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Babilius

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[54] **ISOLATOR CIRCUIT FOR USE WITH ELECTRICAL MEDICAL EQUIPMENT**

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[52] **U.S. Cl.** .... **317/9 R,** 128/2.1 A
[51] **Int. Cl.** **G08c 19/02**
[58] **Field of Search** ...... 317/9 R; 321/2; 128/2.1 A, 128/2.06 R

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Assistant Examiner—Harry E. Moose, Jr.
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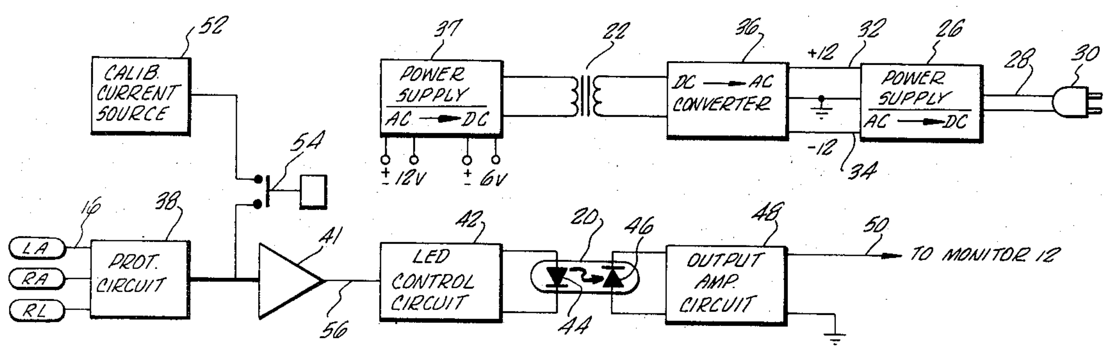
[57] **ABSTRACT**

An isolator circuit for physically and electrically insulating or isolating electrical equipment from a patient to whom the equipment is normally connected by electrodes, is disclosed. The isolator circuit is electrically interposed between the equipment and the patient by having the electrodes connected to the isolation circuit. Signals that are provided from the patient are converted from voltage signals to light signals for transmission via an optical or photo coupler to an optical receiver for subsequent reconversion to a voltage signal that is suitable for use by the electrical equipment. The isolator power supply is multi-staged and includes a transformer having a high breakdown voltage.

19 Claims, 7 Drawing Figures



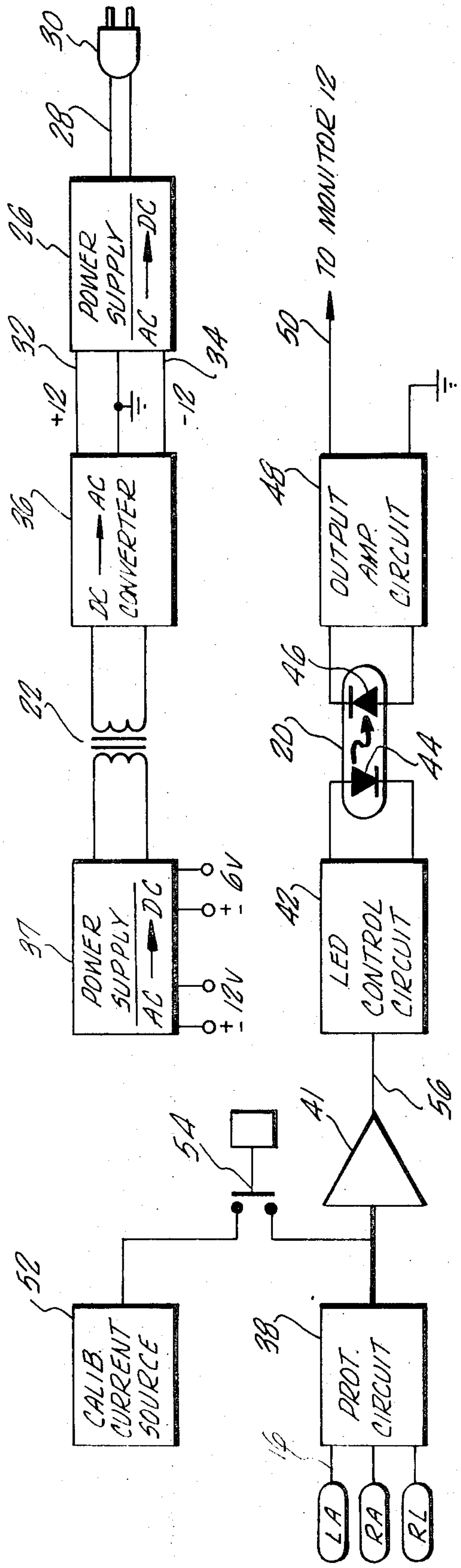

30
28
26
POWER SUPPLY AC → DC
32
+12
-12
34
36
DC → AC CONVERTER
22
37
POWER SUPPLY AC → DC
6V
12V
TO MONITOR 12
50
48
OUTPUT AMP. CIRCUIT
46
20
44
42
LED CONTROL CIRCUIT
41
56
54
52
CALIB. CURRENT SOURCE
38
PROT. CIRCUIT
14
LA
RA
RL

