US006750463B1

(12) **United States Patent**
Riley

(10) **Patent No.: US 6,750,463 B1**
(45) **Date of Patent: Jun. 15, 2004**

(54) **OPTICAL ISOLATION APPARATUS AND METHOD**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/515,266**

(22) Filed: **Feb. 29, 2000**

(51) **Int. Cl.**[7] **G02B 27/00**
(52) **U.S. Cl.** **250/551**; 250/227.14
(58) **Field of Search** 250/221, 227.14, 250/227.24, 551; 340/555, 556, 557; 385/12, 13, 24; 359/152, 154, 188

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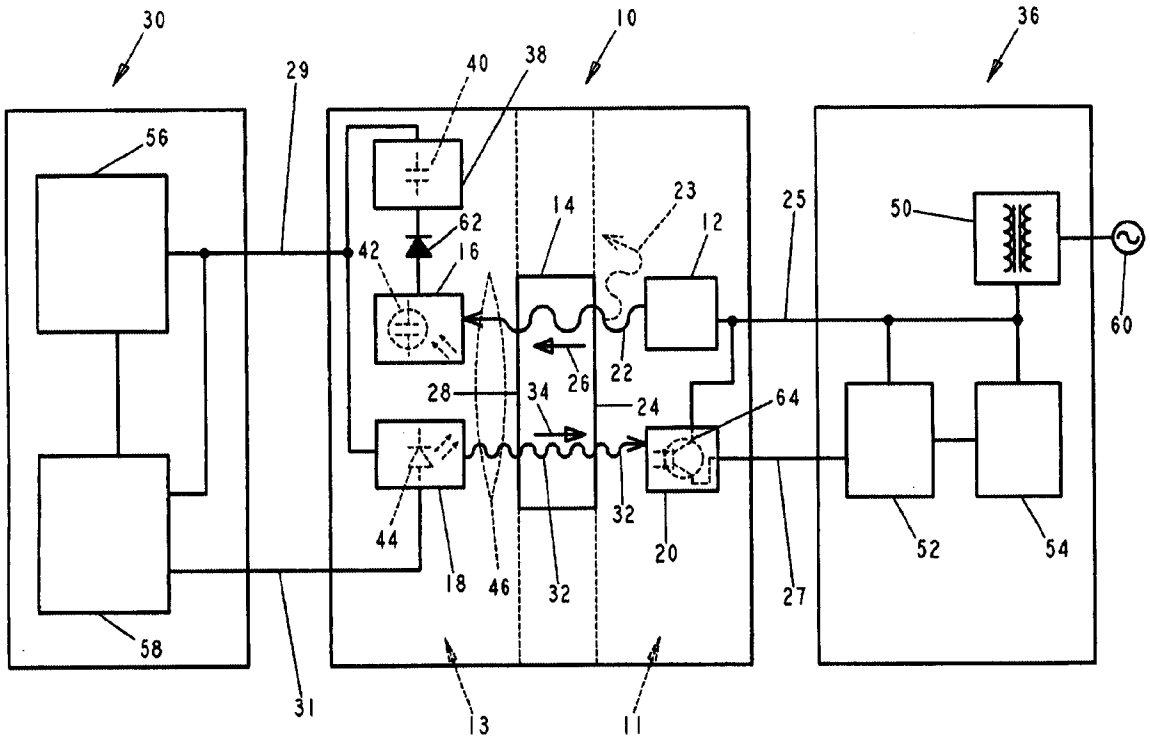
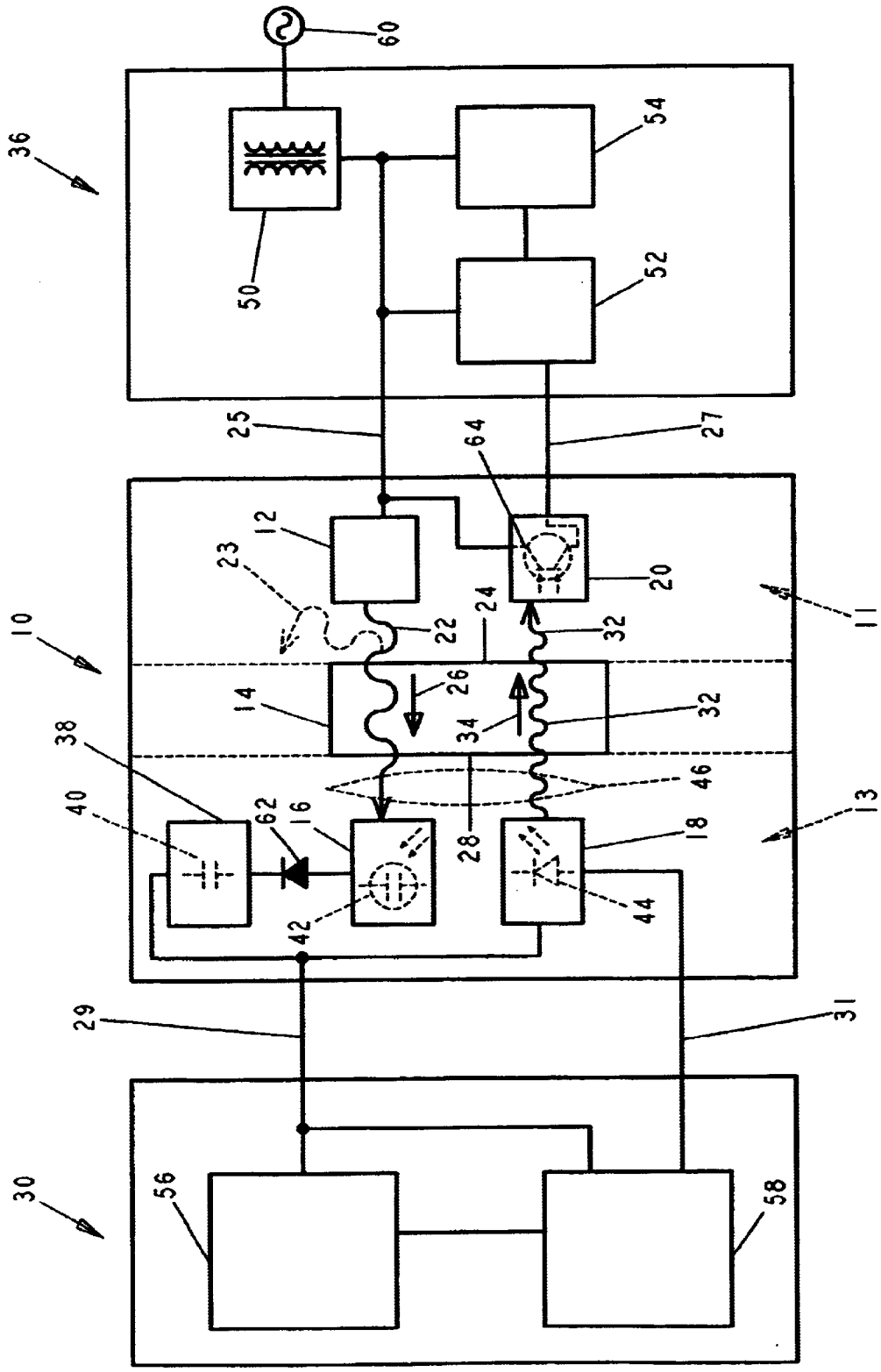
(57) **ABSTRACT**

Optical isolation device (**10**) optically couples and electrically isolates various components on a local source circuit (**36**) from components on a remote isolated circuit (**30**). Light source (**12**) is coupled to opto-electrical detector (**16**) and opto-electrical sensor (**20**) is coupled to optical signal generator (**18**) by optical channel (**14**). The opto-electrical detector (**16**) is electrically coupled to remote isolated circuit (**30**) which is powered by the electricity generated by opto-electrical detector (**16**) in response to being impinged upon by light (**22**). Remote isolated circuit (**30**) is also electrically coupled to optical signal generator (**18**) which generates optical signals (**32**) in response to electrical signals received from remote isolated circuit (**30**). Opto-electrical sensor (**20**) produces electrical signals in response to being impinged upon by optical signals (**32**). Thus, remote isolated circuit (**30**) is completely electrically isolated from, but in communication with and powered by, local source circuit (**36**).

