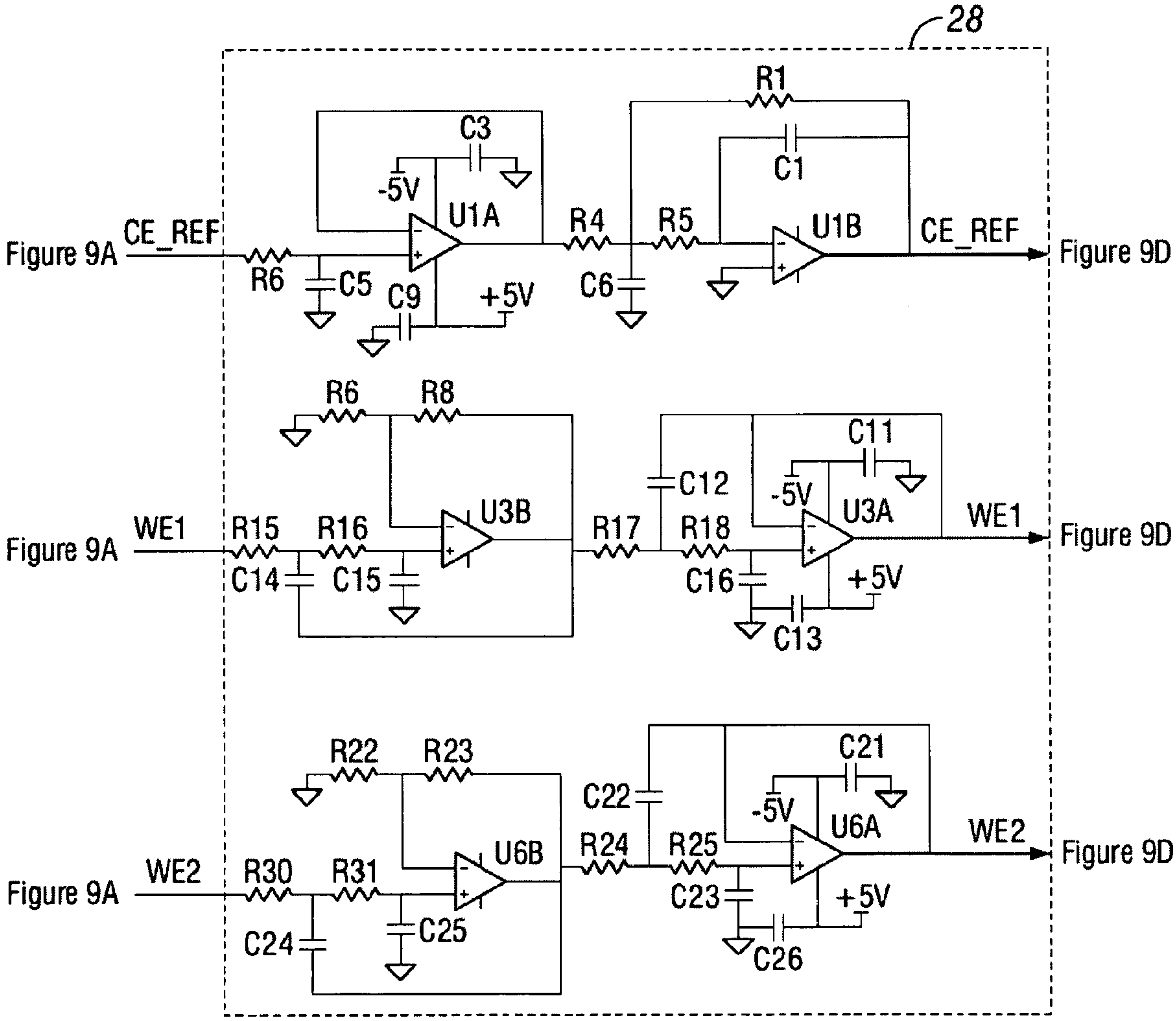