FIG. 2

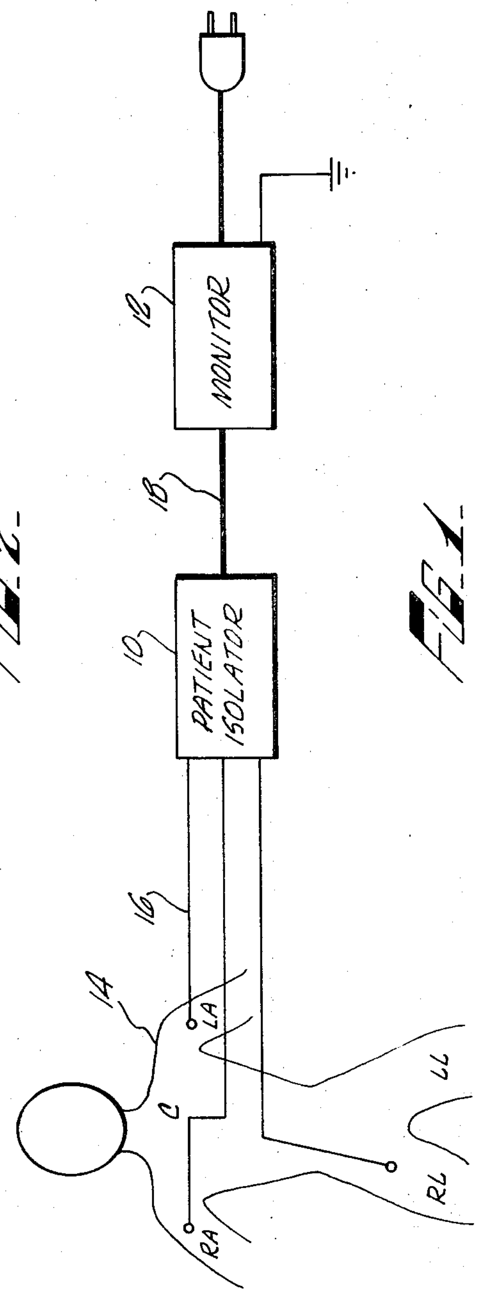
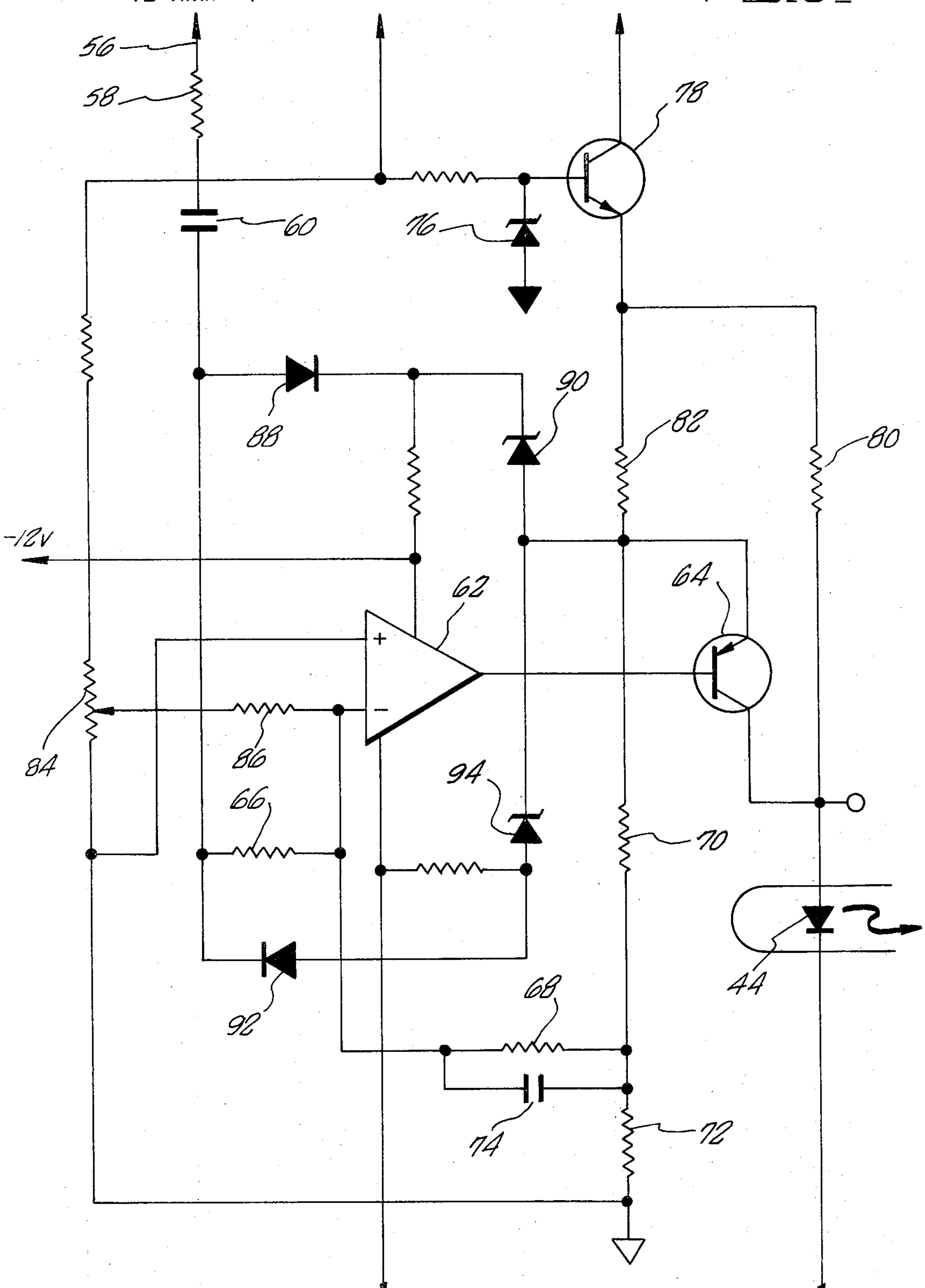

12
MONITOR
18
10
PATIENT ISOLATOR
16
14
LA
C
RA
LL
RL

FIG. 1

FIG. 3


TO AMP. 41
+12V
+6V
56
58
78
60
76
90
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82
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-12V
62
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74
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-12V
-6V