30 Claims, 7 Drawing Sheets

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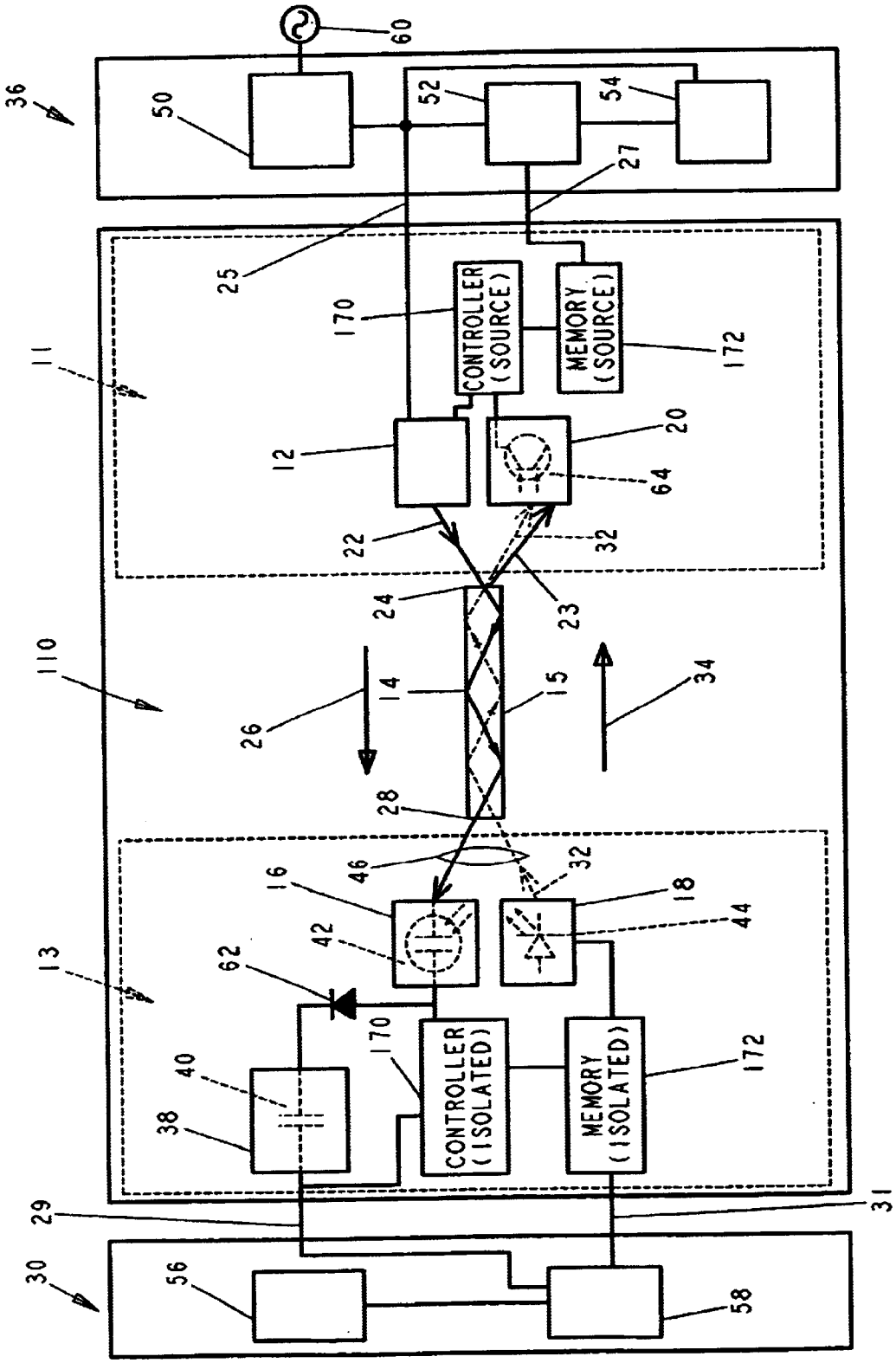
58

FIG. 1


CONTROLLER (SOURCE)
MEMORY (SOURCE)
CONTROLLER (ISOLATED)
MEMORY (ISOLATED)
36
50
52
54
60
27
25
170
172
11
12
20
64
22
32
24
23
110
14
15
26
34
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46
16
18
42
44
13
62
40
38
29
31
30
56
58

