

[54] PATIENT ELECTRODE ISOLATION

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[58] Field of Search 317/9 R, 18 D, 124; 128/2.1, 128/2.06 B; 340/189, 190; 330/30 D, 207 P

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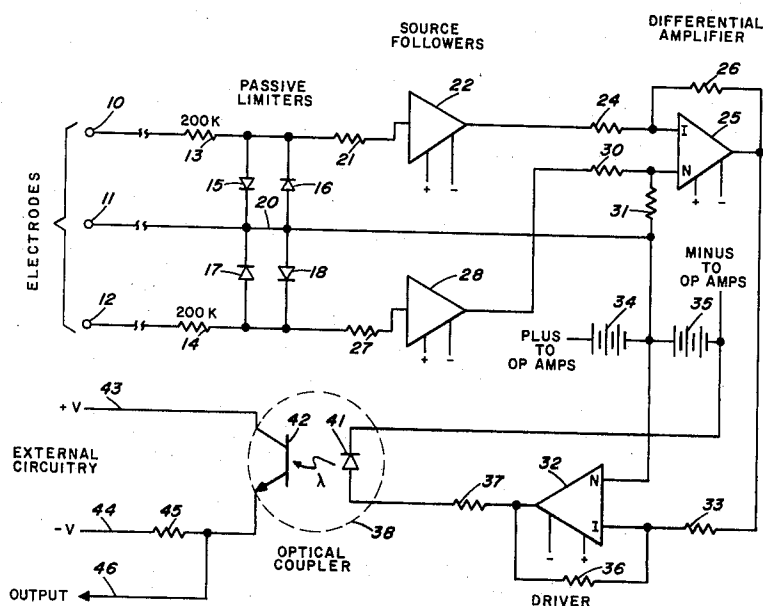
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[57] ABSTRACT

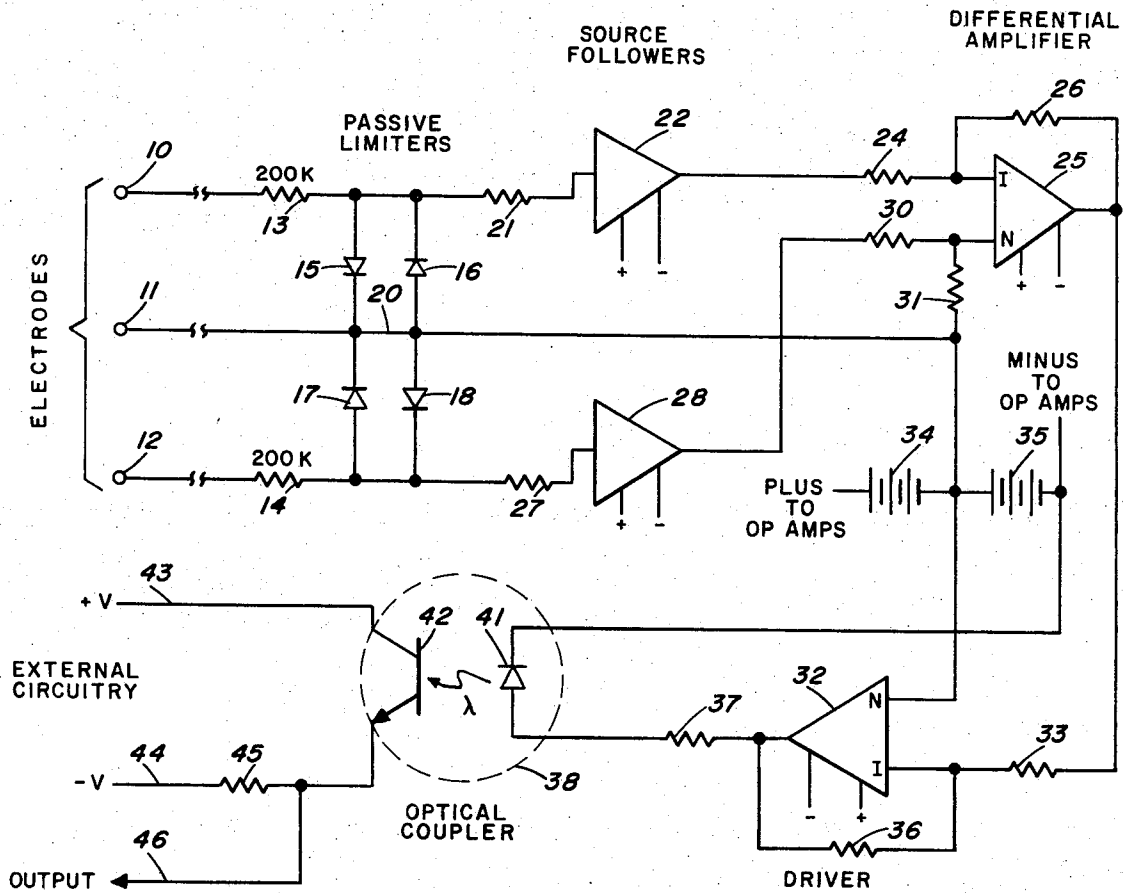
A system for preventing the inadvertent electrocution of a surgical patient through accidental coupling of probes and common equipment to ground. Isolation of the patient from ground is obtained through the use of a light emitting diode and a photo transistor in the probe circuit.