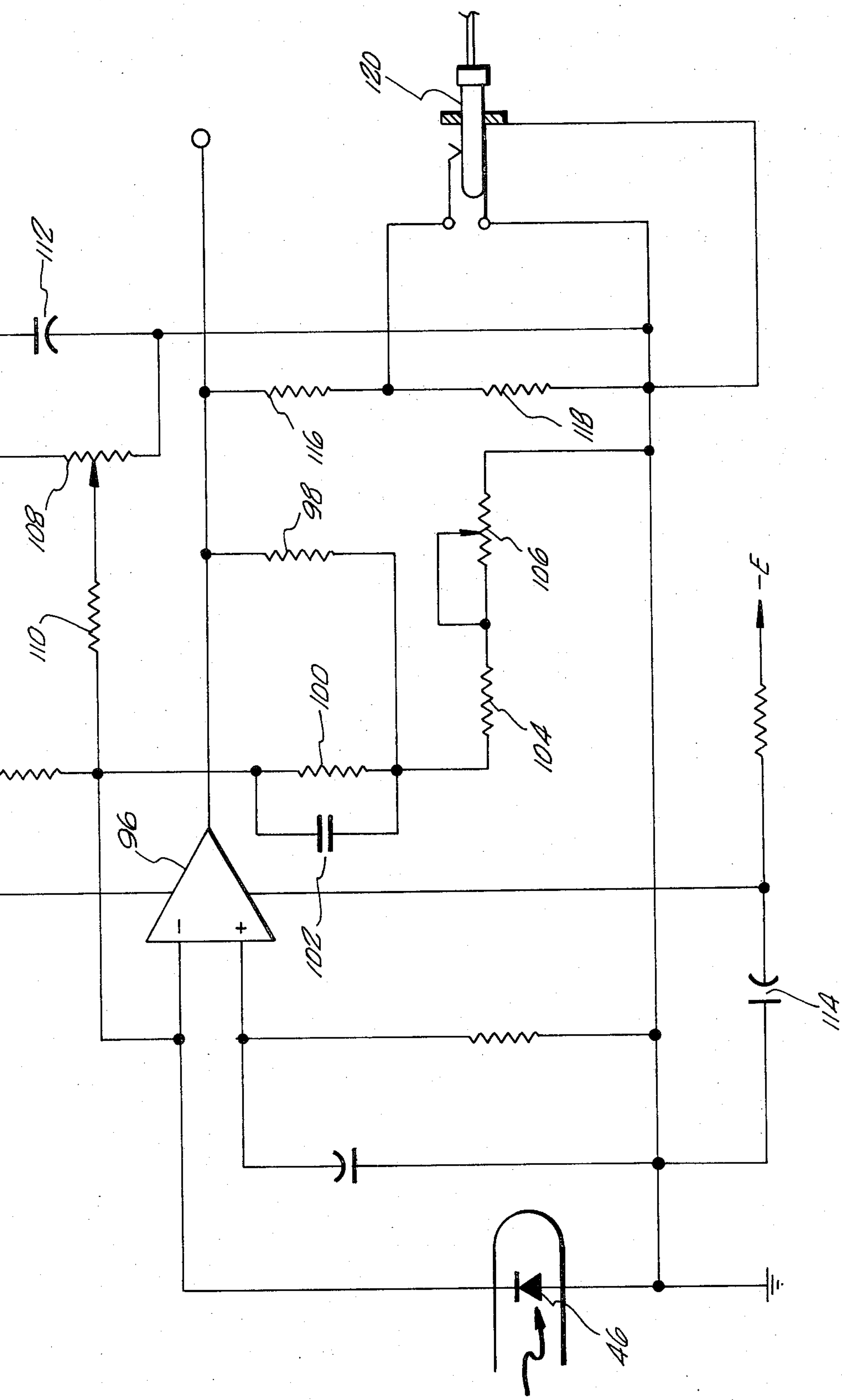

FIG. 4

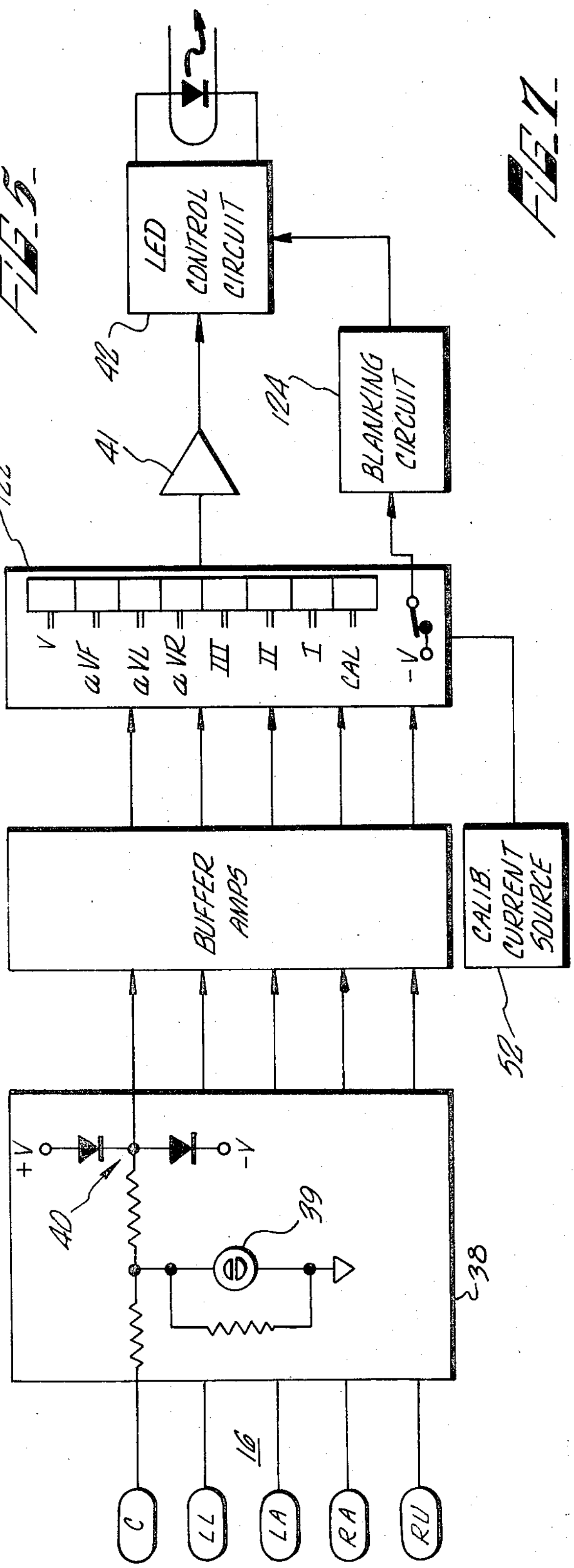

FIG. 5

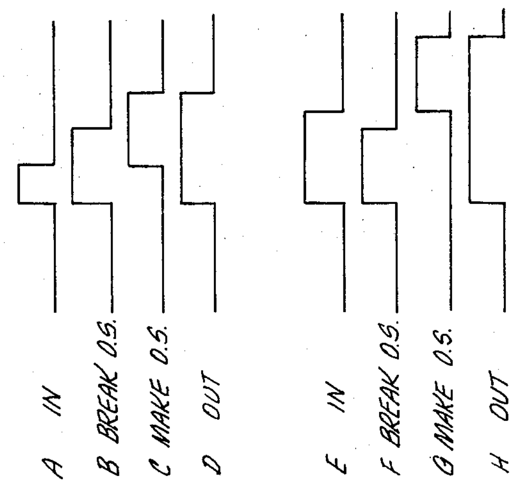

FIG. 7

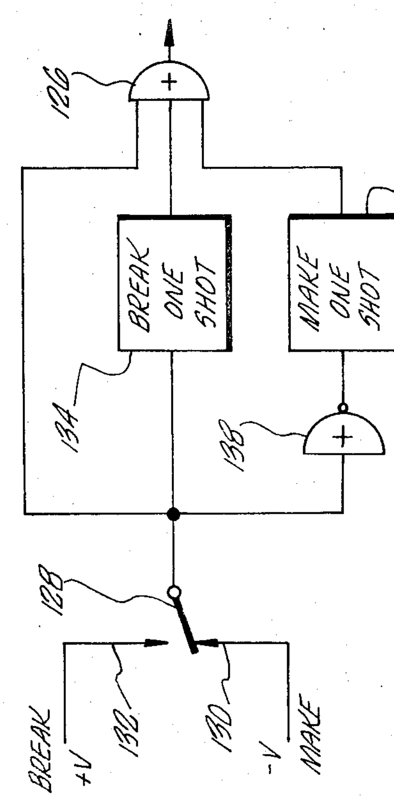

FIG. 6

ISOLATOR CIRCUIT FOR USE WITH ELECTRICAL MEDICAL EQUIPMENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention generally relates to medical electrical equipment that is designed for use by being maintained in contact with a patient. More particularly, the subject invention concerns a circuit for physically and electrically isolating electrical equipment from a patient to which it is attached while yet permitting body generated signals to be conducted from the patient to the equipment for recordation, display or the like.

2. Description of the Prior Art

A variety of electrical equipment is used for medical purposes. Electrodes are commonly used in conjunction with such equipment to provide a conductive path for body generated signals indicative of certain functions of a human body. An electrocardiograph is exemplary of such equipment wherein a plurality of leads or electrodes are attached to the body of a patient to permit the measurement of electrical potentials generated between various combinations of electrodes at the surface of the body as a result of activity within the heart. Generally considered, such equipment is passive in the sense that electrical power is not being applied to the body by the equipment.

Except for certain purposes such as defibrillation, it is not desirable to have electrical current applied to the body for conduction therethrough. Accidental application of electrical current to a patient may cause serious burning of the patient at points where a ground return path is available, i.e., through the electrodes connecting the patient to monitoring or measuring devices, etc. Depending on the health of a patient, and the amount of current, death may result from such accidental application of electrical current. For example, a heart patient in intensive care would be highly susceptible to the inadvertant application of even a moderate amount of electrical energy.

Numerous preventive measures have been devised to reduce or eliminate the accidental electrocution, burning, or other injury of patients by the malfunctioning of electrical equipment to which they may be attached. For example, care is taken to design the equipment to have the casing thereof properly grounded via ground connections extending through the familiar electrical cord and three-prong plug which is inserted into the common wall socket to receive the standard 110 volts, 60 cycle, AC power. Nevertheless, malfunctions in medical equipment continue to occur causing injury and an occasional fatality. Even the passive-types of electrical equipment are problematical since some form of power supply must be included to provide power to the unit itself.