FIG. 2

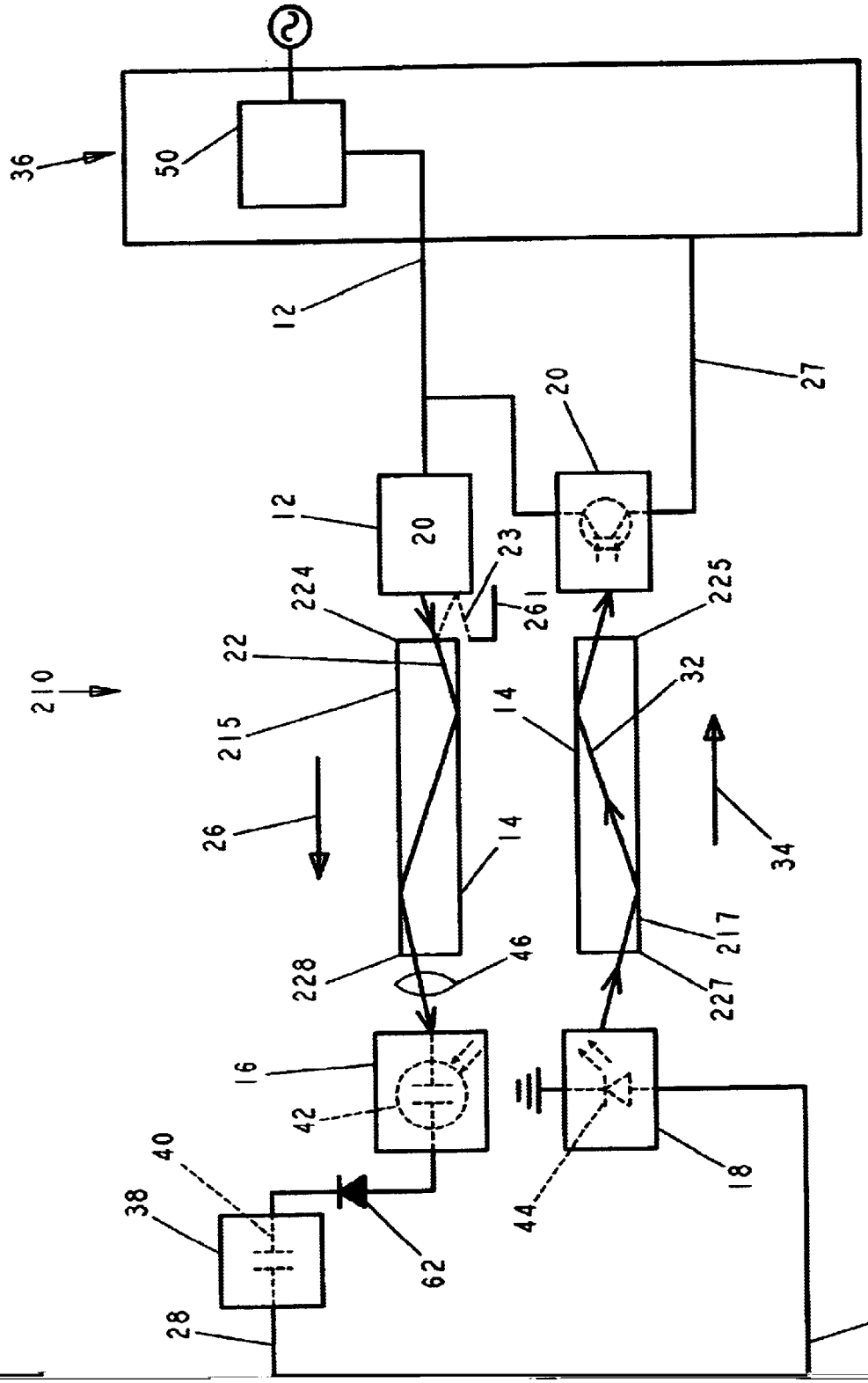

36
50
12
27
20
12
20
23
224
261
225
22
210
215
14
32
26
14
34
217
228
46
227
16
42
18
40
38
44
62
28
31