1 Claim, 1 Drawing Figure



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PATIENT ELECTRODE ISOLATION

BACKGROUND AND SUMMARY

The present invention relates to isolation circuits and, more particularly, to an isolation circuit with an optical arrangement for decoupling an electrical surgical probe from ground.

There are only two ways that a patient can accidentally be electrocuted when connected to electrodes while undergoing an operation or a diagnostic examination. The first of these is through interelectrode leakage or short circuits, where the monitoring device leaks lethal currents between the electrodes. The second is through coupling with other monitoring equipment, common equipment grounding being the most common culprit. Both possibilities must be eliminated, however, to guarantee patient safety.

The hazard of interelectrode leakage can be eliminated by series-connecting a passive current limiting network, i.e., one that introduces no current of itself, between the electrodes and the monitoring device.

The second cause of accidental electrocution is the most probable. Whenever a patient is grounded, he is vulnerable to almost every conceivable interaction between equipments, such as ground loop currents, electromagnetically coupled transients, and even poor hospital grounding techniques. It takes as little as 15 microamperes to set the heart muscle into fibrillation. This could still occur even where using the aforementioned technique since the ground connection to the patient cannot be current limited. However, if the whole input amplification network were floating and battery powered, this major cause would also be eliminated. FM modulation and demodulation techniques suffer from critical frequency controls and bulky component needs, and still do not guard against coupled electromagnetic transients through the transformer windings or leakage currents through transformers leakage capacitances. Optical isolation experiences no such drawbacks and further allows wider frequency bandwidths using practical components.

Thus, the present invention offers many improvements and advancements over the weaknesses and drawbacks of prior systems. The dual-function isolation technique disclosed herein is inexpensive, compact, reliable, and even adaptable to existing equipment. If all patient monitoring equipment were isolated in this manner, accidental electrocution could never occur.

It is, accordingly, an object of the present invention to overcome the defects of the prior art, such as indicated above.

It is another object of the present invention to provide a safe environment to prevent electrocution.

It is yet another object of the present invention to provide a device for isolating a patient, particularly during an operation or a diagnostic evaluation, to prevent electrocution, which device is inexpensive, compact, reliable and readily adaptable to various equipment.

These and other objects and the nature and advantages of the instant invention will be more apparent from the following detailed description of a specific embodiment of the invention taken in conjunction with the drawing wherein:

BRIEF DESCRIPTION OF THE DRAWING

The drawing shows a schematic diagram of the isolation circuitry

DETAILED DESCRIPTION

Referring now to the lone FIGURE of the drawing, which sets out a schematic diagram of the invention, there are provided input terminals 10, 11 and 12, these inputs furnishing signals from other surgical test or diagnostic devices (not shown) in use during an operation, such as intracavitary transducers, electronic probes and the like. Connected to terminal 10 there is a resistance 13, while a similar resistance 14 is tied to terminal 12; terminal 11, on the other hand is connected with a junction point 20.

A pair of oppositely poled diodes 15 and 16 are tied between the far end of resistance 13 and junction point 20, while another pair of oppositely poled diodes 17 and 18 are located between the far end of resistance 14 and junction 20. The output signal from resistance 13 is applied to a series connected resistance 21 from whence it is fed to an FET source follower amplifier 22. From amplifier 22 the signal is impressed on series resistance 24 and then to a differential amplifier 25, this amplifier having a feedback loop to its input and including a resistance 26.

A parallel channel, similar to the one described above, includes a series resistance 27 connected to the output terminal of resistance 14, the output of resistance 27 being applied to an FET source follower amplifier 28. From amplifier 28 the signal goes through a series resistance 30 before acting as a second input to differential amplifier 25. A lone resistance 31 is tied between the output end of resistance 30 and junction point 20. The output of amplifier 25 is applied as an input to a driver amplifier and drives 32 after passing through a series resistance 33. Feedback loop 36 provides the necessary gain control while the other input to amplifier 32 is connected to junction point 20.