More complex preventive safety measures have involved the design of isolator circuits which are interposed between the electrodes and electrical equipment. The isolator circuits are intended to permit transmission of information from the body to medical equipment; but provide electrical isolation between the patient and the measuring equipment such that a malfunction, i.e., short circuited transformer, broken ground connections, etc., will not result in the undesired completion of an electrical path to the patient through which electrical current may be conducted.

Basically, there are two types of prior art insulator circuits. The first simply involves the use of an additional transformer. Electrical body signals from the patient are modulated and transmitted through the transformer to the electrical medical device connected thereto. The transformer itself provides the physical insulation of the patient. In effect, this type of isolator circuit simply adds another transformer in series with the power transformer used in the medical equipment. Theoretically, the possibility of an injury occurring is reduced since the concurrent breakdown of all of the series connected transformers would be required to complete a potentially dangerous electrical connection. Nevertheless, short circuiting of the transformer coils remains as a possibility. Further, the necessity of modulating and demodulating the detected body signals introduces inaccuracy and requires an undesired amount of complexity.

The second type of prior art isolator circuit involves the use of a light coupling device to transmit the electrical body signals via the electrodes to the medical equipment. A bttery is employed to power the active elements of the unit and the body signals are therefore modulated with a low duty cycle to conserve the battery power. The low duty cycle modulation has been found to be inaccurate since heart pulses, for example, occurring during the off-period may be completely missed. Also, the use of a battery requires routine periodic replacement of the battery to ensure operation of the isolator circuit. However, typically there is no uniform maintenance of battery operated equipment at hospitals, medical clinics and/or offices and none can be reasonably expected as a rule. The result is that when such battery powered equipment is put into use, there is no way of accurately determining, on site, whether the battery is of full strength, partial strength, or near dead. Reliability is accordingly a key disadvantage with the second type of prior art devices.