FIG. 3

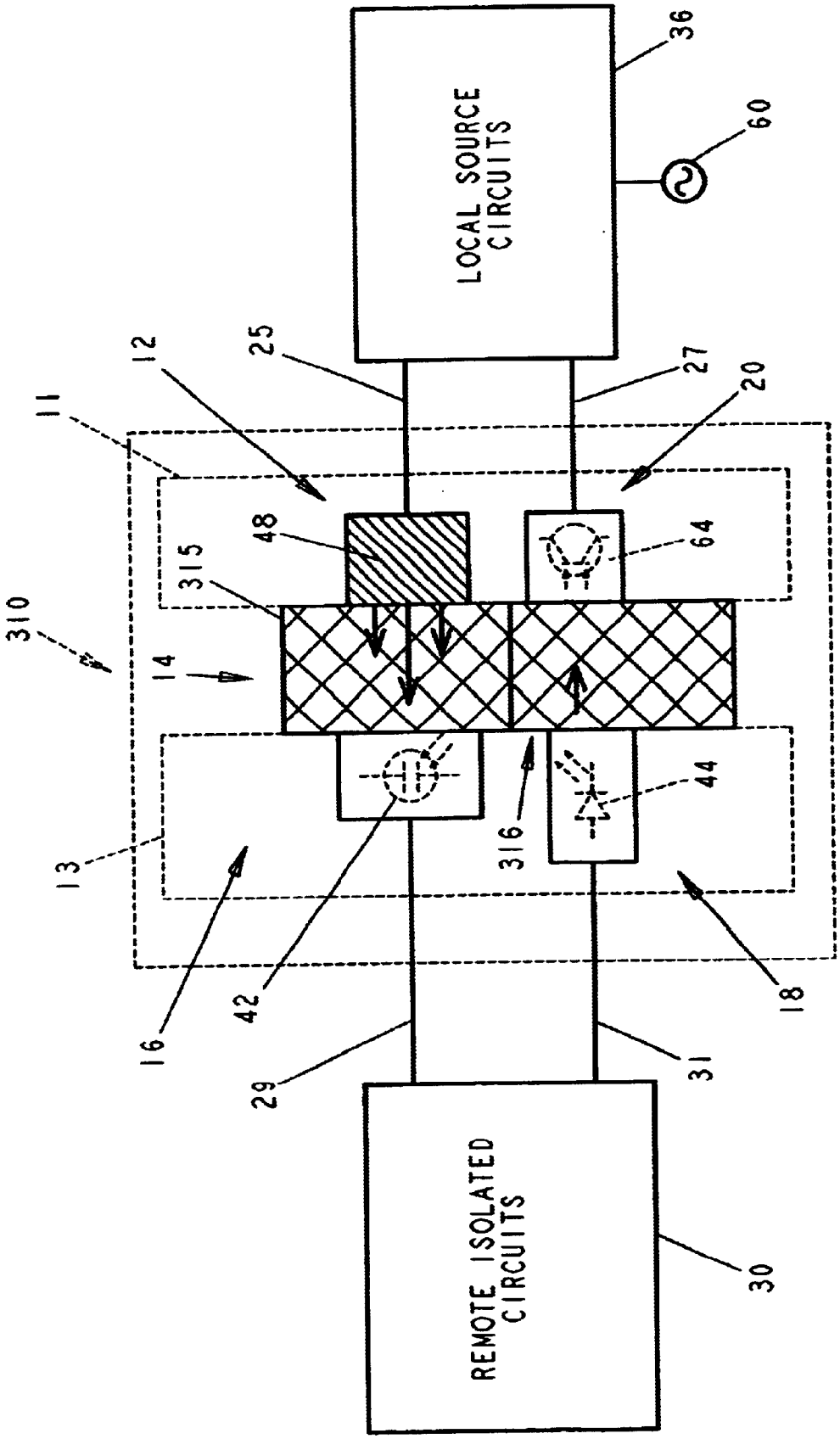

LOCAL SOURCE CIRCUITS
REMOTE ISOLATED CIRCUITS
36
60
25
27
12
20
11
48
64
315
310
14
44
316
13
16
42
18
29
31
30

FIG. 4

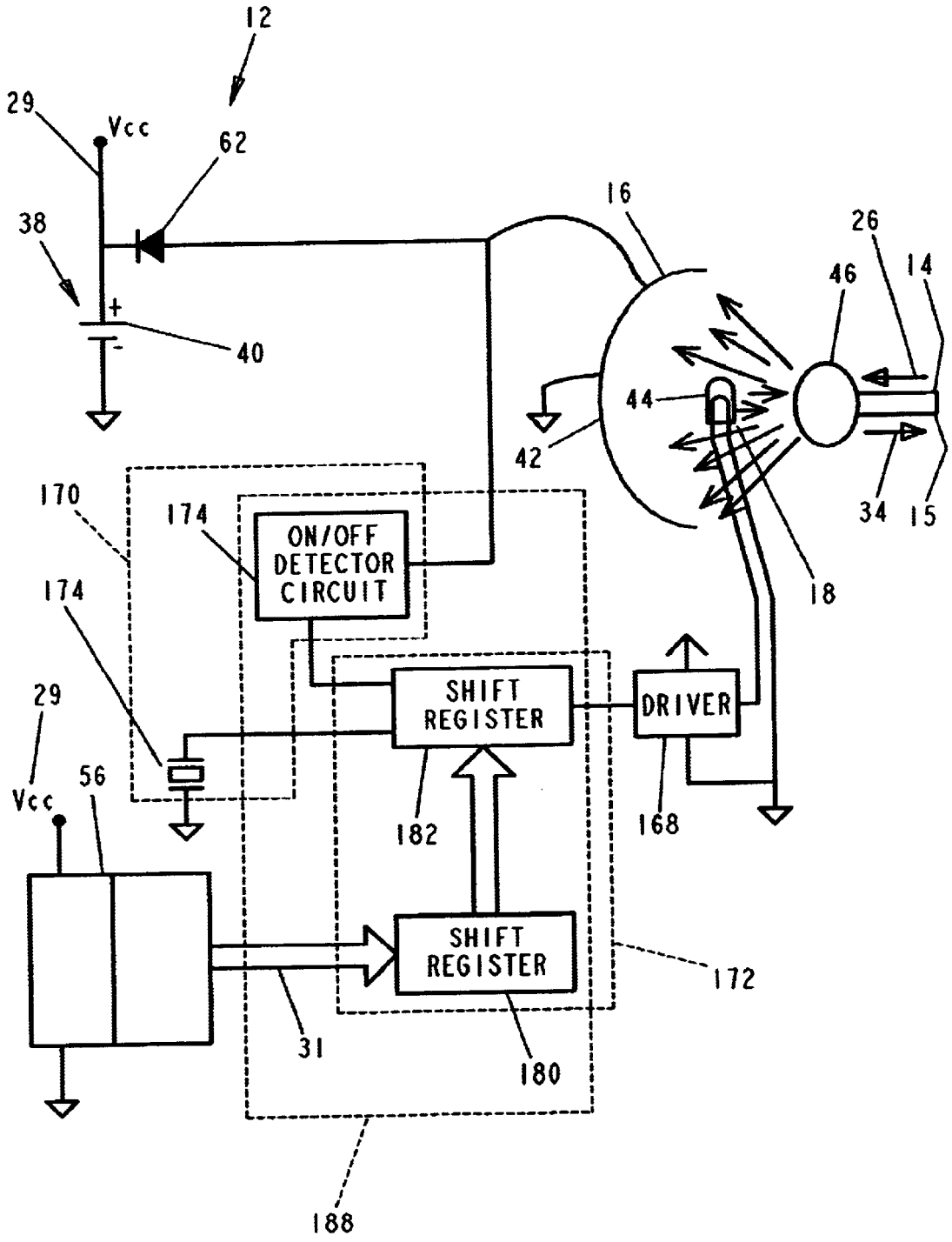

12
29
Vcc
62
38
+
-
40
16
26
46
14
44
42
34
15
18
170
174
ON/OFF DETECTOR CIRCUIT
174
SHIFT REGISTER
DRIVER
29
Vcc
56
182
168
SHIFT REGISTER
172
31
180
188

FIG. 5

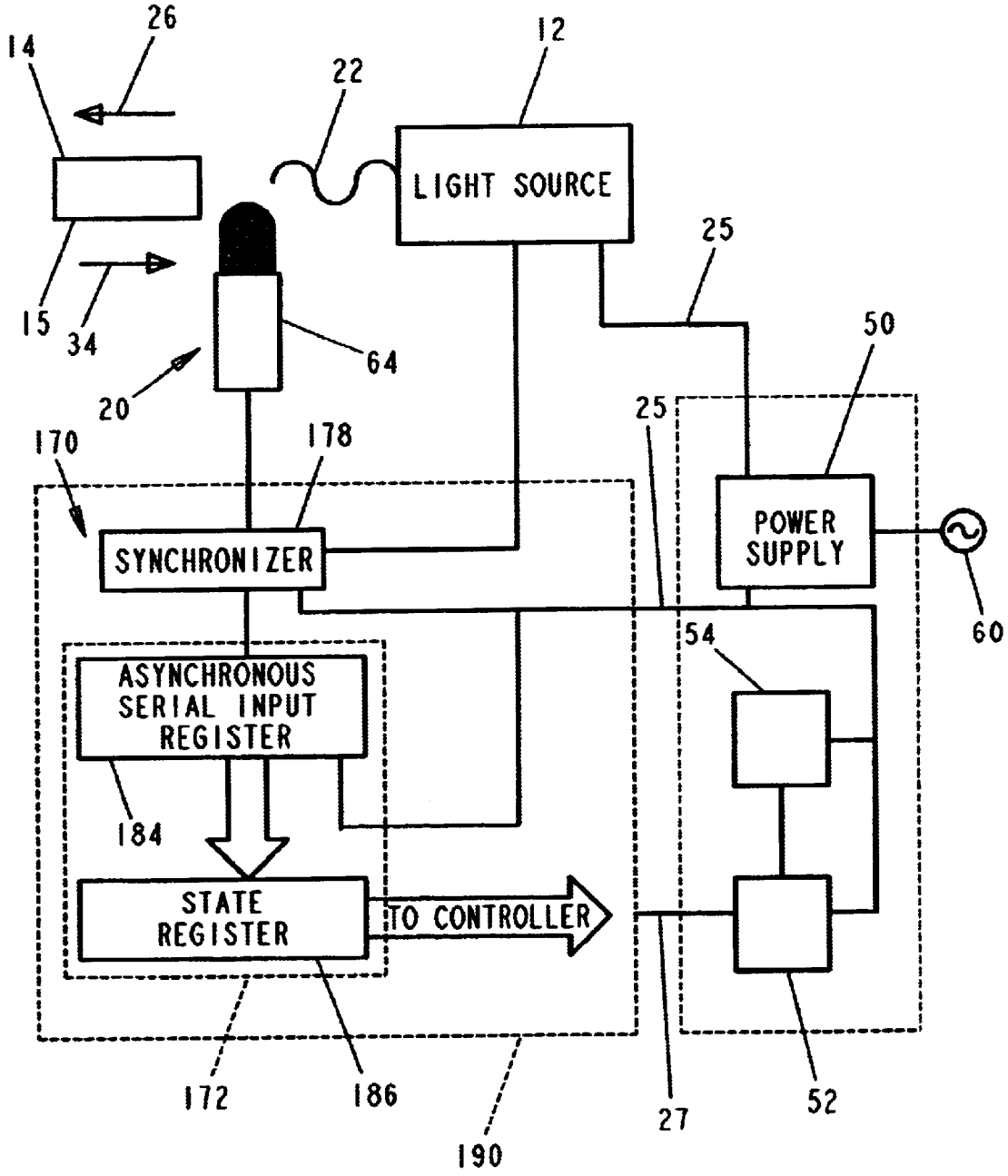
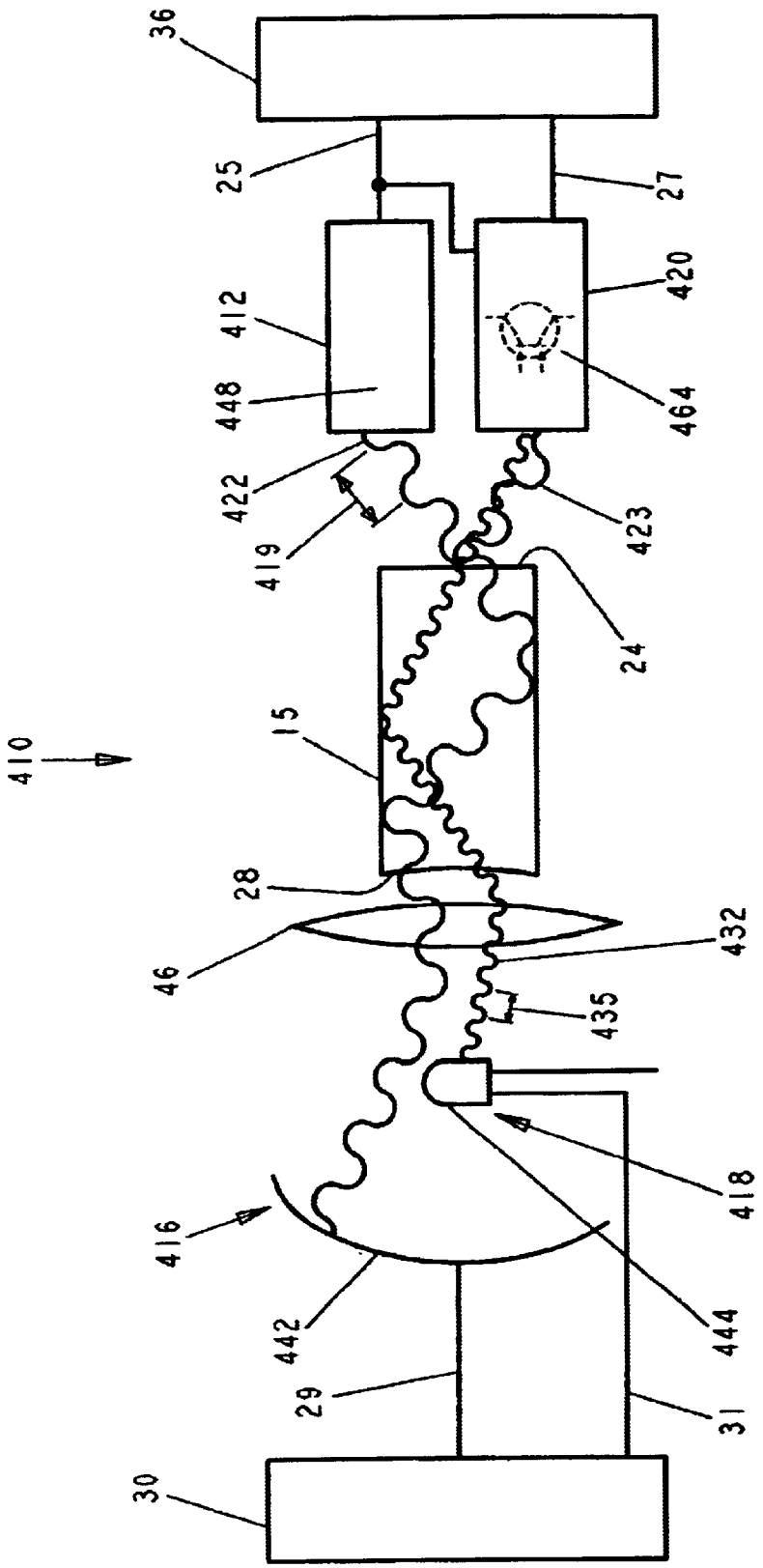

