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(12) **United States Patent**
Abdul-Hafiz

(10) **Patent No.: US 7,371,981 B2**
(45) **Date of Patent: May 13, 2008**

(54) **CONNECTOR SWITCH**

(75) Inventor: **Yassir Abdul-Hafiz**, Lake Forest, CA (US)

(73) Assignee: **Masimo Corporation**, Irvine, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 131 days.

(21) Appl. No.: **11/062,169**

(22) Filed: **Feb. 18, 2005**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 60/546,531, filed on Feb. 20, 2004.

(51) **Int. Cl.**
H01R 33/96 (2006.01)

(52) **U.S. Cl.** ..... **200/51 R**; 200/51.09; 439/188

(58) **Field of Classification Search** ..... 200/43.01, 200/43.04, 43.05, 51 R, 51.05, 51.06, 51.08, 200/51.09, 51.1, 51.11, 51.12, 51.13; 439/188, 439/352, 76.1
See application file for complete search history.

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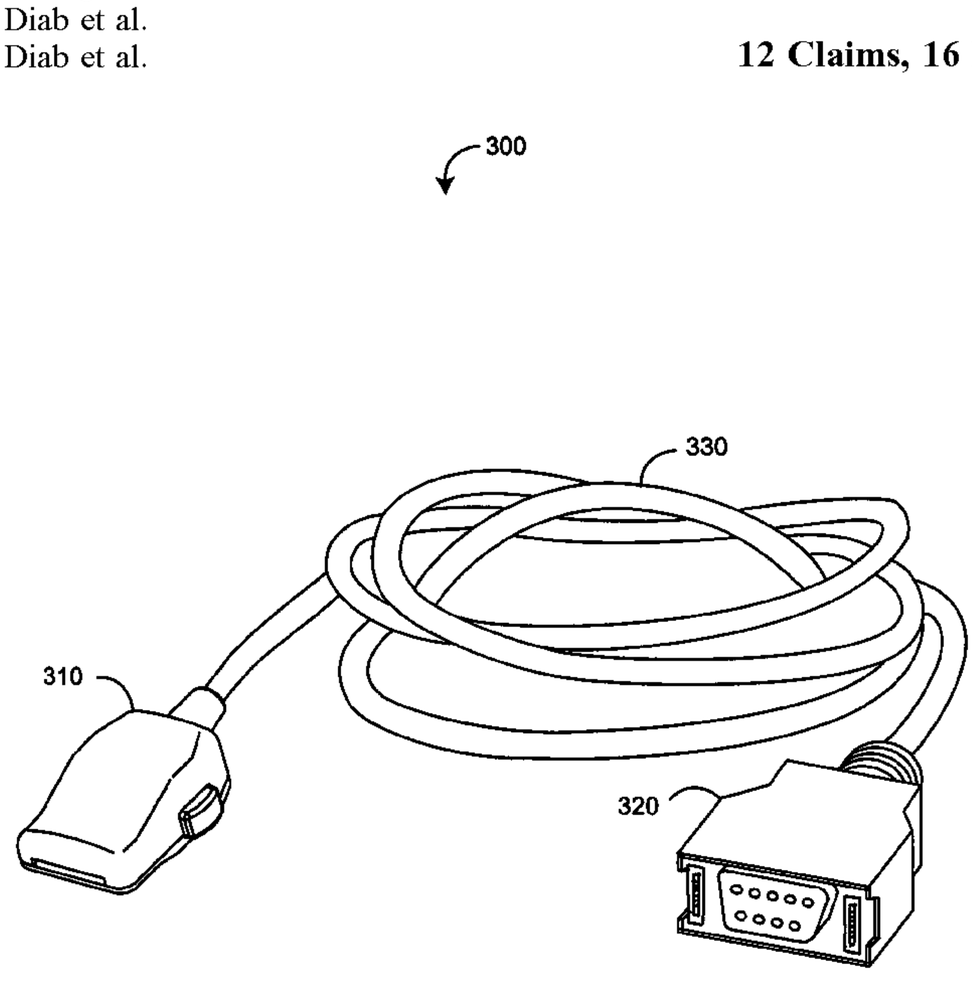
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Primary Examiner—Michael A Friedhofer
(74) *Attorney, Agent, or Firm*—Knobbe, Martens, Olson & Bear, LLP

(57) **ABSTRACT**

An interconnection between a sensor and a monitor has a cable, an information element and a switch. The cable has conductors providing electrical communication between a sensor connector and a monitor connector. The information element is readable by the monitor and mounted in the sensor connector, the monitor connector or the cable. A switch is mounted in the sensor connector and is responsive to the sensor connecting to and disconnecting from the sensor connector so as to alter the readability of said information element.

12 Claims, 16 Drawing Sheets



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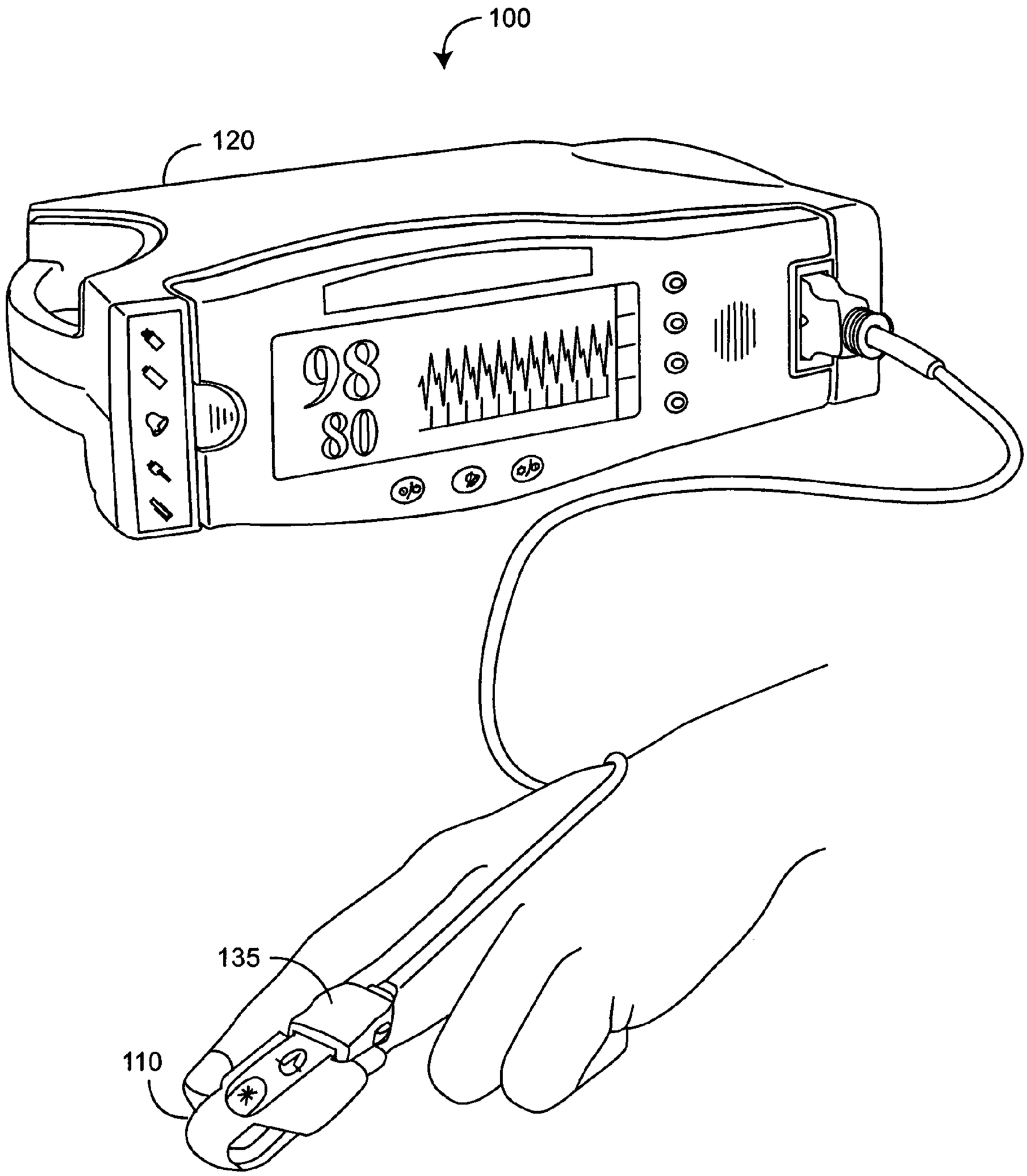


FIG. 1 (Prior Art)