It is accordingly the intention of the present invention to provide a reliable and effective patient isolator circuit that may be readily interposed between the patient and medical electrical equipment, or built into future equipment, to insulate the patient from the equipment by preventing the completion of any electrical path or connection through which electric current may be conducted through the patient either from the equipment connected to the isolator circuit or from other equipment connected to the patient and not having an isolator circuit.

SUMMARY OF THE INVENTION

Briefly described, the present invention involves a patient isolator circuit which transmits body generated signals from a patient to attached medical electrical equipment while insulating the patient from the electrical equipment to prevent the completion of an electrical path from the patient to the equipment.

More particularly, the subject patient isolator includes an optical coupler through which body generated signals are transmitted to the medical equipment. Voltage signals from the body of a patient are amplified and converted to current signals for application to a light transmitter of an optical coupler. Transmitted light signals are received by a light receiver of the optical coupler and provided to an output amplifier circuit to be re-converted to voltage signals for application to the medical equipment. A power supply including a low capacitance transformer having a high breakdown voltage insulates the patient from the power supply and converts AC power available from any conventional wall socket to DC voltages for the isolator circuit.

The objects and many attendant advantages of the invention will be more readily appreciated as the same becomes better understood by reference to the following detailed description which is to be considered in connection with the accompanying drawings wherein like reference symbols designate like parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram illustrating an isolator circuit in accordance with the present invention operatively connected between a patient and medical electrical equipment.

FIG. **2** is a schematic block diagram illustrating a patient isolator circuit in accordance with the present invention.

FIG. **3** is a detailed circuit diagram of a light emitting diode control circuit useable with the subject invention.

FIG. **4** is a detailed circuit diagram illustrating an output amplifier circuit useable with the subject invention.

FIG. **5** is a schematic block diagram illustrating a modified embodiment of a patient isolator circuit in accordance with the subject invention.

FIG. **6** is a schematic block diagram illustrating a blanking circuit that may be used in conjunction with the isolator circuit shown by FIG. **5**.

FIG. **7** is a graphic diagram illustrating a series of waveforms that are useful in discussing the operation of the blanking circuit shown by FIG. **6**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, a patient isolator circuit **10** in accordance with the present invention is intended to be operatively connected between a medical electrical device **12** and a patient **14**. The medical electrical device **12** may be an electrocardioscope, or heart monitor, electrocardiograph, or the like, which are usually employed by being connected to a patient by a plurality of electrodes. As shown, such a plurality of electrodes would be connected to the isolator circuit **10**. A standard electrical cable **18** may be used to connect the isolator circuit **10** to the monitor **12**.

Generally considered, the isolator circuit **10** must serve to transmit electrical body signals from the patient **14** to the monitor **12**; but at the same time provide physical insulation between the monitor **12** and the patient **14** to prevent accidental conduction of electrical energy between the patient **14** and the monitor **12**. Such an accident may occur, for example, as a result of a malfunction in the monitor **12** such as a breakdown of a power transformer (i.e., short circuiting of the coils thereof) or disconnection of a ground return connection for the equipment, as earlier discussed.

The detailed block diagram of FIG. **2** illustrates that insulation is effectively provided by the subject isolator circuit **10** by the use of an optical coupler **20** and a transformer **22** having a high breakdown voltage. The optical coupler **20** permits the transmission of body signals from the patient **14** to the monitor **12**, but will not permit the conduction of electrical energy. The transformer **22** by having a high breakdown voltage permits transfer of power from the standard AC source to a DC power supply **37** for portions of the isolator circuit; but effectively prevents accidental transfer of energy that may be permitted by a breakdown.

Considered in greater detail, the isolator circuit **10** includes an AC to DC converter circuit **26** which is adapted to be connected to the standard 110 volt, 60 cycle, AC source by an electrical cable **28** and socket **30**. The power supply **26**, may be any conventional type that is adapted to provide positive ane negative DC voltages at a pair of output leads **32** and **34**, respectively. The DC voltages are provided to a converter circuit **36** which may be a chopper circuit of conventional type. The converter circuit **36** thus will provide chopped DC signals to the primary coil of the transformer **22**. The converter circuit **36** is preferably designed to provide high frequency chopped DC signals. For example, a frequency of 20 kHz has been found to be suitable.

The use of a high frequency permits the transformers **22** to be of a low capacitance-type to further enchance the safety factor. The tranformer **22** preferably has a breakdown voltage in the neighborhood of 10 kilovolts which far exceeds any possible electrical power that may be accidentally applied to the transformer. For example, defibrillators presently in use involve a maximum of 2 kilovolts.

The chopped DC signals are provided from the secondary coil of the transformer **22** to a DC power supply **37** which provides DC power to portions of the isolator circuit **10** that are electrically connected to a patient by the electrodes **16**. The DC power supply **37**, for purposes of the subject isolator circuit **10** may provide ±12 volts at output terminals that are appropriately connected (not shown) as is necessary to provide desired DC power to the various circuit elements. The power supply **37** may be of any conventional configuration. As an example, a pair of rectifier circuits may be used to provide the desired DC voltages.

The electrodes **16**, which are connected to the patient **14**, are connected to a bank of protection circuits **38** which serve to prevent damage to the electronic components in the isolator circuit **10** by high amplitude signals that may be provided from the patient via the electrodes **16**. Any suitable circuit configuration may be used. A simple protection circuit **38** is shown by FIG. **5** and may include a neon lamp that connects the associated electrode to a common terminal. A conventional rectifier pair **40** may be used to further limit the maximum voltages that may be provided over an electrode. Each of the electrodes to be accommodated would be connected to a neon bulb **39** and a rectifier pair **40**.