Potential for the isolation network is supplied by two batteries 34 and 35; the positive terminal of battery 35 and the negative terminal of battery 34 connecting to junction point 20.

The driver signal, as produced by amplifier 32, passes through a dropping resistance 37 before being applied to an optical coupler 38, shown generally within the dotted lines. The return from coupler 38 is connected to the negative terminal of battery 35.

The optical coupler 38 consists of a light emitting diode 41 and a phototransistor 42. Positive potential is supplied to the phototransistor by means of a lead 43 connected to one electrode, while negative potential is furnished by lead 44 and resistance 45 connected to the output electrode of the phototransistor.

The output of the optical coupler, and therefore of the isolation network is furnished by an output terminal 46, connected to the output electrode of the phototransistor 42, this output converted from the infrared radiation generated by diode 41 acting as a variable resistance to generate a proportional current for subsequent amplification.

In operation the isolation network receives input signals on input terminals 10, 11 and 12, as from intracavitary transducers, and other surgical instruments,

and electrically decouples or isolates these signals before applying them to monitoring equipment via output terminal 46. Interelectrode leakage, or short circuits, where the monitoring device leaks lethal current between electrodes is eliminated by series connecting a passive current limiting network, or one that introduces no current of itself, between the electrodes and the monitoring devices, and including such passive network as a portion of the present overall isolation network. Resistances 21 and 27 limit any current from the amplifiers 22 and 28 to a low enough value so as not to exceed the rating of diodes 15, 16, 17 and 18, even if full battery supply voltages were short-circuited. Two diode pairs 15, 16, 17 and 18, reverse connected, can handle either positive or negative voltages. Since the junction of the diodes can never exceed ± 0.7 volts (silicon), 0.7 volts through resistances 13 and 14 limit interelectrode current to 3.5 microamperes, which is sufficiently low for safe connection even to intracavitary transducers. The high 200K input resistors 13 and 14 necessitate amplifiers 22 and 28 to have very high input impedances (FET source follower) with extremely low bias currents; otherwise the amplifiers could not track the input waveforms. Diodes 15, 16, 17 and 18 must be fast acting so as to dissipate the transient energy arising from a defibrillator pulse. Here, the 200K input resistors 13 and 14 limit the high voltage current.

The elimination of accidental coupling between monitoring and other equipment, by forming a common ground, is accomplished by the circuitry of the source follower amplifiers 22 and 28, differential amplifier 25, driver amplifier 32 and optical coupler 38. Optical isolation experiences none of the drawbacks of electromagnetic coupling or interaction between components since electrical current flow is broken by the beam of light. An operational amplifier 32 modulates the light emitting diode 41 and is biased sufficiently far in the linear operating region to preserve signal fidelity. Thus the emitted infrared radiation is optically coupled to a phototransistor 42 which acts as a variable resistor to generate a proportional current at its output terminal 46 for subsequent amplification and use by monitoring equipment.

From the above description of the structure and operation of the invention, it is obvious that the present device offers a number of improvements over the drawbacks and shortcomings of prior art isolation circuits. The device discloses a dual function isolation technique that is inexpensive, compact, reliable and adaptable to existing present day equipment. If all patient monitoring equipment were isolated in this manner, accidental electrocution could never occur.

Obviously many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A patient electrode isolation circuit for preventing accidental electrocution of a patient comprising
 - first, second, and third input means for receiving signals from electrical equipment as might be used in the treatment of a patient;
 - a first passive current limiting network connected between the first and second input means, said network being a resistance and a diode, said resistance preventing possible high voltage on the first and second input means from breaking down the diode;
 - a second passive current limiting network connected between the second and third input means, said network being a resistance and a diode, said resistance preventing possible high voltage on the second and third input means from breaking down the diode;
 - a first source follower series connected in the first input means;
 - a second source follower series connected in the third input means;
 - a third passive current limiting network connected between the input of the first source follower and the second input means, said network being a resistance and a diode, said diode being poled oppositely from the diode in the first passive current limiting network and the resistance preventing any excessive interelectrode leakage in the first source follower from breaking down the diode;
 - a fourth passive current limiting network connected between the input of the second source follower and the second input means, said network being a resistance and a diode, said diode being poled oppositely from the diode in the second passive current limiting network and the resistance preventing any excessive interelectrode leakage in the second source follower from breaking down the diode;
 - a differential amplifier connected to receive the outputs of the first and second source followers;
 - a driver amplifier connected to receive the output of the differential amplifier;
 - an optical coupler consisting of a diode and a phototransistor connected to the output of the driver; and
 - output means connected to the phototransistor.

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