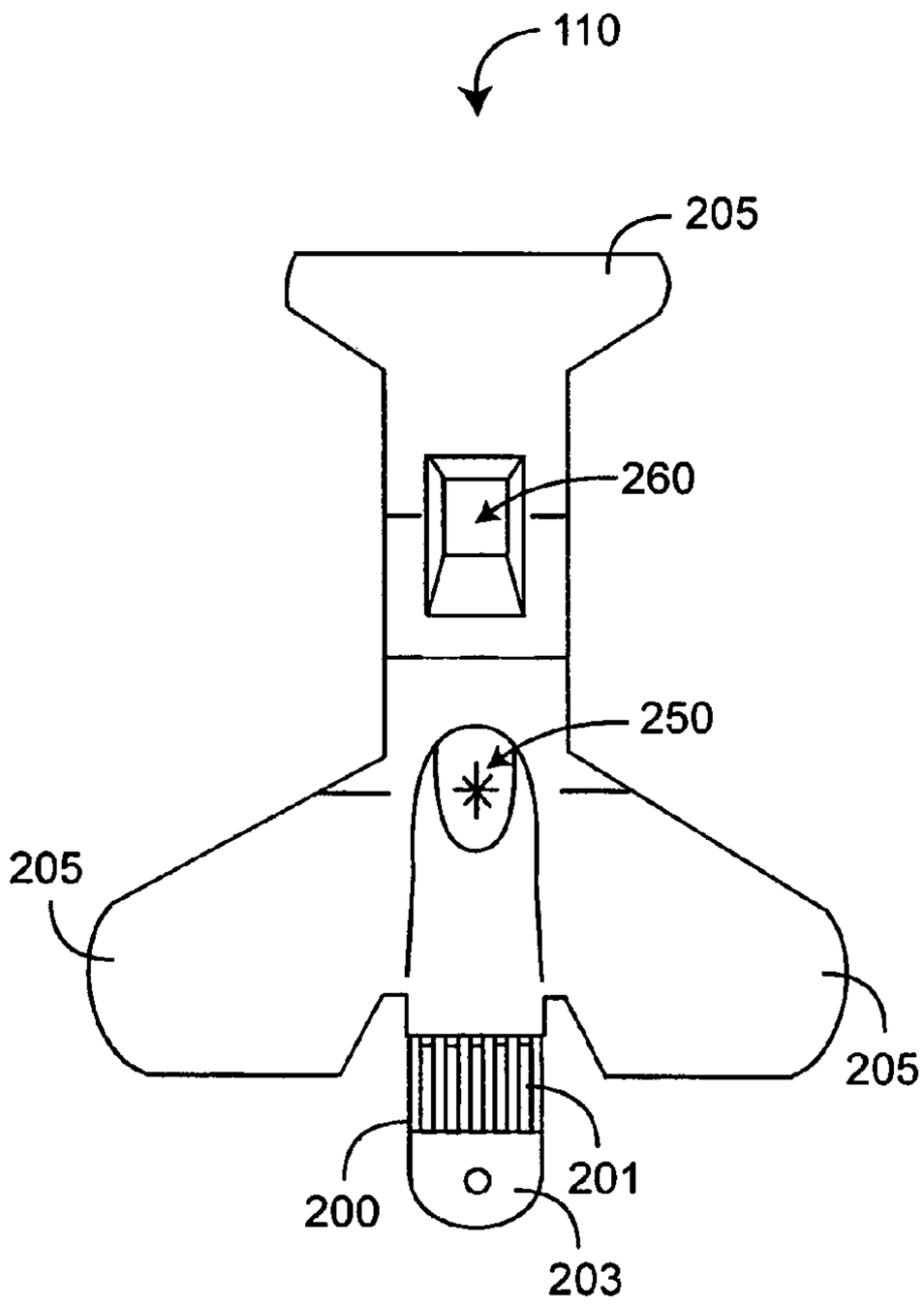


FIG. 2A (Prior Art)

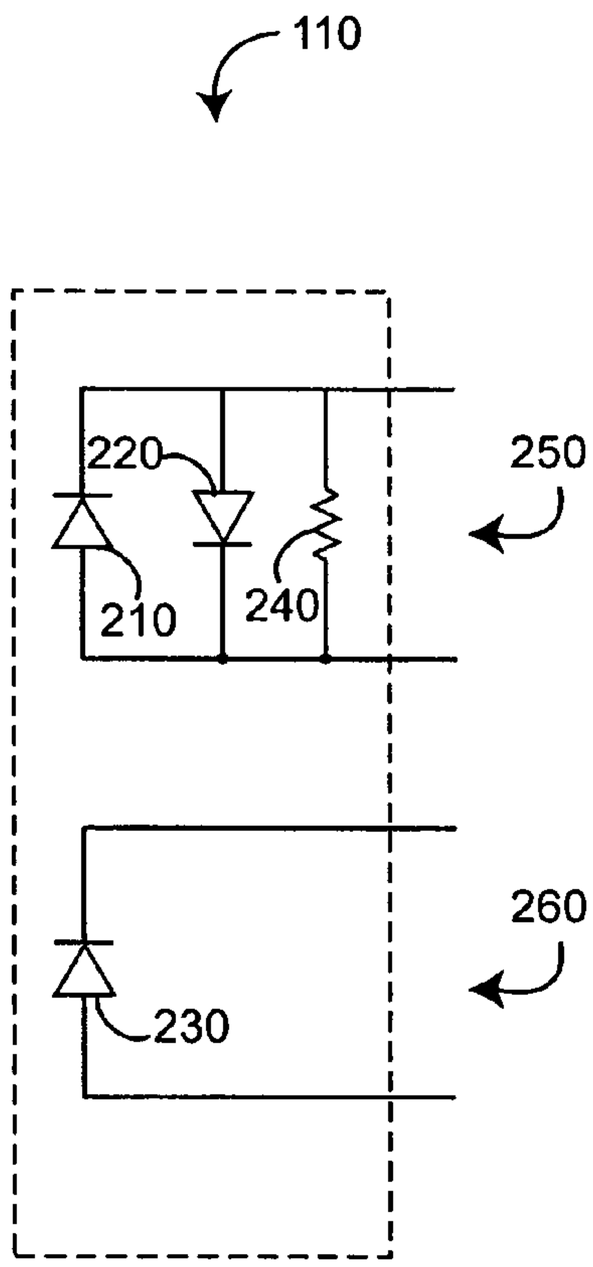


FIG. 2B (Prior Art)