26
14
22
12
LIGHT SOURCE
25
15
34
64
50
20
25
170
178
POWER SUPPLY
SYNCHRONIZER
60
54
ASYNCHRONOUS SERIAL INPUT REGISTER
184
STATE REGISTER
TO CONTROLLER
172
186
190
27
52

FIG. 6


36
25
27
412
420
448
464
422
423
419
24
410
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28
46
432
435
416
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444
29
31
30

FIG. 7

OPTICAL ISOLATION APPARATUS AND METHOD

FIELD OF THE INVENTION

This invention relates to isolation devices and more particularly to isolation devices which use an optical channel to isolate a remote circuit from a source circuit.

BACKGROUND OF THE INVENTION

In certain environments it is necessary to establish substantial electrical isolation between electrical control and power circuits. An example of such an environment is an electric hospital bed. Bed motion control circuits are often found in side rails, footboards, headboards, and in pendants connected via an umbilical cord to the motor power circuits. Metal and other conductive surfaces may be incidentally contacted by patients, caregivers, and even critical care equipment. When contact is made, a potential hazard exits if the conductive surface provides a path for current flow to earth ground. For this reason, regulatory bodies impose strict requirements on patient connected equipment and identify equipment in regard to its insulation abilities.

Having non-isolated electrical control circuitry in exposed areas such as side rails and footboards, presents a challenge to design engineers. It is known to provide power to a remote isolated circuit with an isolated power supply and send optically isolated control signals from the remote isolated circuit to the local source circuit which controls actuators powered by a non-isolated power supply. Signals generated by the remote isolated circuit are optically transmitted to the local source circuit and power to the remote isolated circuit is provided through bulk cables from the isolated power supply. However, isolated power supplies can be very costly.

SUMMARY OF THE INVENTION

The optical isolation device of the present invention transmits power from a power supply on a local source circuit optically along an optical channel to a remote isolated circuit. Signals generated by the remote isolated circuit are optically transmitted to a local source circuit which controls various actuators. Thus the remote isolated circuit is completely electrically isolated from the local source circuit.

An optical isolation device for transmitting power to and signals from an isolated electrical device in accordance with the present invention includes a light source for generating light, an optical channel having a first end on which the light impinges and a second end optically coupled to the first end, and an opto-electrical detector adjacent the second end producing electrical power to drive the isolated electrical device when impinged upon by the light. An optical signal generator generates optical signals in response to input provided by the isolated electrical device, the optical signals impinge upon the second end of the optical channel and are transmitted to an opto-electrical sensor adjacent the first end of the optical channel that generates electrical signals in response to the optical signals. The light and optical signals are both propagated through the optical channel.

Also in accordance with the invention is an opto-electric device including a first circuit having a first light source, a second circuit having a second light source, and a photovoltaic cell configured to provide energy to at least a portion of the second circuit. An optical channel couples the first and second circuits, and light from the first light source is transmitted to the photovoltaic cell over the optical channel, and light from the second light source is transmitted to the first circuit over the optical channel.

A method of the present invention for electrically isolating a remote circuit from a source circuit includes the steps of generating a first light signal in the source circuit, optically coupling the first light signal to the remote circuit so that the remote circuit receives the first light signal from the source circuit, generating power in the remote circuit from the first light signal received by the remote circuit, and powering the remote circuit by the generated power.