Referring again to FIG. **2**, the body signals are provided to an amplifier circuit **41** from the protection circuits **38**. The amplifier circuit **41** may be designed to provide a gain of fifty-times where the usual amplitude of an electrical body signal applied thereto is in the neighborhood of 1 milivolt.

The amplified body signals are applied to a light emitting diode control circuit **42** for application to a light emitting diode **44** included in the optical coupler **20**. The light emitted by the diode **44** is received by a light receiving diode **46** of the optical coupler **20**. Current signals from the diode **46** are applied to an output amplifier circuit **48** which operates to convert the current signals to voltage signals that are suitable for use by the monitor **12** that may be connected to an output terminal lead **50**.

The light emitting diode control circuit **42** operates to convert the voltage signals provided from the amplifier **41** to current signals for application to the diode **44** of the optical coupler **20**. The control circuit **42** also serves to maintain the diode **44** partially conductive during ambient conditions such that the increases and decreases in the amplitude of body generated signals can be readily followed by corresponding changes in the intensity of the light provided by the diode **44**.

A calibration current source **52** of any conventional design well known in the prior art is connected to provide a calibration current to the control circuit **42** via the amplifier **41**. A switch may be used to permit manually controlled application of the calibration current. As an example, a one milivolt calibration signal may be employed.

FIG. 3 illustrates an exemplary control circuit **42** that may be used in conjunction with the subject invention. Electrical body signals are provided from the amplifier **41** via a lead **56** which includes a serially connected input resistor **58** and capacitor **60** through which the body signals are applied to the inverting input terminal of an operational amplifier **62**. The output signal of the amplifier **62** is varied according to the amplitude of input signals and is applied to the base of an output transistor **64** to control the conductivity thereof. The amount of current applied to the light emitting diode **44** is varied by control of the conductivity of the transistor **64**.

A current limiting resistor **66** is connected in series with the inverting input terminal of the amplifier **62**. A conventional feedback circuit is provided and includes a feedback resistor **68** connected in series with one of a pair of resistors **70** and **72** to complete the feedback connection to the emitter terminal of the output transistor **64**. The values of the resistors **70** and **72** may be suitably adjusted to control the gain of the amplifier **62**. A capacitor **74** is connected in parallel with the feedback resistor **68** to control the roll-off frequency response of the amplifier **62**.

The current to be applied through the diode **44** is supplied by an accurate current source. The combination of a zener diode **76** and a transistor **78** may be used for this purpose. Current to maintain the light emitting diode **44** at the desired level of ambient illumination is provided via a bias resistor **80**. The current is carefully selected to have the diode **44** emit a median amount of light. Control of the conductivity of the transistor **64** accordingly permits greater or lessor amounts of current to be conducted via the transistor **64** and a bias resistor **82** to the diode **44** such that the intensity of light emitted thereby is varied as a direct function of the amplitude of electrical body signals provided to the amplifier **62**.

Fine adjustment of the amount of bias current provided to the diode **44** under ambient conditions is permitted by the use of a variable resistor **84** which is connected to the inverting input of the amplifier **62** through a connecting resistor **86**.

A clamping circuit is provided to limit the maximum output of the amplifier **62**. Such clamping is necessary to prevent damage to the mechanical meter movements that may result from large transients such as may be produced by movement of a patient. The clamping circuit thus prevents voltages exceeding a preselected amount from being applied to the emitter of the transistor **64**. The clamping circuit includes a serially connected diode **88** and a zener diode **90** which are biased to accommodate positive transient voltages. A serially connected diode **92** and zener diode **94** are biased to accommodate negative transient voltages.

The light emitted by the diode **44** is received by the diode **46** of the optical coupler **20**. Resulting current signals are applied to the output amplifier circuit **48**. A suitable output amplifier circuit **48** for use with the subject invention is illustrated by FIG. **4**. As earlier mentioned, the output amplifier circuit operates to convert the current signals provided from the light receiving diode **46** to suitable voltage signals for application to, and use by, monitoring or other electrical equipment.

As shown by FIG. **4**, the output amplifier circuit **48** may also include an operational amplifier **96**. Current signals are provided from the diode **46** to the inverting input terminal of the amplifier **96**. An amplifier feedback path includes a resistor **98** connected in series with a parallel connected resistor **100** and capacitor **102**. As with the amplifier **62** in the control circuit **42**, the capacitor **102** and resistor **100** permit adjustment of the roll-off frequency response of the amplifier **96**. Amplifier gain adjustment is permitted by a resistor **104** connected in series with a variable resistor **106**.

Fine adjustment of the desired ambient output voltage levels is permitted by a variable resistor **108** and a connecting resistor **110** connected to the inverting input of the amplifier **96**. Capacitors **112** and **114** are connected to provide filtering for the power supply connections.

Voltage signals to be applied to associated medical equipment is developed across an output resistor **118** connected in series with a larger resistor **116**. Any suitable output terminal configuration may be used such as the illustrated socket structure that is designed to accommodate a standard plug **120**.

The embodiment of FIG. 2 is notably designed for use with a three electrode system. A typical three electrode system would involve an electrocardioscope which may typically be used to monitor the heartbeat of a patient. In the case of electrocardiographs, a greater number of electrodes is normally required. Typically, at least five electrodes are connected to the arms, legs, and chest of a patient. Different combinations of these electrodes are interconnected to obtain standard measurement in accordance with established medical practice.

Table I hereinbelow identifies seven standard electrocardiograph measurements and the associated combinations of electrodes.

TABLE I

Measurements	Connections (+)	Connections (−)
Lead I ECG	LA	RA
Lead II ECG	LL	RA
Lead III ECG	LL	LA
Augmented vector right (aVR)	RA	LA+LL
Augmented vector left (aVL)	LA	RA+LL
Augmented vector front (aVF)	LL	RA+LA
Precordial (V)	C	RA+LA+LL

As may be observed, switching between the various electrodes is required to obtain these standard measurements. Such switching is usually accomplished with an appropriate switch bank on the electrocardiograph. However, the isolator circuit 10 may be equipped with a bank of mechanical switches 122 to assume the switching function.