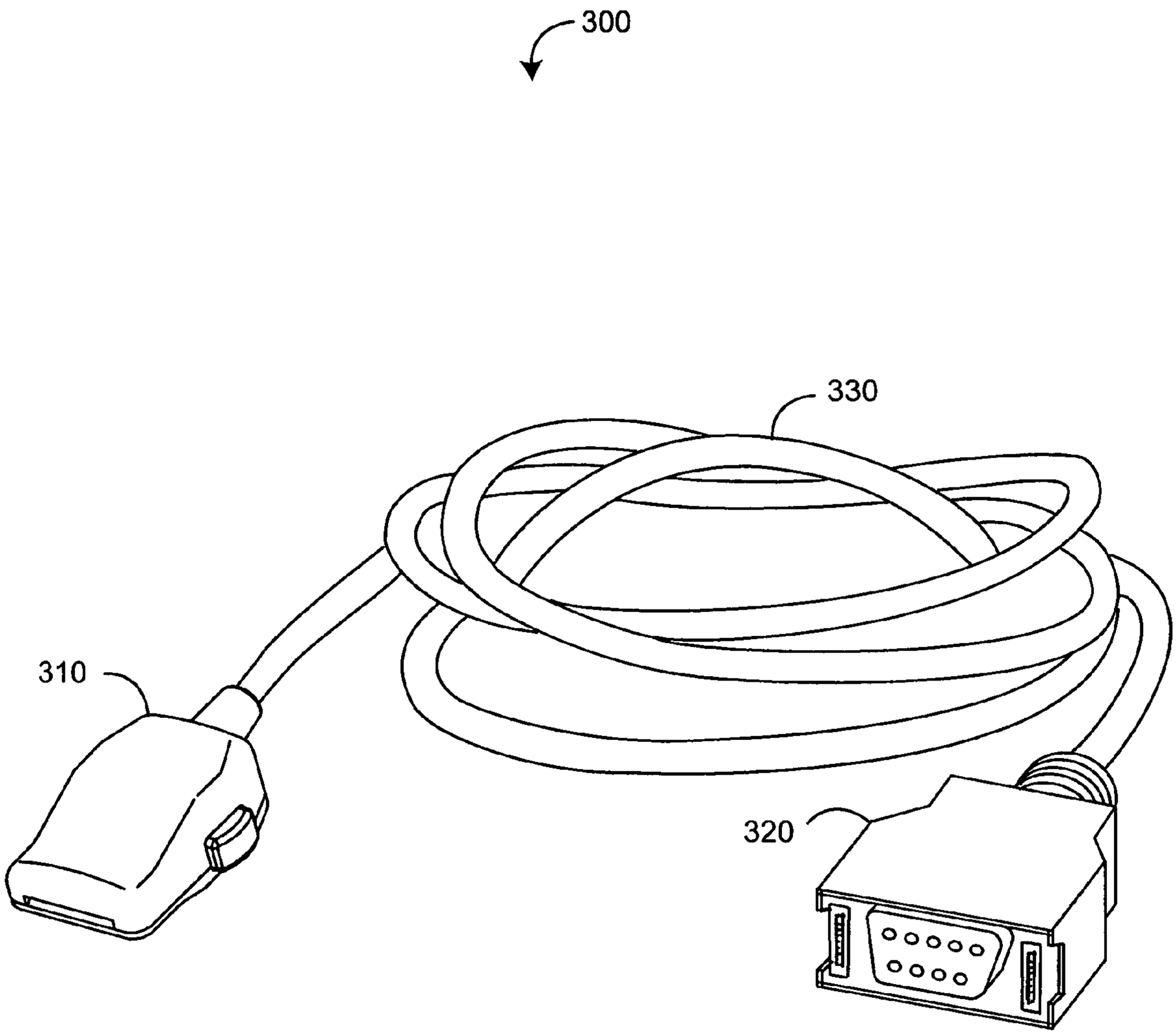


FIG. 3

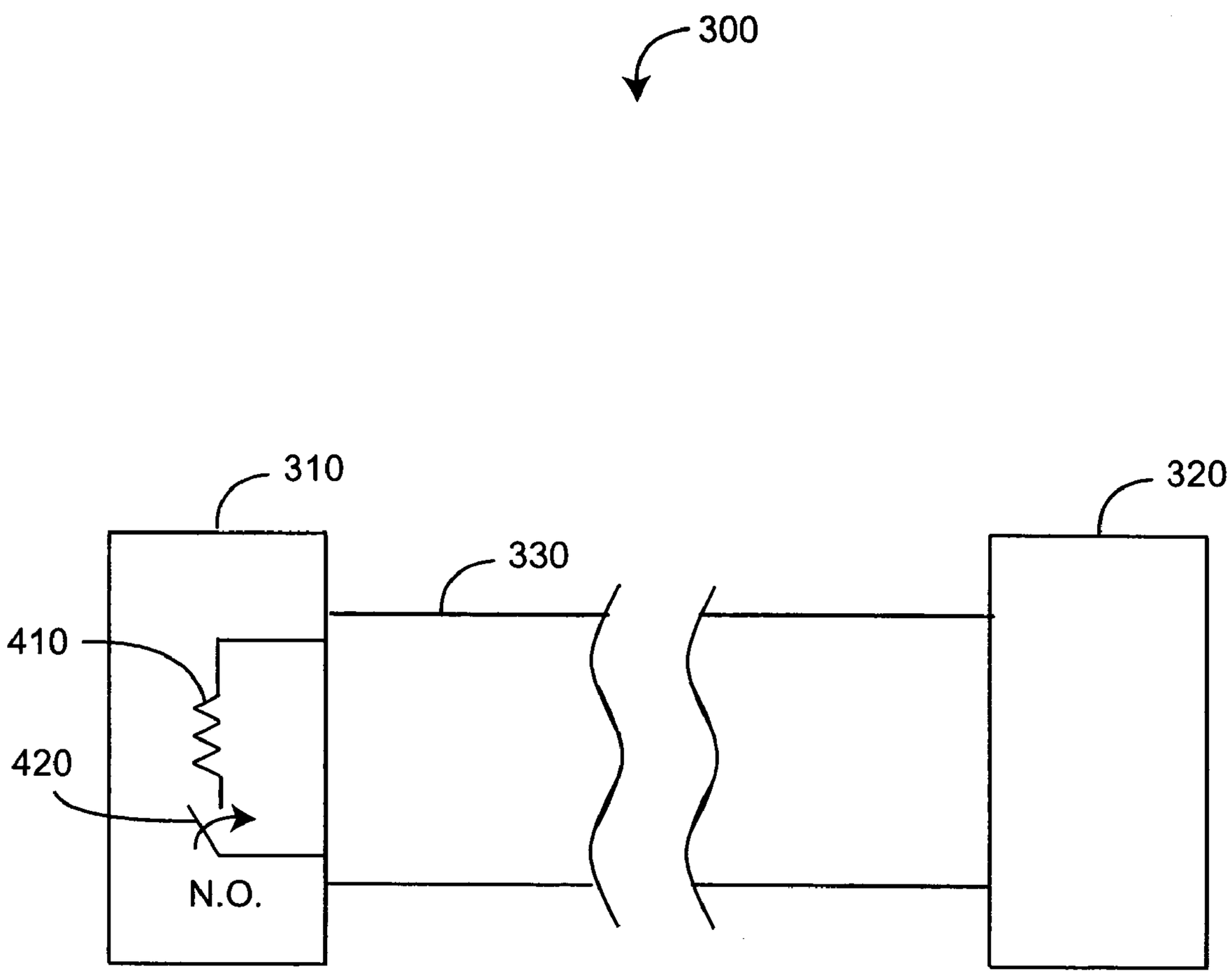


FIG. 4

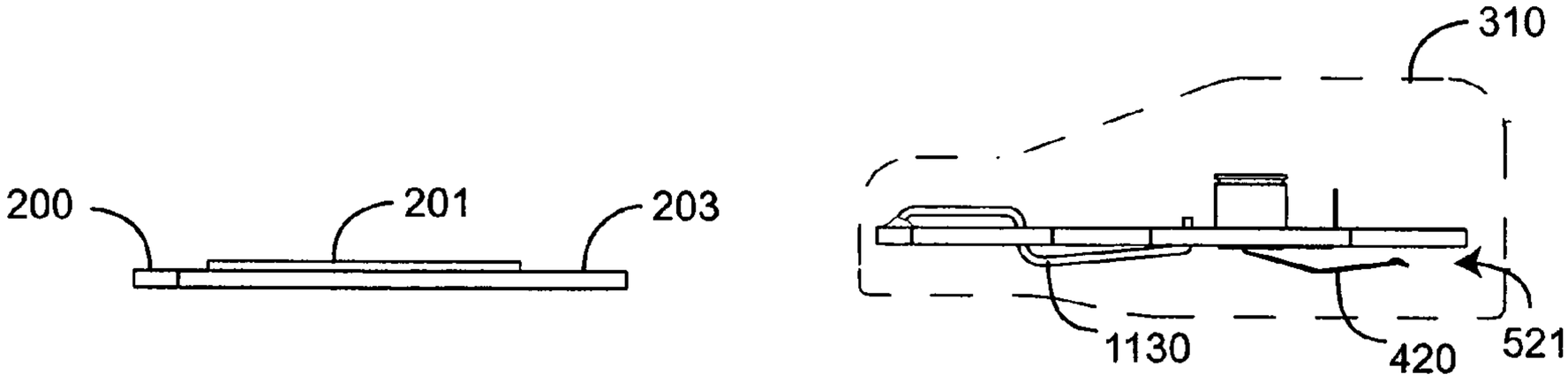


FIG. 5A

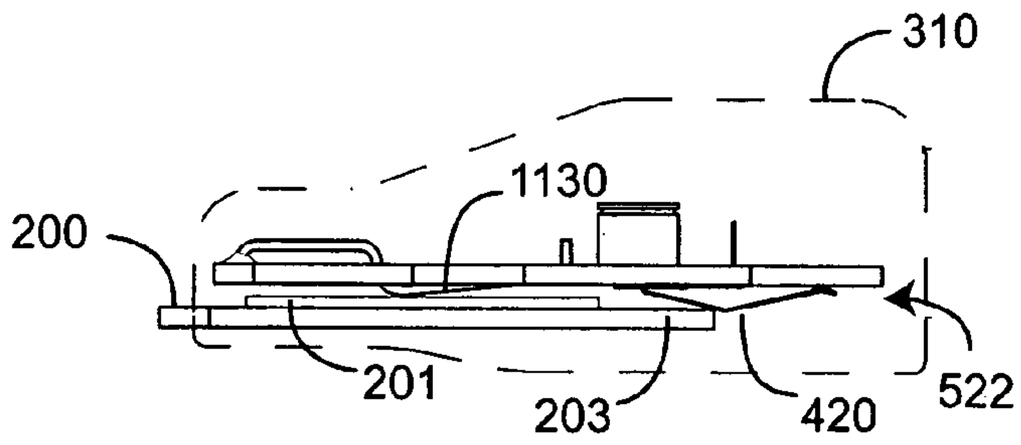


FIG. 5B

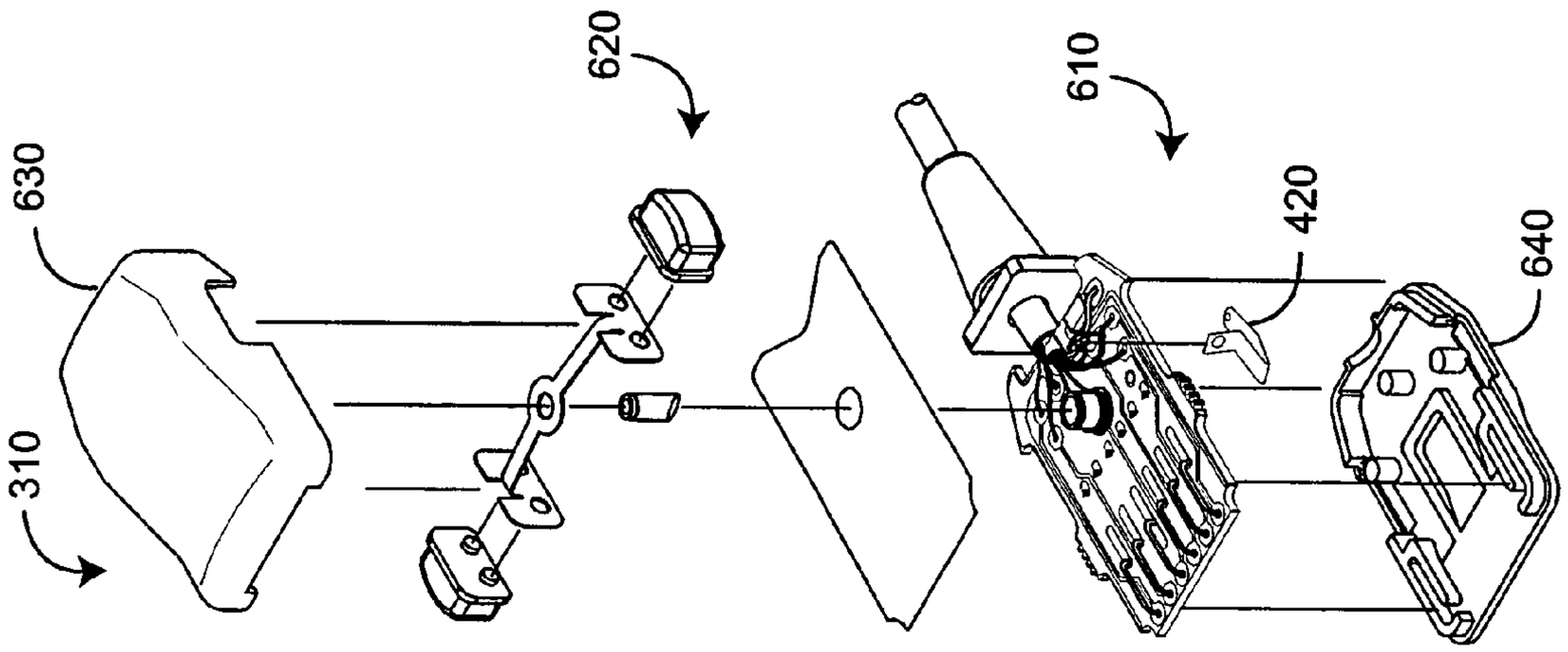


FIG. 6B