Additional features and advantages of the present invention will become apparent to those skilled in the art upon consideration of the following detailed description of illustrated embodiments exemplifying the best mode of carrying out the invention as presently perceived.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic view of an optical isolation device according to the present invention optically coupling and electrically isolating a local source circuit depicted on the right of the drawing and a remote isolated circuit depicted on the left of the drawing showing a light source and a opto-electrical sensor of the device coupled electrically to local source circuit and optically by an optical channel to an opto-electrical detector and optical signal generator which are electrically coupled to the remote isolated circuit, high intensity light generated by light source impinges upon a first end of the optical channel and propagates along the channel exiting through a second end of the optical channel where it impinges upon the opto-electrical detector, power generated by opto-electrical detector is stored in a power storage device which supplies power to the remote isolated circuit and the optical signal generator, optical signal generator generates an optical signal that is transmitted along the optical channel so that the opto-electrical sensor adjacent to the first end is impinged upon by the optical signal;

FIG. **2** is a block diagram of a half-duplex, single channel fiber optic isolation device in accordance with the present invention showing a local source circuit optically coupled to and electrically isolated from a remote isolated circuit by a single fiber optic filament and also showing controller and memory elements on a source side and an isolated side of the device to facilitate half-duplex operation;

FIG. **3** is a block diagram of a full-duplex, dual channel fiber optic isolation device in accordance with the present invention showing a local source circuit optically coupled to and electrically isolated from a remote isolated circuit by a first fiber optic optical channel through which high intensity light is transmitted from a light source powered by a local source circuit to power remote isolated circuit and a second fiber optic optical channel through which low intensity light signals are transmitted responsive to electrical signals generated by the remote isolated circuit to the local source circuit;

FIG. **4** is a block diagram of a full-duplex, single optical channel isolation device in accordance with the present invention showing a local source circuit optically coupled to and electrically isolated from a remote isolated circuit by a single optical channel, a high intensity light source on a source side of the device coupled to an opto-electrical detector on an isolated side of the device through the optical medium, and a low intensity light source on the isolated side of the device optically coupled to an opto-electrical sensor on the source side of the device through the optical medium;

FIG. **5** is a diagrammatic view of the optical channel, opto-electrical detector, isolated side memory and controller components, and optical signal generator of the half-duplex, single channel fiber optic isolation device of FIG. **4** and the remote isolated circuit showing a photovoltaic cell serving as an opto-electrical detector for detecting high intensity light and generating power to be stored in the storage device for powering the components on the remote isolated circuit and optical signal generator, a user interface for providing input to devices on the local source circuit, a clock, an on/off detector for determining when high intensity light is and is not being received, a low intensity light source such as an LED acting as optical signal generator for transmitting optical signals indicating the state of the user interface based on state information stored in state registers and shift registers and converted to electrical signals by an LED driver;

FIG. **6** is a diagrammatic view of the optical channel, high intensity light source, source side memory and controller components, and opto-electrical sensor of the half-duplex, single channel fiber optic isolation device and the local source circuit of FIG. **4** showing a power supply powering the various components of the source side of the device and the local source circuit and also showing the opto-electrical sensor receiving the optical signals from the remote isolated circuit and converting them to electrical signals, a synchronizer for controlling the duty cycle of the high intensity light source and the opto-electrical sensor, a serial input register for storing the electrical signals, and a state register for communicating the stored electrical signals to a controller controlling devices on the local source circuit; and,

FIG. **7** is a block diagram of a full-duplex, fiber optic isolation device in accordance with the present invention showing a light source generating light at a first wavelength which light is optically transmitted along a fiber optic filament to be refracted by a lens to impinge upon an opto-electrical detector sensitive in a bandwidth including the first frequency, and an optical signal generator producing optical signals centered about a second frequency which optical signals are refracted by the lens and optically transmitted along the fiber optic filament to impinge upon an opto-electrical sensor sensitive in a bandwidth including the second frequency but not the first frequency.

DETAILED DESCRIPTION OF THE DRAWINGS

An optical isolation device **10** according to the present invention is illustrated in FIG. **1**. Optical isolation device **10** optically couples and electrically isolates various components on a local source circuit **36** from components on a remote isolated circuit **30**. Optical isolation device **10** includes a light source **12**, an opto-electrical sensor **20**, an optical channel **14**, an opto-electrical detector **16**, and an optical signal generator **18** and may also include a lens **46** (shown in phantom lines in FIG. **1**) and an electrical energy storage device **38** such as a capacitor **40** (shown in phantom lines in FIG. **1**). Energy storage device **38** aids in providing a steady potential difference from which a user interface circuit **56** and other components of remote isolated circuit **30** may be powered. Other electrical storage devices **38** such as rechargeable batteries or power cells are also within the teaching of the invention. Energy storage device **38** is electrically coupled to opto-electrical detector **16** which in the illustrated embodiment is a photovoltaic cell **42**.

Illustratively, local source circuit **36** includes a power source **50** for driving light source **12** and powering opto-electrical sensor **20** of optical isolation device **10**, a controller **52** for receiving electrical signals generated by sensor **20** in response to optical signals **32** and generating control signals for actuators, and actuators **54**. Remote isolated circuit **30** includes a user interface **56** and an electrical signal generator **58** powered by electricity produced by the opto-electrical detector **16** of optical isolation device **10**. Electrical signal generator **58** produces electrical signals triggered by user interface **56** and is coupled to the optical signal generator **18** of device **10** which converts the electrical signals to optical signals **32**. In the illustrated embodiment, optical signal generator **18** includes light emitting diode ("LED") **44**. However it should be understood that other sources for generating optical signals may be used within the teaching of the invention. Optical signals **32** are propagated along optical channel **14** between remote isolated circuit **30** and local source circuit **36**.

Illustratively, light source **12** and opto-electrical sensor **20** are on a source side **11** of optical isolation device **10** which is optically coupled by optical channel **14** with isolated side **13** of optical isolation device **10**. Illustratively, isolated side **13** of optical isolation device **10** includes lens **46**, opto-electrical detector **16**, optical signal generator **18**, and storage device **38**.

Optical channel **14**, such as a fiber optic filament **15**, includes a first end **24** communicating with light source **12** and opto-electrical sensor **20** and a second end **28** communicating with opto-electrical detector **16** and optical signal generator **18**. Light source **12** is electrically coupled to power supply **50**. Source side **11** and isolated side **13** of device **10** are isolated electrically from one another by optical channel **14**, yet may transmit optical signals **32** and light **22** between one another. Optical isolation device **10** is electrically coupled at source side **11** by power line **25** and signal line **27** to a local source circuit **36** (See FIG. **1**) including power supply **50**, control circuitry **52**, and actuators **54**. Likewise, optical isolation device **10** is electrically coupled at isolated side **13** by power line **29** and signal line **31** to remote isolated circuit **30** including power consuming devices such as user interface **56** and electrical signal generator **58**.

Light **22** generated by light source **12** impinges upon first end **24** of optical channel **14** and is transmitted in a first direction **26** along optical channel **14** exiting through second end **28** of optical channel **14** to impinge upon opto-electrical detector **16**. While the term light may be strictly defined as visible light having a wavelength in the visible spectrum (i.e. ~0.4 **82** m—~0.76 μm), as used in this application such light will be referred to as visible light and the term light and similar terms and prefixes such as optical, opto- and photo- shall be deemed to include electromagnetic radiation in the near ultraviolet, visible, and near infrared spectrums. Opto-electrical detector **16** produces electricity when impinged upon by light **22**.