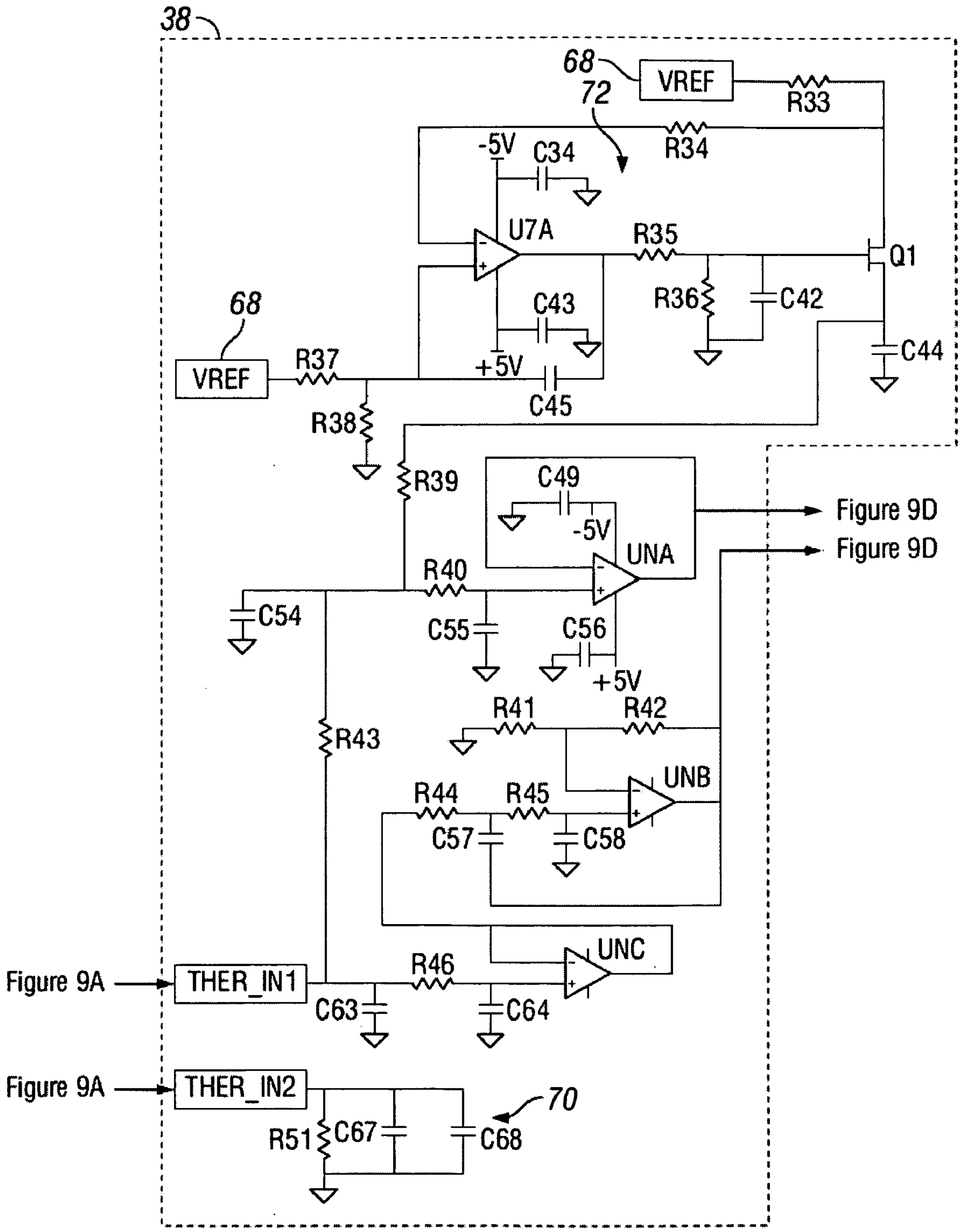