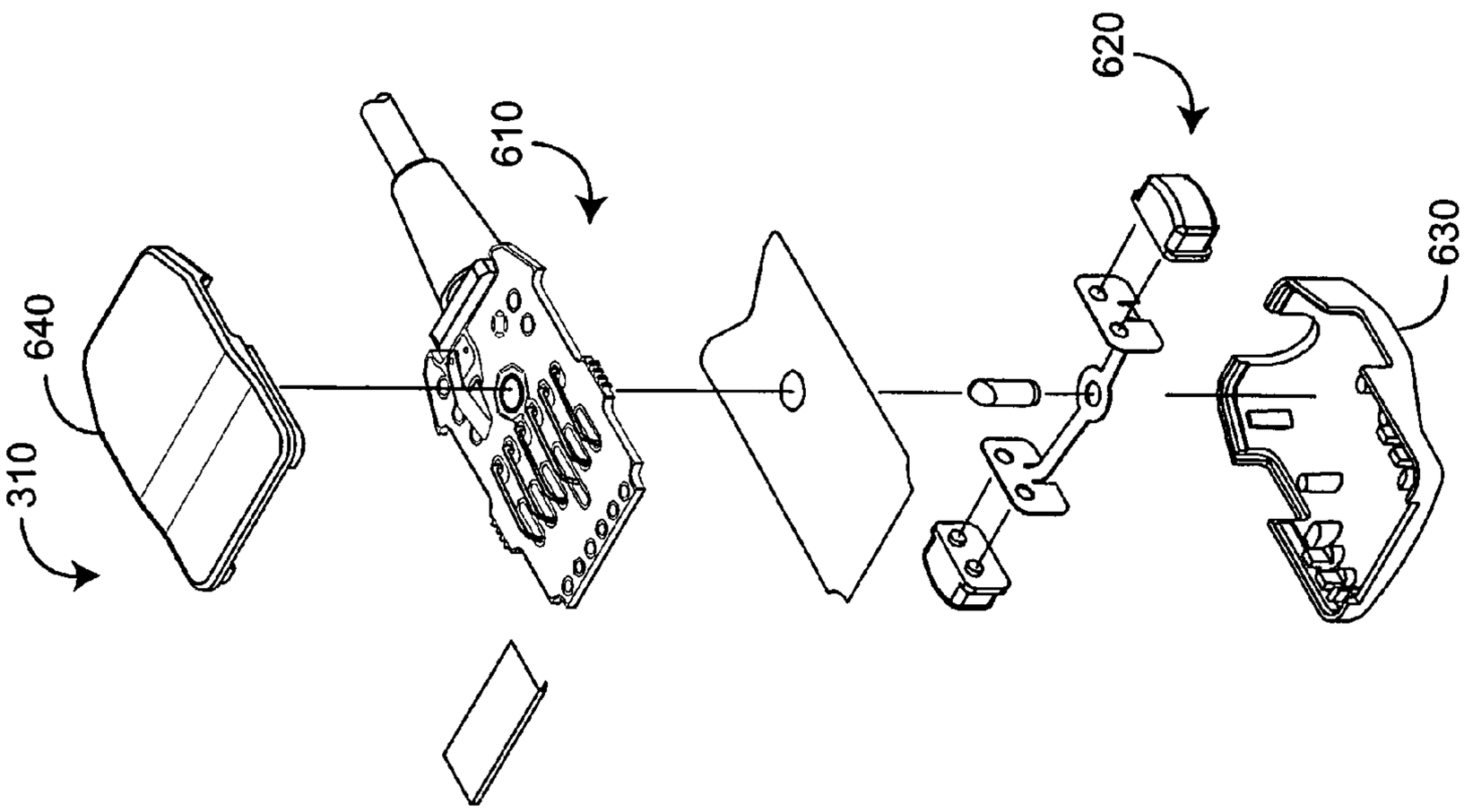


FIG. 6A

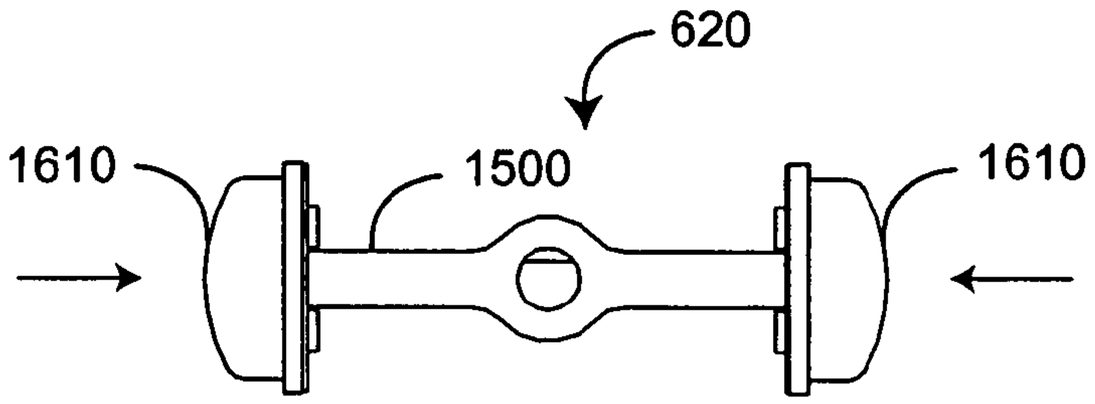


FIG. 7A

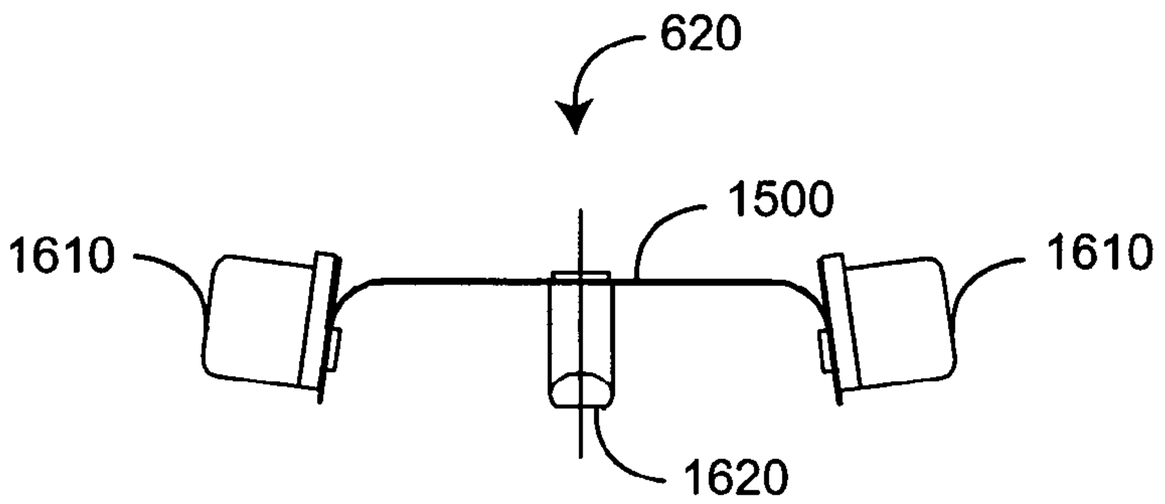


FIG. 7B

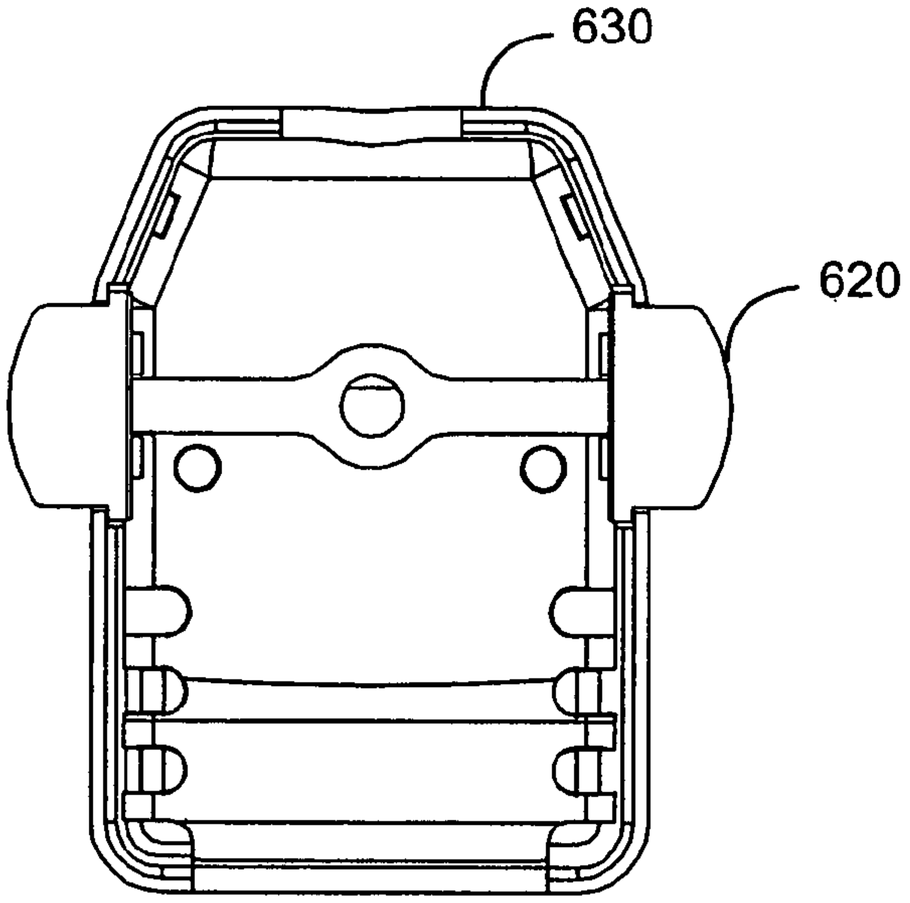


FIG. 7C

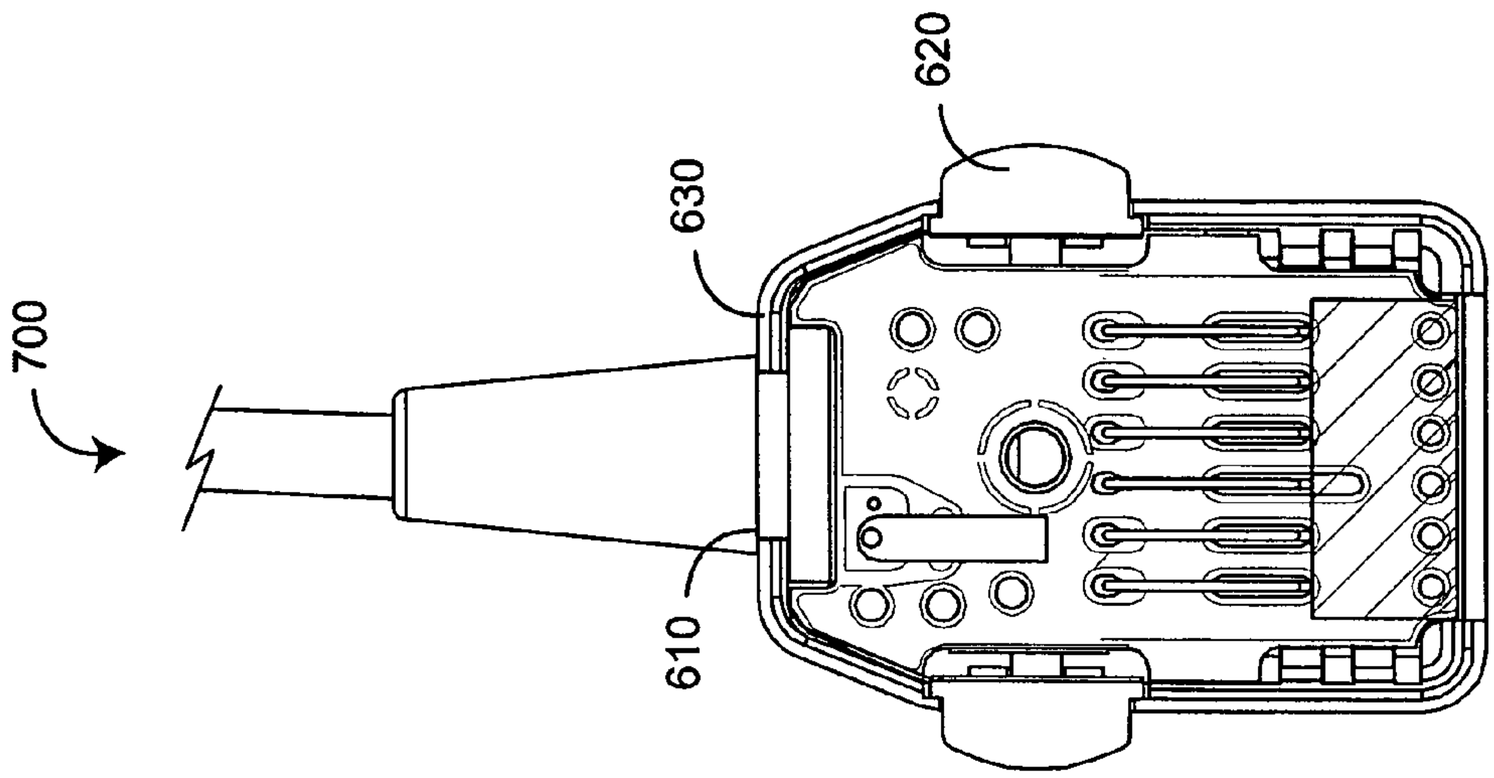


FIG. 8B