As shown, for example, in FIG. **1**, opto-electrical detector **16** is electrically coupled by power line **29** to remote isolated circuit **30** which is powered by the electricity generated by opto-electrical detector **16** in response to being impinged upon by light **22**. Remote isolated circuit **30** is also electrically coupled by signal line **31** to optical signal generator **18** which generates optical signals **32** in response to electrical signals received from remote isolated circuit **30**.

Optical signals **32** impinge upon second end **28** of optical channel **14** and are transmitted in a second direction **34** along optical channel **14** exiting through first end **24** to impinge upon opto-electrical sensor **20**. Opto-electrical sensor **20** produces electrical signals in response to being

impinged upon by optical signals **32**. Illustratively, opto-electrical sensor **20** is electrically coupled by signal line **27** to local source circuit **36** which performs tasks in response

38 is charged by current flowing from photovoltaic cell when light **22** passes through lens **46** and optical channel **14** from light source **12**. Illustratively, a diode **62** is associated

side **11** of device **110**. On/off detector **174** is a high input impedance monitoring device that detects when high intensity light **22** is present at photovoltaic cell **42**. When light source **12** is OFF so that no light **22** impinges on photovoltaic cell **42**, an enabling signal is sent to shift register **182** as a signal for it to send the contents of the state register **180** to the driver **168** and optical signal generator **18**. Shift register **182** is an asynchronous serial communications circuit similar to, but not necessarily limited to, the standard RS232 communications protocol circuits. State register **180** collects and makes available to shift register **182** the current state of user interface **56**. User interface **56** can be switches indicating an open/closed condition, levers indicating directional states, digitized outputs of potentiometers, or digitized outputs of position sensing devices as well as other condition and state indicating devices. On/Off detector **174**, shift register **182**, and state register **180** can be created from discrete components (IC's) or be functions of software in a micro-controller **188** (shown in phantom lines in FIG. **5**).

As shown in FIG. **6**, source side **11** of device **110** includes a high intensity light source **12** focused on optical channel **14** which illustratively is fiber optic cable **15**. Synchronizer **178** is used to periodically turn light source **12** off and on and to indicate to the asynchronous serial input register **184** that data may be coming in.

During the periods that high intensity light source **12** is off, remote isolated circuit **13** may send data via optical signals **32** at low intensity light levels in a serial protocol fashion. Opto-electrical detector **20** is a low intensity light receiver such as a photo-transistor **64** which will detect the incoming data stream carried by optical signals **32** and convert it to electrical impulses to be sent to the asynchronous serial input register **184**. Once the serial data is received and converted to parallel data, the information is passed to state register **186** which makes the data available to other systems, such as controller **52** for actuators **54** in local source circuit **36**, as needed. In the example mentioned earlier, the state data could be used by motor driver circuits for moving the platform surfaces of a hospital bed. Optionally, synchronizer **178**, asynchronous serial input register **184**, and state register **186** could be functionally provided by software and a micro-controller **190** (shown in phantom lines in FIG. **6**).

Referring to FIG. **3**, there is shown a full-duplex, dual channel fiber optic isolation device **210**. Full-duplex, dual channel fiber optic isolation device **210** includes a light source **12**, a power fiber optic filament **215** having a first end **224** and a second end **228**, a dispersion lens **46** adjacent the second end **228**, an opto-electrical detector **16**, an optical signal generator **18**, a signal fiber optic filament **217** having a first end **225** and a second end **227**, an opto-electrical sensor **20** adjacent first end **225** of signal fiber optic filament

light **22** is refracted at first end **224** of power fiber optic filament **215**. Shield **261** is positioned to prevent reflected high intensity light **23** from impinging upon opto-electrical sensor **20**, thereby preventing reflected light **23** from swamping out or interfering with optical signals **32**. Refracted high intensity light **22** enters power fiber optic filament **215** at an angle which will cause total internal reflection of the light **22** at the boundary of the optical filament **215** so that refracted light **22** is propagated along power fiber optic filament **215** in a first direction **26** between first end **224** and second end **228**. Light **22** exiting second end **228** of power fiber optic filament **215** is refracted by lens **46** to impinge upon opto-electrical detector **16**. Opto-electrical detector **16** converts light **22** to electrical power.

Power line **29** electrically couples opto-electrical detector **16** to remote isolated circuit **30** which is powered by the electricity generated by opto-electrical detector **16**. Remote isolated circuit **30** generates an electrical signal containing information to be transmitted to local source circuit **36**. Signal line **31** electrically couples remote isolated circuit **30** to optical signal generator **18** which generates optical signals **32** in response to electrical signals generated by remote isolated circuit **30**. Illustratively optical signal generator **18** includes an LED **44**. LED **44** is adjacent second end **227** of signal optic filament **217** so that the optical signals **32** generated impinge on second end **227** of signal fiber optic filament **217**. Optical signals **32** propagate along signal fiber optic filament **217** exiting at first end **225** to impinge upon opto-electrical sensor **20**.

Since high intensity light **22** and optical signals **32** are transmitted along different filaments **215**, **217** and opto-electrical detector **220** is optically shielded from light source **12** and from high intensity light **23** reflecting from first end **224** of power fiber optic filament **215**, there is no need to include a controller or memory elements to control the duty cycle of light **12** and optical signal generator **18** and store state data. It should also be noted that the illustrated embodiment of full-duplex, dual channel fiber optic isolation device **210** need not include an electrical storage device **38**, because light source **12** can always remain on allowing light **22** to continually impinge upon opto-electrical detector **16** thereby providing an uninterrupted supply of power to remote isolated circuit **30**. In the illustrated embodiment, full-duplex, dual channel fiber optic isolation device **210** is provided with electrical storage device **38** in order to provide a more stable power source for remote isolated circuit **30**.

Referring to FIG. **4**, a full-duplex, single channel optical isolation device **310** is illustrated. Full-duplex, single channel optical isolation device **310** includes a light source **12** such as a laser **48**, an optical channel **14**, an opto-electrical detector **16** such as a flat photocell **342**, an optical signal generator **18**, such as an LED **44**, and an opto-electrical

electrical detector **16**, and optical signal generator **18** can be made by conventional wiring techniques such as power line **29** and signal line **31**. Electrical isolation is still maintained in that there is no electrically conductive connection between remote isolated circuit **30** and local source circuit **36**. Flat photovoltaic cell **342** or an array of cells is used to convert light energy to electrical energy. The electrical energy may be stored prior to use in a storage device **38** (not shown in FIG. **4**) and used later or may be directly used as described below.

In a hospital bed, where mains voltage **60** is used to power electric motors, pumps, or other actuators, local supply circuit **32** is located with device **310** near the high power components. Power and signal lines **29**, **31** are routed away from the higher power circuitry to remote isolated circuit **30** containing user interface **56** (not shown in FIG. **4**) containing control switches located for example, in the side rails or foot board. Patients and caregivers are protected from potentially hazardous energies. Energy levels in the remote isolated circuit **30** and power and signal lines **29**, **31** are limited to safe current and voltage levels. Because of the optical isolation, there exists no surface which could provide a path for current flow between a patient or caregiver and the hazardous mains supply **60**.