28
Figure 9A
CE_REF
R6
C5
C9
C3
-5V
U1A
+5V
R4
R1
C1
R5
U1B
C6
CE_REF
Figure 9D
R6
R8
U3B
Figure 9A
WE1
R15
R16
C14
C15
R17
C12
R18
C11
-5V
U3A
C16
+5V
C13
WE1
Figure 9D
R22
R23
U6B
Figure 9A
WE2
R30
R31
C24
C25
C22
R24
R25
C21
-5V
U6A
C23
+5V
C26
WE2
Figure 9D

FIG. 9B



38
68
VREF
R33
72
R34
-5V
C34
U7A
R35
Q1
R36
C42
C43
C44
68
VREF
R37
+5V
C45
R38
R39
C49
-5V
UNA
Figure 9D
Figure 9D
R40
C54
C55
C56
+5V
R41
R42
R43
UNB
R44
R45
C57
C58
UNC
Figure 9A
THER_IN1
R46
C63
C64
Figure 9A
THER_IN2
70
R51
C67
C68

FIG. 9C

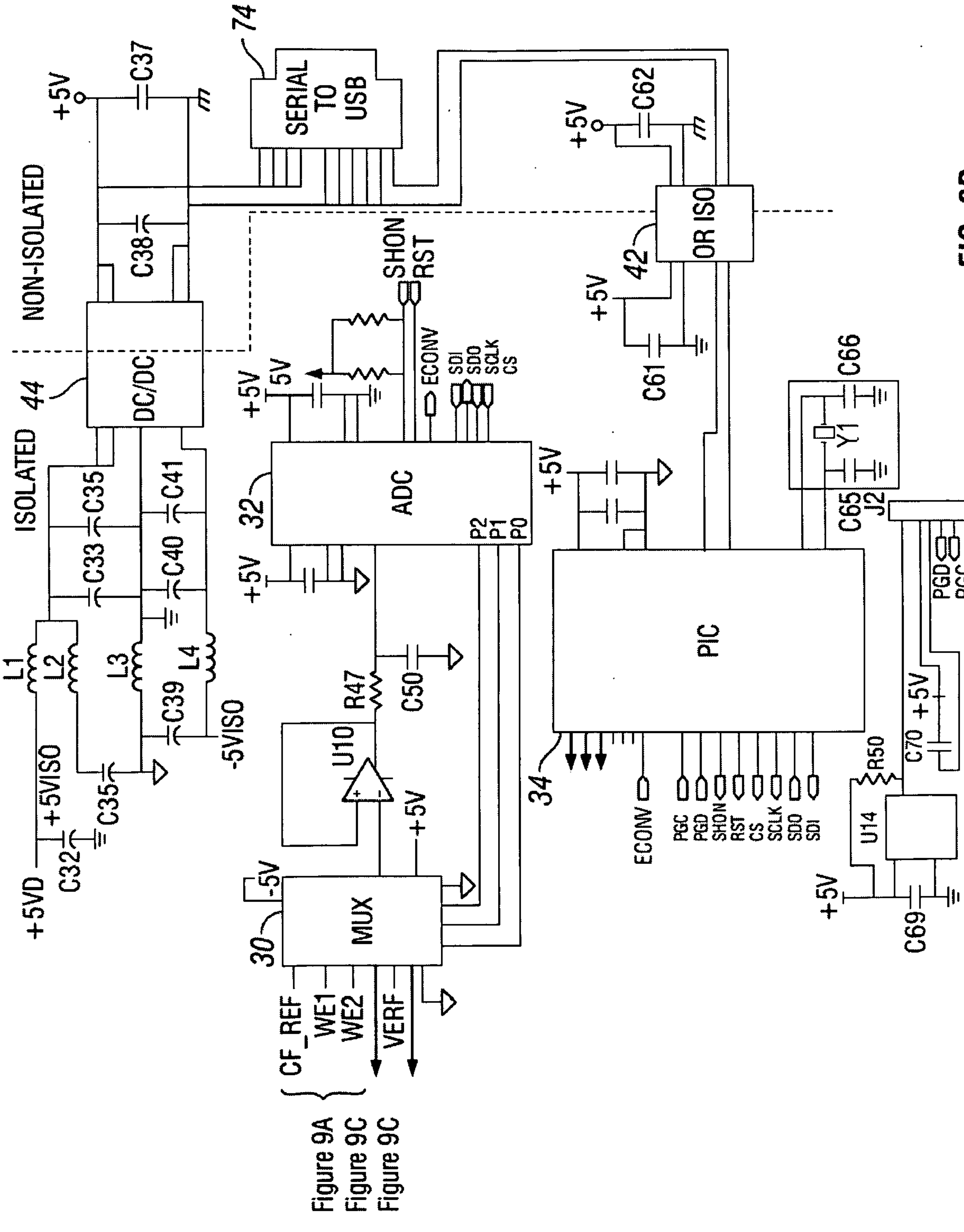

NON-ISOLATED
ISOLATED
+5V
C37
74
SERIAL TO USB
+5V
C62
42
OR ISO
+5V
C61
44
DC/DC
C38
SHON
RST
+5V
5V
ECONV
SDI
SDO
SCLK
CS
ADC
32
P2
P1
P0
+5V
C35
C41
C33
C40
L1
L2
L3
L4
C39
-5VISO
+5VISO
C35
+5VD
C32
R47
C50
U10
+5V
-5V
MUX
30
CF_REF
WE1
WE2
VERF
Figure 9A
Figure 9C
Figure 9C
+5V
PIC
34
ECONV
PGC
PGD
SHON
RST
CS
SCLK
SDO
SDI
C66
Y1
C65
J2
PGD
PGC
+5V
C70
R50
U14
+5V
C69

FIG. 9D

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/082071

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/025663 A1 (TALBOT CARY D [US] ET AL TALBOT CARY D [US] ET AL) 2 February 2006 (2006-02-02) paragraphs [0002], [0063], [0072], [0100], [0103], [0104]; figure 5B	1,8,12, 16
Y	US 2007/249007 A1 (ROSERO SPENCER Z [US]) 25 October 2007 (2007-10-25) paragraphs [0014], [0015], [0030], [0061]	1-18
Y	US 2007/004988 A1 (WU XIAOYU [CN] ET AL) 4 January 2007 (2007-01-04) paragraphs [0014], [0021], [0030] - [0032]; figure 4	1-18

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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专利名称(译)	分析物监测系统能够检测并提供对可能影响监测系统的外部系统产生的信号噪声的保护		
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摘要(译)

分析物监测系统包括用于检测血液中分析物浓度的生物传感器。监测系统包括传感器，用于检测工具或其他设备是否产生可能影响生物传感器操作的电噪声。如果检测到这样的电噪声，则系统在检测到的其他工具或设备的操作期间隔离生物传感器。在一些实施例中，系统测量生物传感器周围环境中的信号噪声和温度，以确定另一工具或其他设备当前是否在运行。该系统还可以包括辅助电源，以在生物传感器被隔离放置期间将生物传感器保持在偏置状态。