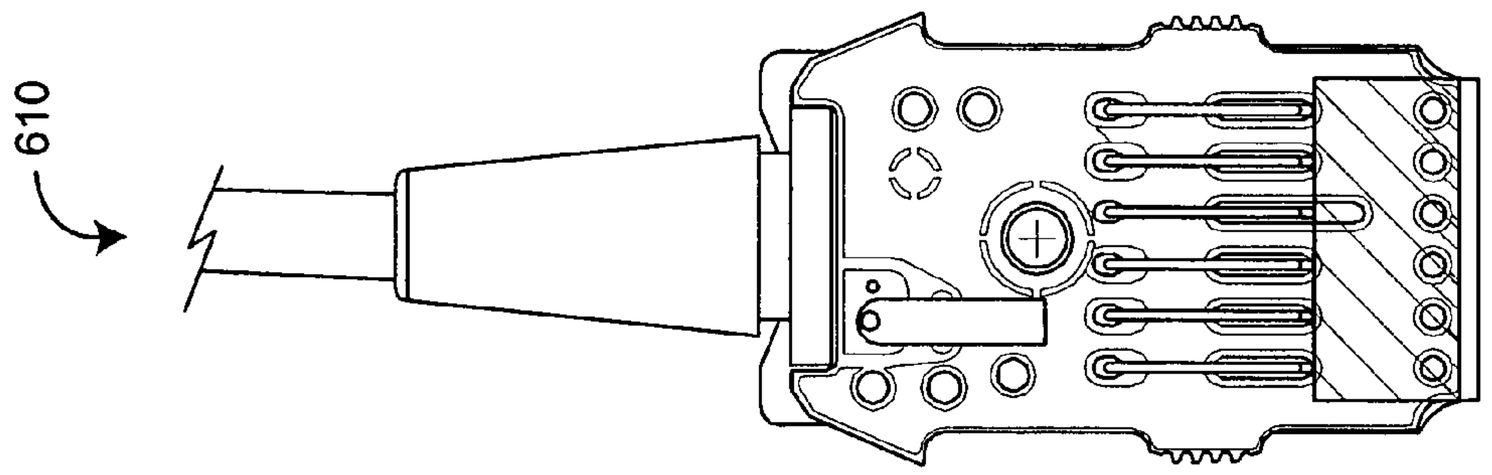


FIG. 8A

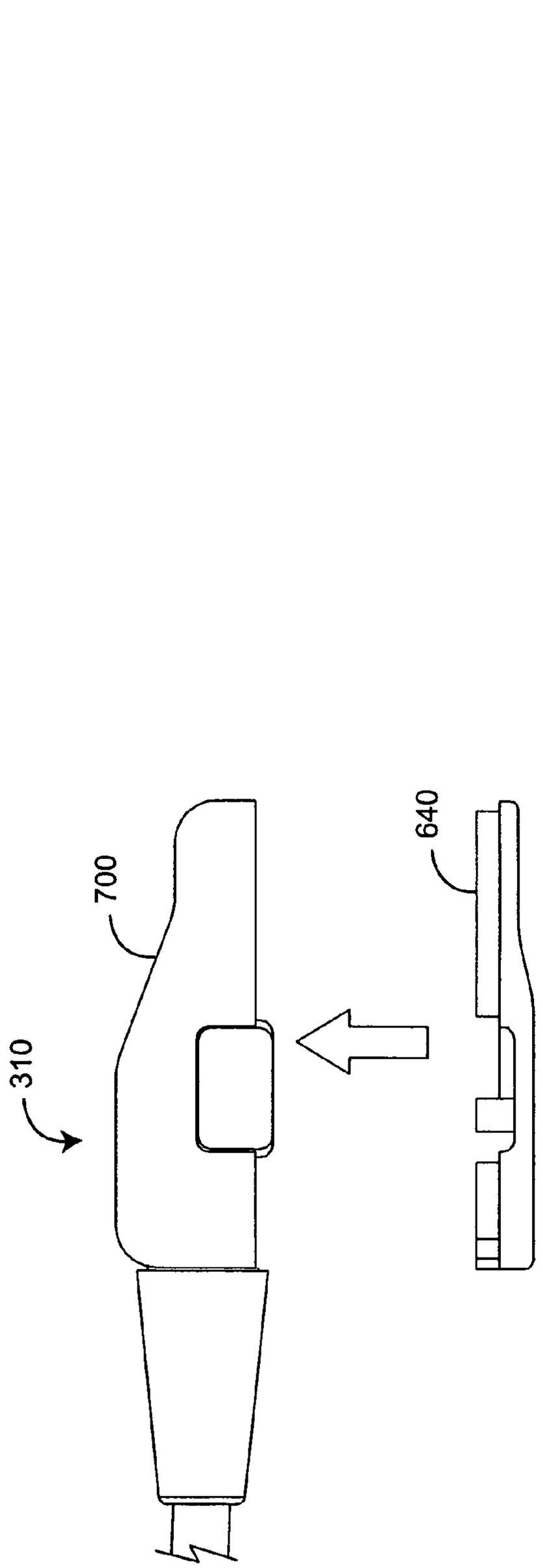


FIG. 9A

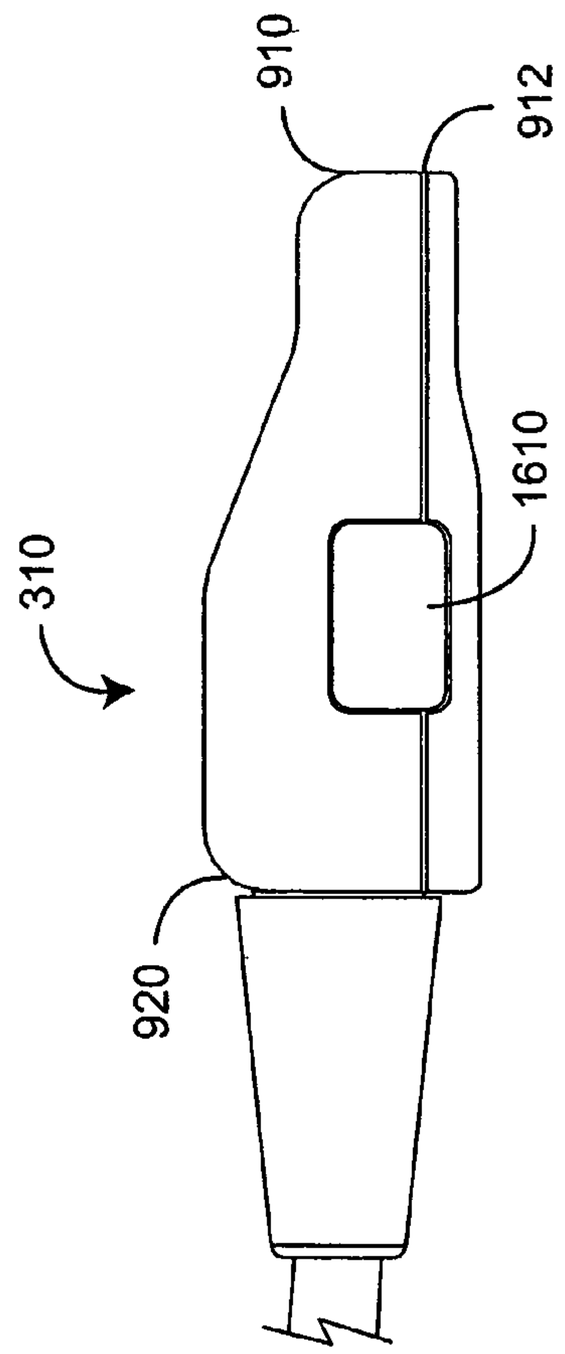


FIG. 9B

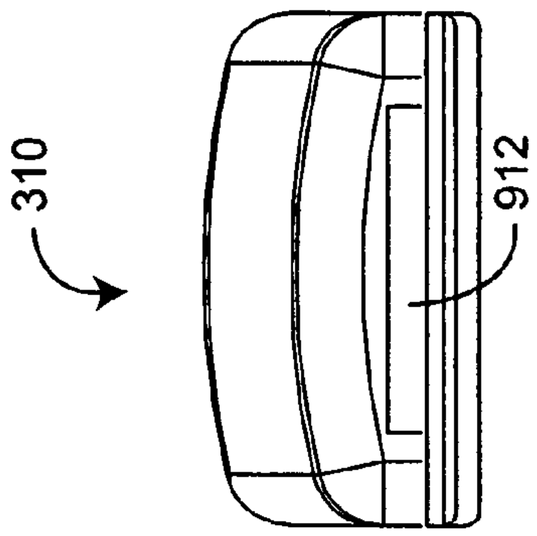


FIG. 9C

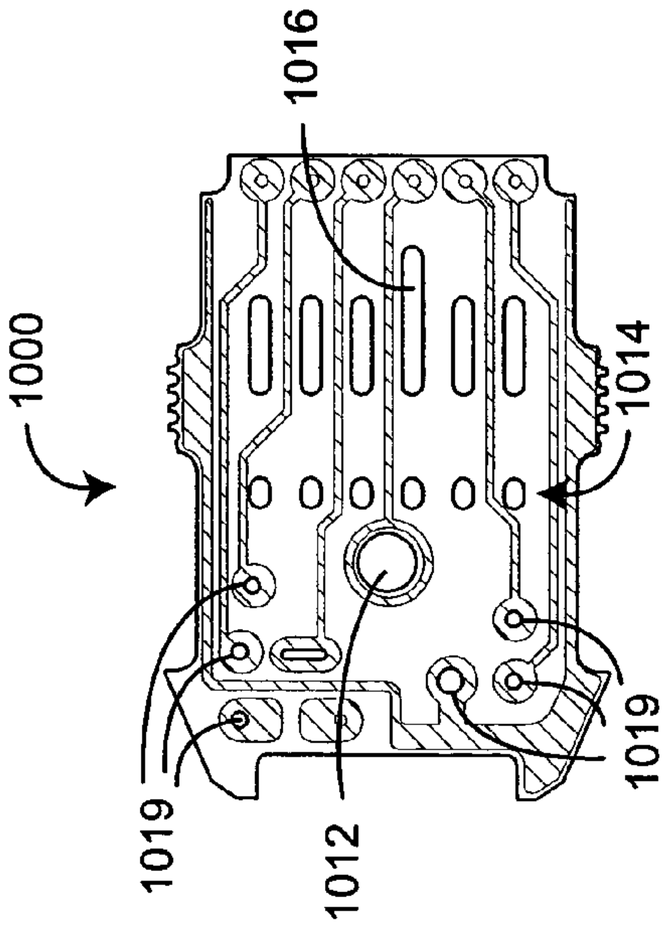


FIG. 10