Generally, the switch bank 122 may involve a plurality of individual switches which when operated will close or make a number of ganged contacts after opening or breaking the contacts of any already closed switch. The electrodes are appropriately connected to the various switch contacts to form the desired combinations. A single one of the contacts of each switch may be connected to a voltage source such that a distinguishable high signal is provided when one of the switches is closed and a negative signal is provided when any of the switches is closed.

As is well known, transients accompany operation of switches. To prevent any adverse effects of such transients, the control circuit 42 may be disabled by a blanking circuit 124 which is connected to provide a blanking pulse whenever any switch in the switch bank is operated.

Referring briefly to FIGS. 6 and 7, the blanking circuit 124 may simply include three parallel connections for applying input signals to an OR gate 126. A high output signal will be provided by the OR gate 126 whenever a high signal is applied as an input thereto from any of the input channels. Assume that a contact 128 symbolically represents the switching bank 122 wherein when any switch in the bank 122 is closed or made, a low voltage signal is applied to the contact 128 from a negative source 130 and wherein when none of the switches in the bank 122 is closed, a high voltage signal is provided to the contact 128 from a positive source 132.

Waveforms A and E of FIG. 7 illustrate pulsed signals that would be effectively produced by the operation of any switch in the bank 122, i.e., opening a previously closed switch and reclosing a switch. As shown, the low signal prevailing when any switch is closed is changed to a high signal by the opening of the closed switch. The high signal remains until another switch in the bank 122 is closed at which time a low signal is again provided. The width of the pulse of waveforms A and E corresponds to the length of time during which none of the switches in the bank 122 is closed. As indicated by waveforms D and H, the output of the OR gate 126 immediately becomes high upon all of the switches being broken due to the attendant high signal provided over the input lead 133. The high signal also triggers a one-shot circuit 134 which supplies a high signal to the OR gate 126 for a predetermined length of time as is illustrated by waveforms B and F. Upon any switch in the bank 122 being subsequently closed, the resulting low signal triggers a one-shot circuit 136 which receives a high signal from the inverter circuit 138. A high signal is thus provided to the OR gate 126 for a predetermined length of time following any closing of a switch as is illustrated by waveforms C and G. Accordingly, a blanking pulse will be provided by the output of the OR gate 126 for at least the time duration during which no switch is closed plus the preset time corresponding to the pulse provided by the one-shot 136 as shown by waveform H. However, when a connected switch is opened and another switch is promptly closed as shown by waveform A, the duration of the blanking pulse from the OR gate 126 of the blanking circuit 124 would be shorter as shown by waveform D of FIG. 7.

The control circuit 42 may be disabled by using the blanking pulse to operate an appropriate switching element such as a transistor. For example, a transistor may be connected between the resistor 84 and a common ground terminal and operate to short circuit the inverting input terminal of the amplifier 62 of the control circuit 42 when the transistor is rendered conductive by the blanking pulse.

Referring once again to FIG. 5, the plurality of electrodes 16 that are used would each be connected to have a protection circuit as earlier discussed in conjunction with FIG. 2. Each of the electrodes would then be connected to a buffer amplifier before being appropriately connected to the contacts of the switch bank 122. Each buffer amplifier would preferably have unity gain and would simply serve to compensate for the high input impedance presented by the mechanical switches.

Use of the circuit configuration illustrated by FIG. 6 would eliminate the need for any operation of the switching mechanism on an electrocardiograph and is as such intended to replace such switching mechanism. In the instances where the subject isolator circuit is incorporated with medical electrical equipment as an integral part thereof, the switching bank 122 would be the same as the presently used switching mechanism on such equipment.

From the foregoing description it is now clear that the subject application provides an isolator circuit that may be used to effectively transmit body generated signals from a patient to medical electrical equipment for display or recordation without the use of any modulation technique, or the like, which has heretofore been used on known prior art devices. The result is that the subject invention is highly accurate and significantly less complex. Also of importance is the added reliability of the subject isolator circuit due to the use of a power supply that is operated by standard AC power that is readily and continually available. It is also clear that the subject isolator circuit by the use of the low capacitance transformer 22 having a high breakdown voltage and the optical coupler 20 prevents any undesirable electrical path from being completed through the isolator circuit from the patient to the electrical equipment. Accordingly, no injury due to the conduction of electrical energy through a patient via such a path is possible.

While a preferred embodiment of the present invention has been described hereinabove, it is intended that all matter contained in the above description and shown in the accompanying drawings be interpreted as illustrative and not in a limiting sense and that all modifications, constructions and arrangements which fall within the scope and spirit of the invention may be made.

What is claimed is:

1. An isolator circuit for electrically isolating input terminals from output terminals, body generated signals supplied to said input terminals from a patient via connecting electrodes being transmitted from said input terminals to said output terminals wherein a plurality of different input terminals are available to provide body generated signals, said isolator circuit comprising:

optical coupling means for transmitting an optical signal between a light transmitter and a light receiver thereof, said optical signal being light having a controlled intensity in response to control signals applied to said light transmitter;

control means operatively connected to said input terminals, for continuously applying control signals to said light transmitter for varying the intensity of said light in response to the amplitude of body generated signals applied to said input terminals, said intensity of said light being continuously representative of the amplitude of said body generated signals;

output means operatively connected to said light receiver for providing electrical output signals at said output terminals, said electrical output signals having the same waveshape as said body generated signals; and

power supply means for providing DC voltages to the components of said isolator circuit, said power supply means including:

first converter means for converting standard AC voltages to first DC voltages,

second converter means for converting said first DC voltages to a chopped DC voltage signal,

third converter means for providing said DC voltages to the components of said isolator circuit in response to the application of said chopped DC voltage signals to said third converter means, and

a low capacitance transformer having a breakdown voltage that is at least several times the maximum voltage that is applied to said transformer, said transformer operating to apply said chopped DC voltage signals to said third converter means.