Referring to FIG. **7**, a full-duplex, single channel optical fiber isolation device **410** is illustrated. Full-duplex, single channel optical fiber isolation device **410** includes a light source **412** generating light **422** having a bandwidth centered around a first frequency corresponding to a first wavelength **419**, a fiber optic filament **15** having a first end **24** and a second end **28**, a lens **46** adjacent second end **28** of fiber optic filament **15**, an opto-electrical detector **416** in optical communication with the second end **28** of fiber optic filament **15**, an optical signal generator **418** for generating optical signals **432** having a bandwidth centered about a second frequency corresponding to a second wavelength

Optical signal generator **418** is illustratively an LED **444** producing light in a bandwidth centered about a second frequency corresponding to second wavelength **435**. Optical signals **432** centered about second wavelength **435** are refracted by lens **46** and transmitted along fiber optic filament **15** between second end **28** and first end **24**. Optical signals **432** exit first end **24** of fiber optic filament and impinge upon opto-electrical sensor **420**.

Optical electrical sensor **420** is sensitive to light in a bandwidth including the second frequency corresponding to the second wavelength **435**. Preferably opto-electrical sensor **420** has a sensitivity bandwidth which does not include the frequency corresponding to the first wavelength **419** of the reflected high intensity light **423**, so that opto-electrical sensor **420** detects only the optical signals **432** generated by optical signal generator **418**. Alternatively, a filter (not shown) which filters out light having the first wavelength and allows substantial amounts of light having the second wavelength to pass through could be placed over the junction of the photo-transistor **464** so that the response of opto-electrical detector **420** will be dictated by optical signals **432** and unaffected by reflected light **423**.

Although the invention has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope and spirit of the invention as described and defined in the following claims.

What is claimed is:

1. An optical isolation device comprising:

an optical channel having a first end and a second end;

a light source adjacent the first end for transmitting light through the optical channel;

a detector adjacent the second end for producing electrical power when impinged upon by the transmitted light;

a signal generator adjacent the second end powered by the electrical power from the detector, the signal generator

435, and an optical sensor **420**. Illustratively, light source **412** is a laser **48** which generates high intensity collimated monochromatic light **422** having the first wavelength **419**. Laser light **422** impinges upon first end **24** of fiber optic filament **15** at an angle resulting in some of laser light **423** being reflected while other of laser light **422** is refracted at first end **24**. The angle of incidence of laser light **422** on first end **24** is such that refracted laser light **422** is totally

transmitting optical signals through the optical channel in response to input from a remote isolated circuit at the second end, the input being generated by a user of the remote isolated circuit; and

a sensor adjacent the first end for producing electrical signals in response to the optical signals.

2. The device of claim **1** wherein the optical channel includes a fiber optic filament

10. The device of claim **9** wherein the light source generates monochromatic light.

11. The device of claim **10** wherein the sensor is not sensitive to the monochromatic light.

12. The device of claim **9** wherein the sensor is not sensitive to light in the bandwidth centered about the first frequency.

13. The device of claim **9** wherein the light source is a laser.

14. The device of claim **13** wherein the laser is a semiconductor laser.

15. The device of claim **13** wherein the signal generator includes a light emitting diode.

16. The device of claim **9** wherein the light source has a narrow bandwidth.

17. An optical isolation device comprising:

an optical channel having a first end and a second end;

a light source adjacent the first end for transmitting light through the optical channel;

a detector adjacent the second end for producing electrical power when impinged upon by the transmitted light;

a signal generator adjacent the second end powered by the electrical power from the detector, the signal generator transmitting optical signals through the optical channel in response to input from a remote isolated circuit, the input being generated by a user of the remote isolated circuit;

a sensor adjacent the first end for producing electrical signals in response to the optical signals; and

a controller coupled to the light source and the sensor, the controller causing a task to be performed in response to receipt of the optical signals.

18. The device of claim **17** wherein the controller is further coupled to the signal generator, the controller inducing the light source to generate light in pulses having an on time and an off time and inducing the signal generator to generate optical signals during the off time of the light.

19. The device of claim **18** further comprising an electrical storage device electrically coupled to the detector.

20. A method of electrically isolating a remote circuit from a controller, the method comprising the steps of:

transmitting a first light signal;

converting the transmitted first light signal to electrical power only;

powering the remote circuit with the electrical power;

converting an electrical output signal from the remote circuit to a second light signal;

transmitting the second light signal; and

converting the transmitted second light signal to an electrical input signal for the controller to cause the controller to perform a task corresponding to the remote circuit electrical output signal;

wherein the first and second light signals are optically coupled over a signal optical channel.

21. The method of claim **20**, wherein power is generated by the first light signal impinging a photovoltaic cell.

22. The method of claim **20**, further comprising the step of communicating the first light signal and the second light signal in a half-duplex mode.

23. The method of claim **22**, wherein the step of communicating the first and second light signals in half-duplex mode comprises the steps of:

communicating the first light signal according to a duty cycle having an on state and an off state; and

communicating the second light signal during the off state of the duty cycle.

24. The method of claim **20**, further comprising the step of communicating the first light signal and second light signal in full-duplex mode.

25. The method of claim **24**, wherein the step of communicating the first and second light signals in full-duplex mode comprises the steps of:

selecting a first frequency for the first light source;

selecting a second frequency for the second light source, the second frequency being different from the first frequency;

providing a photovoltaic cell responsive to the first frequency; and

providing an opto-electrical sensor responsive to the second frequency.

26. The method of claim **20**, wherein the first light signal is transmitted over a first optical channel and the second light signal is transmitted over a second optical channel.

27. The method of claim **26**, wherein the first and second light signals are transmitted in a full-duplex mode.

28. The method of claim **27**, further comprising the step of optically shielding the first and second optical channels to inhibit optical communication between the first and second optical channels.

29. An optical isolation device for isolating a user of a remote circuit for controlling equipment in a point of care environment from a circuit for powering the equipment, the device comprising:

an optical channel;

a light source for transmitting light in a first direction through the channel;

a detector for producing power in response to the transmitted light;

a signal generator powered by the power from the detector and electrically coupled to the remote circuit, the signal generator transmitting optical signals in a second direction through the channel in response to user-generated input signals from the remote circuit; and

a sensor for producing electrical signals for controlling the equipment in response to the transmitted optical signals.

30. An optically isolated control system, including:

a remote circuit for providing an input signal;

source circuit including a power source, a controller, and an actuator controlled by the controller;

an isolation device for optically isolating the remote circuit from the source circuit, the isolation device including

an optical channel,

a light source powered by the power source for transmitting light through the channel,

a detector for converting the transmitted light to electrical power for powering the remote circuit,

an optical signal generator, powered by the electrical power, for converting the input signal from the remote circuit to an optical signal, the optical signal generator transmitting the optical signal through the channel, and

a sensor for converting the transmitted optical signal to an electrical signal;

wherein the source circuit controller responds to the electrical signal by causing the actuator to perform a task corresponding to the input signal from the remote circuit.

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