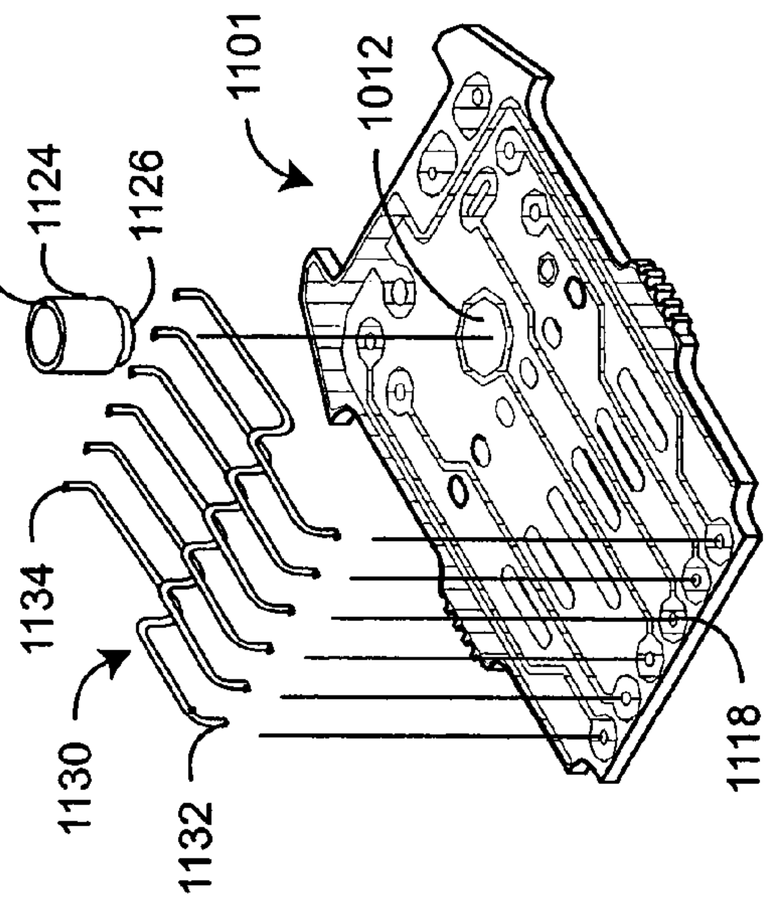


FIG. 11A

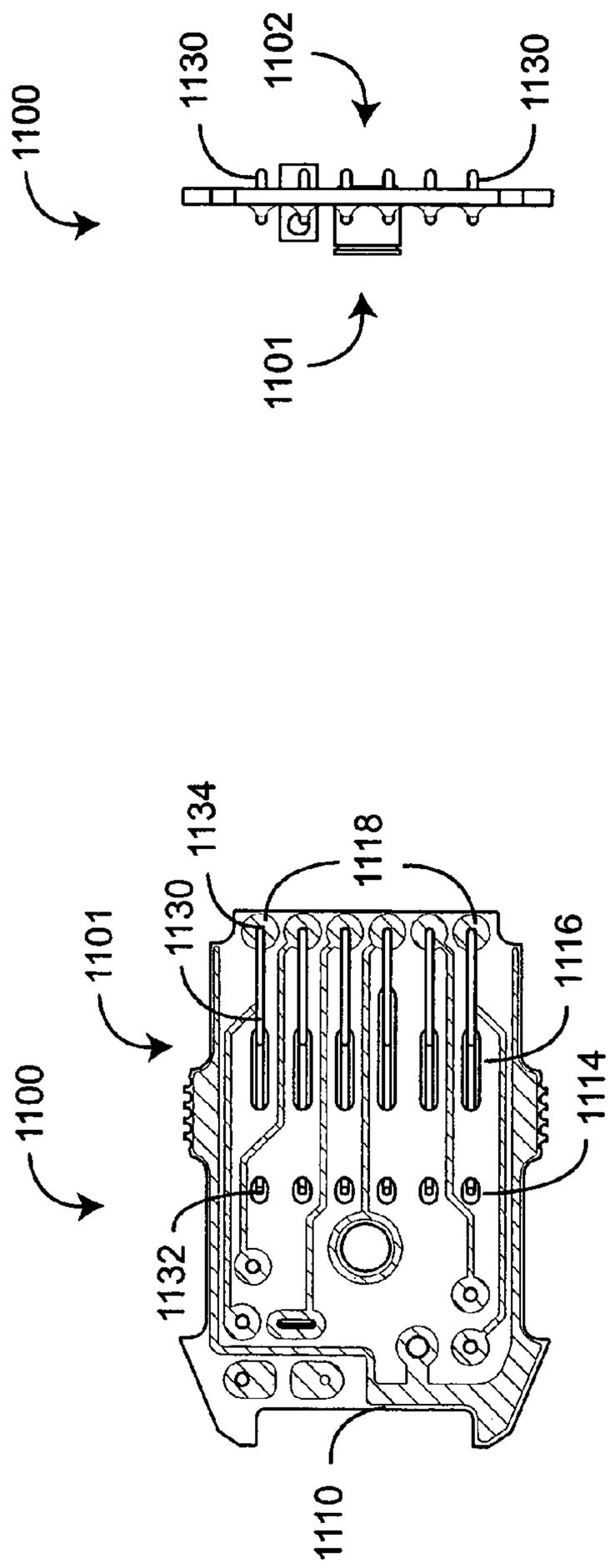


FIG. 11C

FIG. 11B

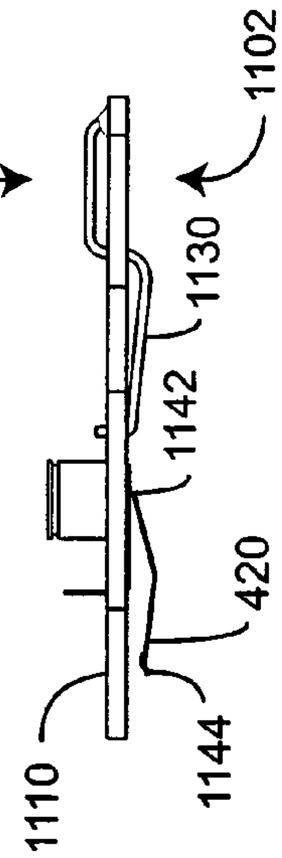


FIG. 11D

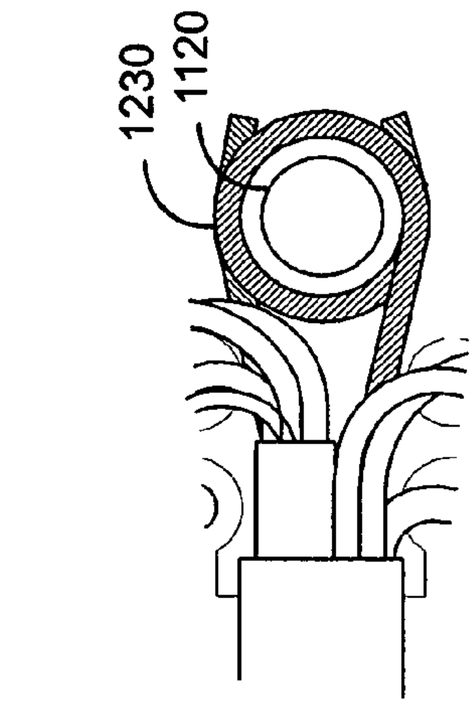


FIG. 12C

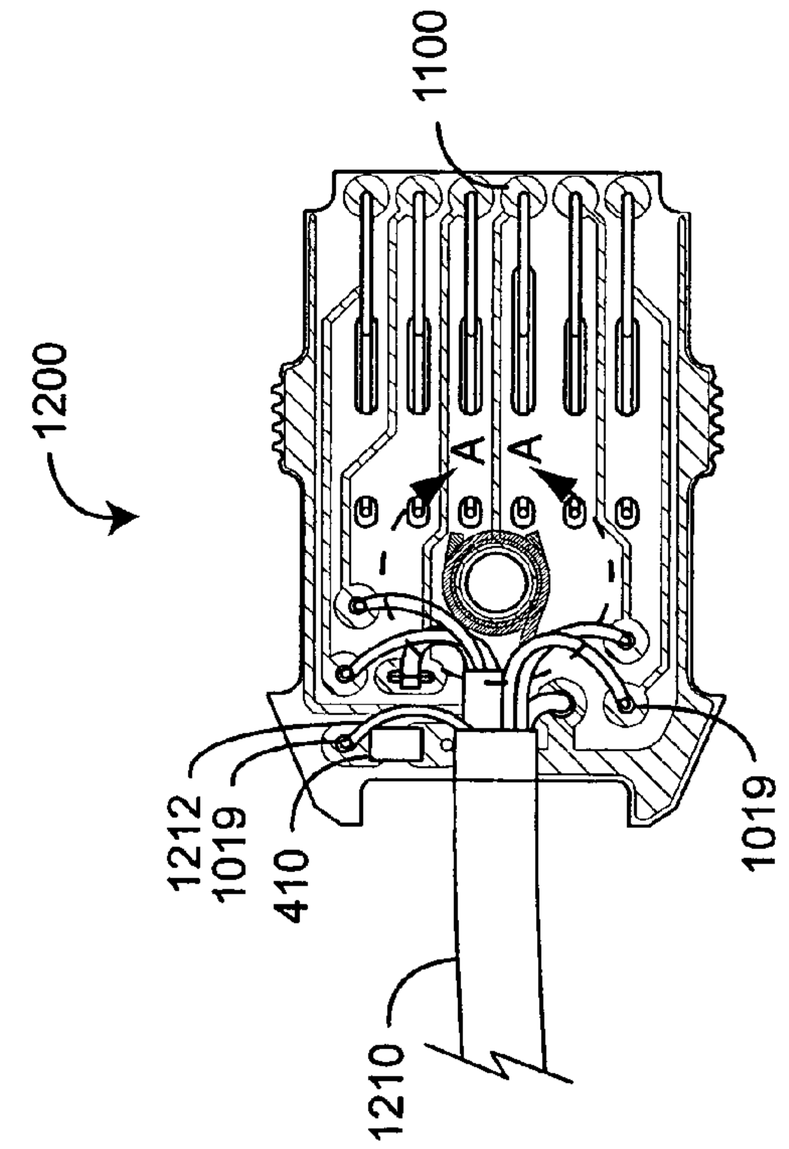