2. The isolator circuit defined by claim **1**, wherein said body generated signals are voltage signals and said control signals are current signals, said control means including voltage-to-current converter means for converting voltage signals representative of said body generated signals to current signals for use as said control signals, changes in the amplitude of said current signal corresponding to changes in the amplitude of said voltage signals.

3. The isolation circuit defined by claim **1**, wherein said light receiver provides current signals to said output means in response to light from said light transmitter impinging on said light receiver, said output means including means for converting the current signals provided from said light receiver to voltage signals for use as said electrical output signals, changes in the amplitude of said electrical output signals corresponding to changes in the amplitude of said current signals from said light receiver.

4. The isolator circuit defined by claim **1**, further including protection means for protecting said control means against damage resulting from the application thereto of high amplitude transients.

5. The isolator circuit defined by claim **1**, said control means including:

means for providing control signals to said light transmitter to have light of a selected ambient intensity emitted by said light transmitter during ambient conditions when no body generated signals are applied to said input terminals; and

means for causing said control signals to be varied to increase the intensity of said light beyond said selected ambient intensity in response to variations in the amplitude of said body generated signals.

6. The isolator circuit defined by claim **5**, said control circuit further including means for limiting the amplitude of said control signals to be between preselected positive and negative threshold values.

7. The isolation circuit defined by claim **5**, wherein said light receiver provides current signals to said output means in response to light from said light transmitter impinging on said light receiver, said output means including means for converting the current signals provided from said light receiver to voltage signals for use as said electrical output signals, changes in the amplitude of said electrical output signals corresponding to changes in the amplitude of said current signals from said light receiver.

8. The isolator circuit defined by claim **7**, wherein said body generated signals are voltage signals and said control signals are current signals, said control means including voltage-to-current converter means for converting voltage signals representative of said body generated signals to current signals for use as said control signals, changes in the amplitude of said current signal corresponding to changes in the amplitude of said voltage signals.

9. The isolator circuit defined by claim **8**, said control circuit further including means for limiting the amplitude of said control signals to be between preselected positive and negative threshold values.

10. The isolator circuit defined by claim **9**, further including protection means for protecting said control means against damage resulting from the application thereto of high amplitude transients.

11. An isolator circuit for electrically isolating input terminals from output terminals, body generated signals supplied to said input terminals from a patient via connecting electrodes being transmitted from said input terminals to said output terminals wherein a plurality of different input terminals are available to provide body generated signals, said isolator circuit comprising;

optical coupling means for transmitting an optical signal between a light transmitter and a light receiver thereof, said optical signal being light having a controlled intensity in response to control signals applied to said light transmitter;

control means operatively connected to said input terminals, for continuously applying control signals to said light transmitter for varying the intensity of said light in response to the amplitude of body generated signals applied to said input terminals, said intensity of said light being continuously representative of the amplitude of said body generated signals;

output means operatively connected to said light receiver for providing electrical output signals at said output terminals, said electrical output signals having the same waveshape as said body generated signals;

switching means for controllably applying body generated signals to said control means from selected combinations of said input terminals; and

blanking means for disabling said control means for selected periods of time in response to operation of said switching means to change the combination of input terminals applying said body generated signals to said control means.

12. The isolator circuit defined by claim **11**, said switching means including a plurality of switches, and means for providing a first signal when any switch thereof is closed and a second signal when none of the switches thereof are closed, said blanking means including:

first means, responsive to said second signal, for providing an enabling signal whenever a closed switch is opened;

second means, responsive to said second signal, for providing an enabling signal whenever none of said switches are closed;

third means, responsive to said first signal, for providing an enabling signal whenever a switch is closed following none of said switches being closed; and

gating means responsive to said enabling signals for providing said blanking signals.

13. The isolator circuit defined by claim **11,** said control means including:

means for providing control signals to said light transmitter to have light of a selected ambient intensity emitted by said light transmitter during ambient conditions when no body generated signals are applied to said input terminals; and

means for causing said control signals to be varied to increase the intensity of said light beyond said selected ambient intensity in response to variations in the amplitude of said body generated signals.

14. The isolation circuit defined by claim **13,** wherein said light receiver provides current signals to said output means in response to light from said light transmitter impinging on said light receiver, said output means including means for converting the current signals provided from said light receiver to voltage signals for use as said electrical output signals, changes in the amplitude of said electrical output signals corresponding to changes in the amplitude of said current signals from said light receiver.

15. The isolator circuit defined by claim **14,** wherein said body generated signals are voltage signals and said control signals are current signals, said control means including voltage-to-current converter means for converting voltage signals representative of said body generated signals to current signals for use as said control signals, changes in the amplitude of said current signal corresponding to changes in the amplitude of said voltage signals.

16. The isolator circuit defined by Claim **15,** said switching means including a plurality of switches, and means for providing a first signal when any switch thereof is closed and a second signal when none of the switches thereof are closed, said blanking means including:

first means, responsive to said second signal, for providing an enabling signal whenever a closed switch is opened;

second means, responsive to said second signal, for providing an enabling signal whenever none of said switches are closed;

third means, responsive to said first signal, for providing an enabling signal whenever a switch is closed following none of said switches being closed; and

gating means responsive to said enabling signals for providing said blanking signals.

17. The isolator circuit defined by claim **16,** further including power supply means for providing DC voltages to the components of said isolator circuit, said power supply means including:

first converter means for converting standard AC voltages to first DC voltages;

second converter means for converting said first DC voltages to a chopped DC voltage signal;

third converter means for providing said DC voltages to the components of said isolator circuit in response to the application of said chopped DC voltage signals to said third converter means; and

a low capacitance transformer having a breakdown voltage that is at least several times the maximum voltage that is applied to said transformer, said transformer operating to apply said chopped DC voltage signals to said third converter means.

18. The isolator circuit defined by claim **17,** further including protection means for protecting said control means against damage resulting from the application thereto of high amplitude transients.

19. The isolator circuit defined by claim **18,** said control circuit further including means for limiting the amplitude of said control signals to be between preselected positive and negative threshold values.

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