FIG. 12A

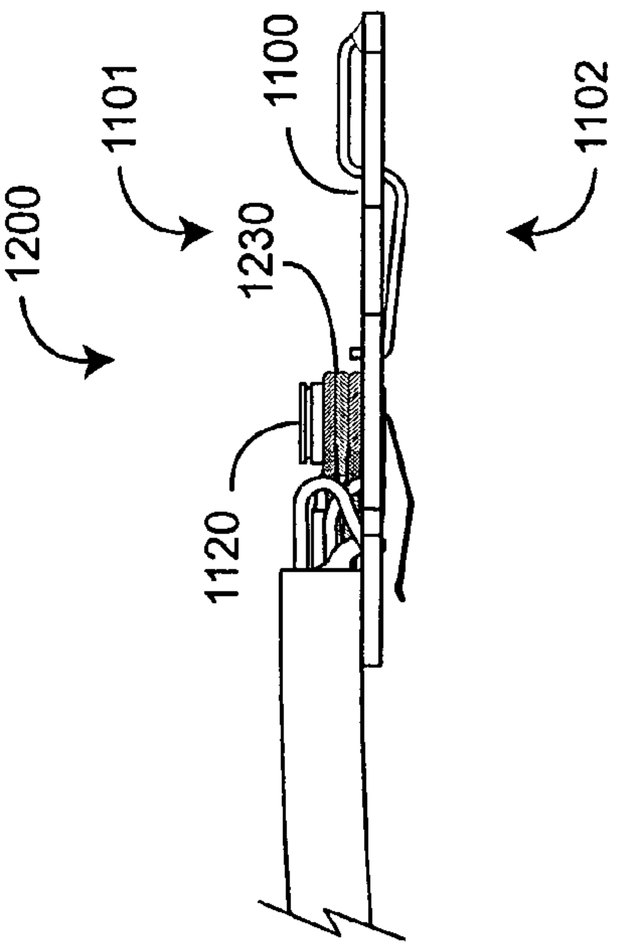


FIG. 12B

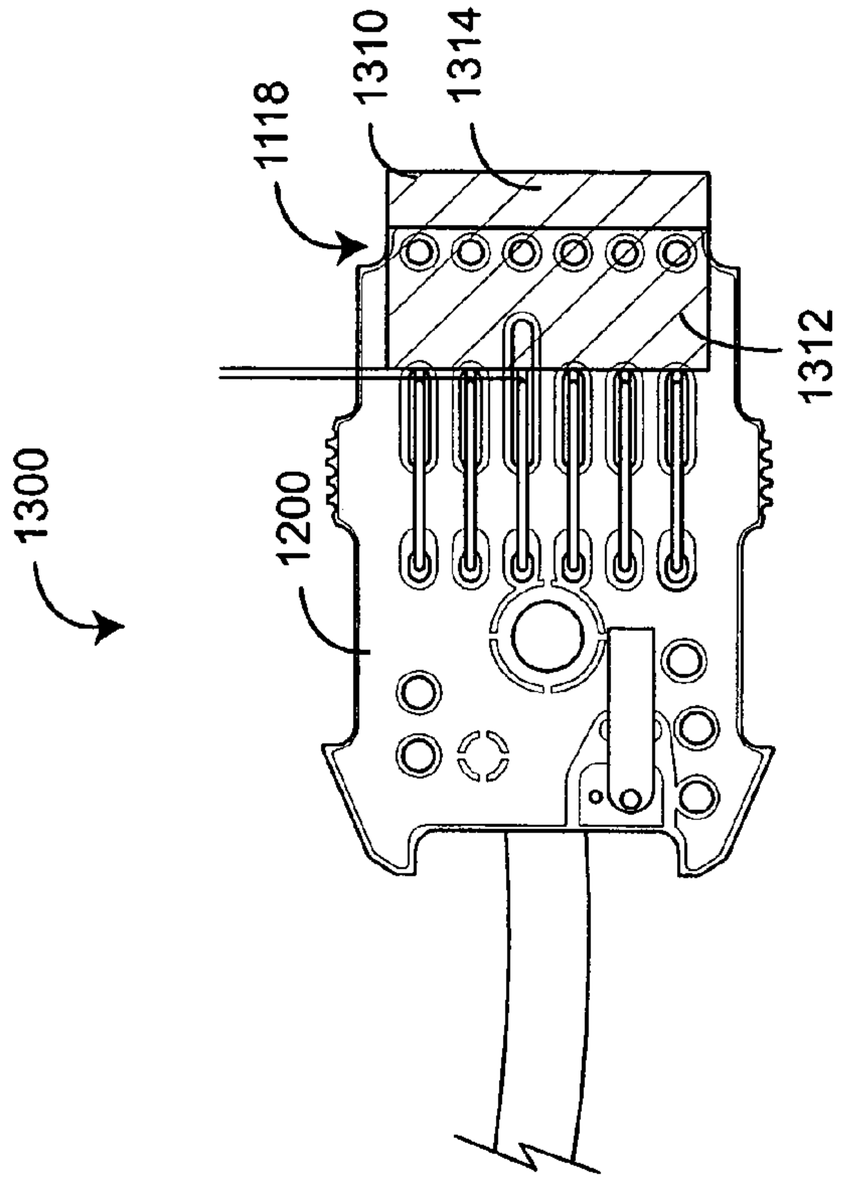


FIG. 13A

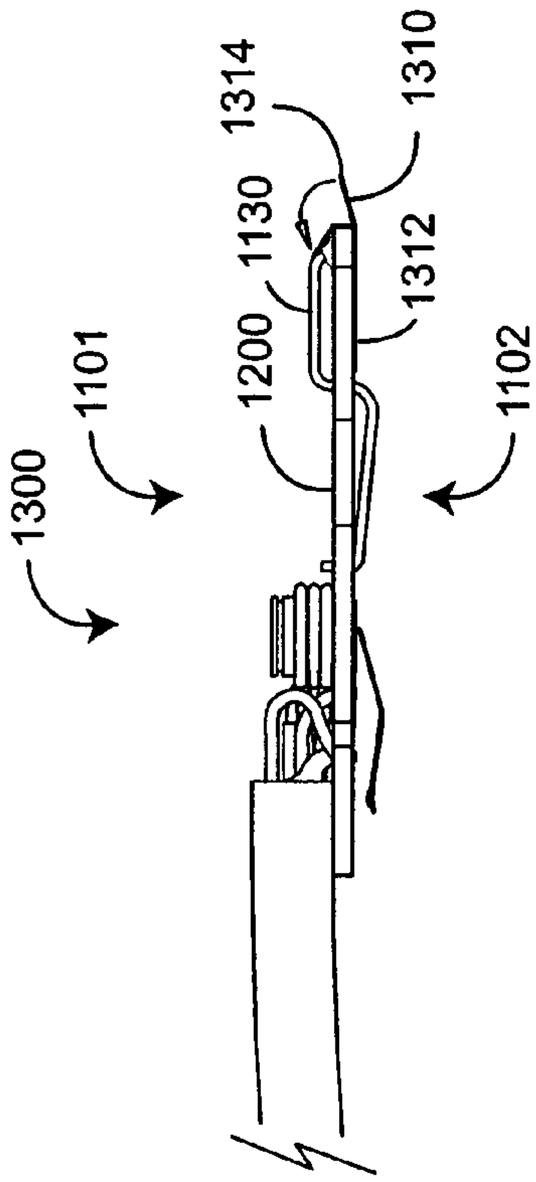


FIG. 13B

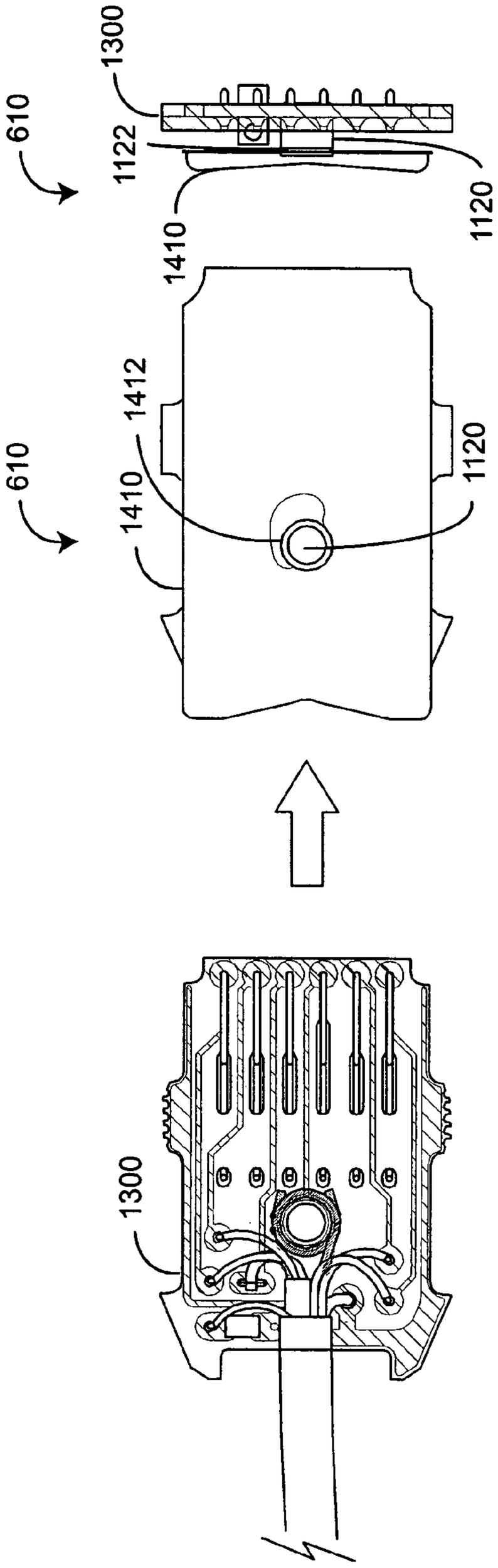


FIG. 14B

FIG. 14A

FIG. 13C

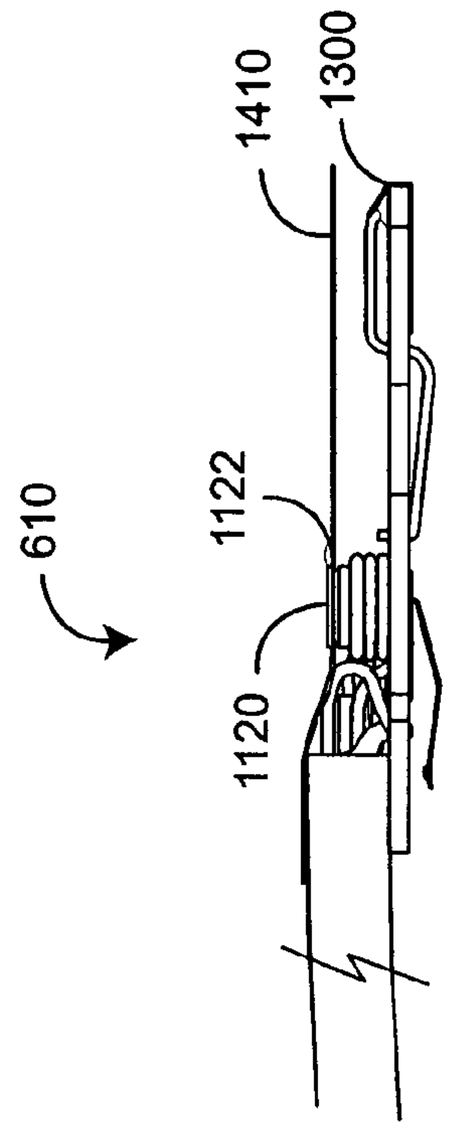


FIG. 14C

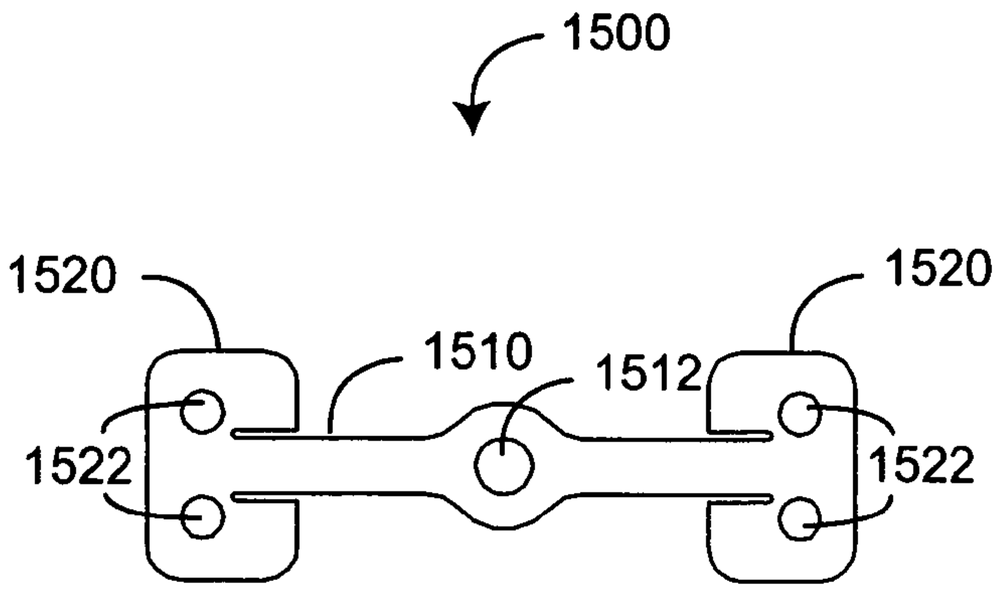


FIG. 15A

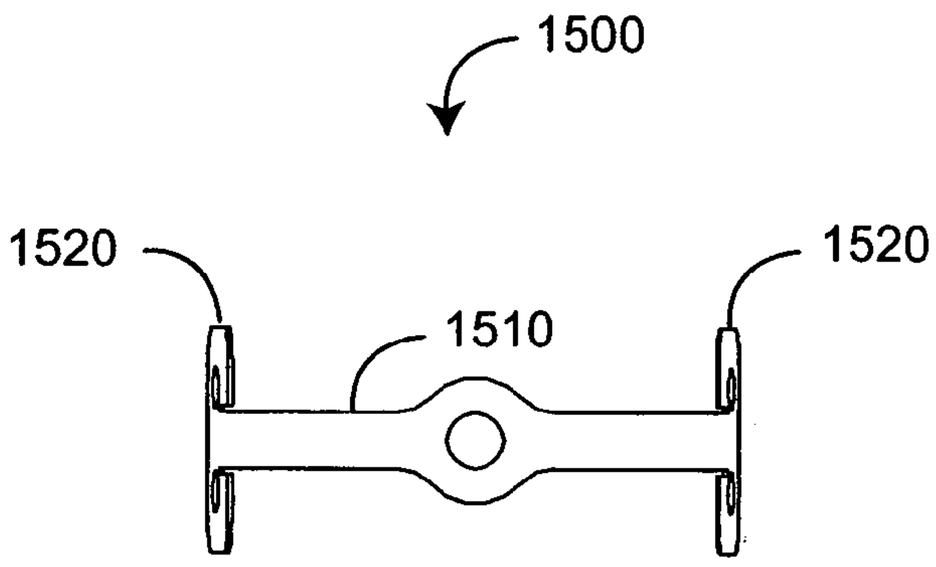


FIG. 15B

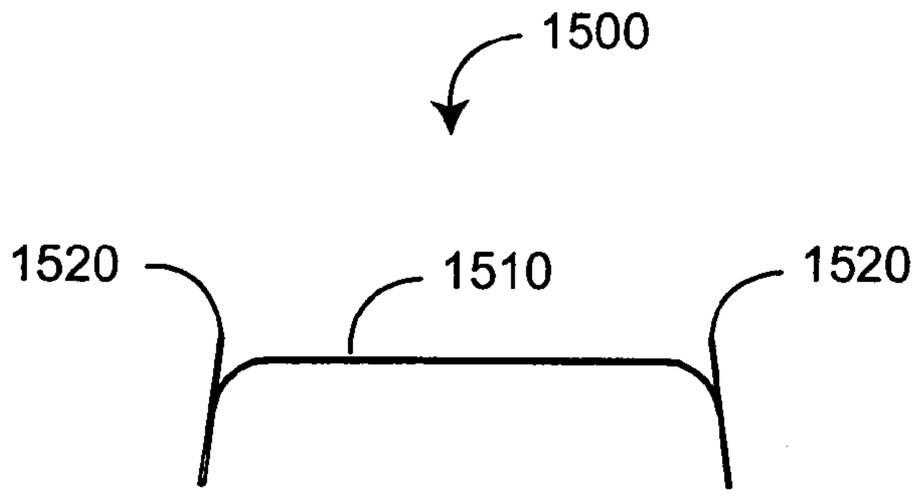


FIG. 15C

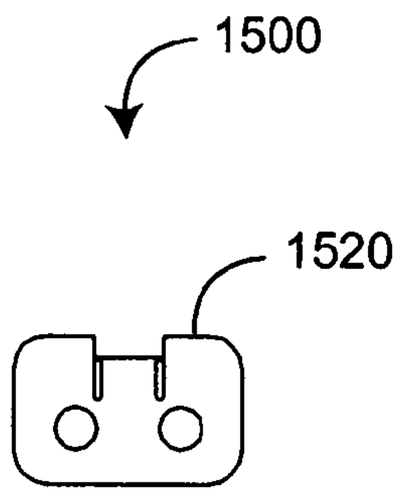


FIG. 15D

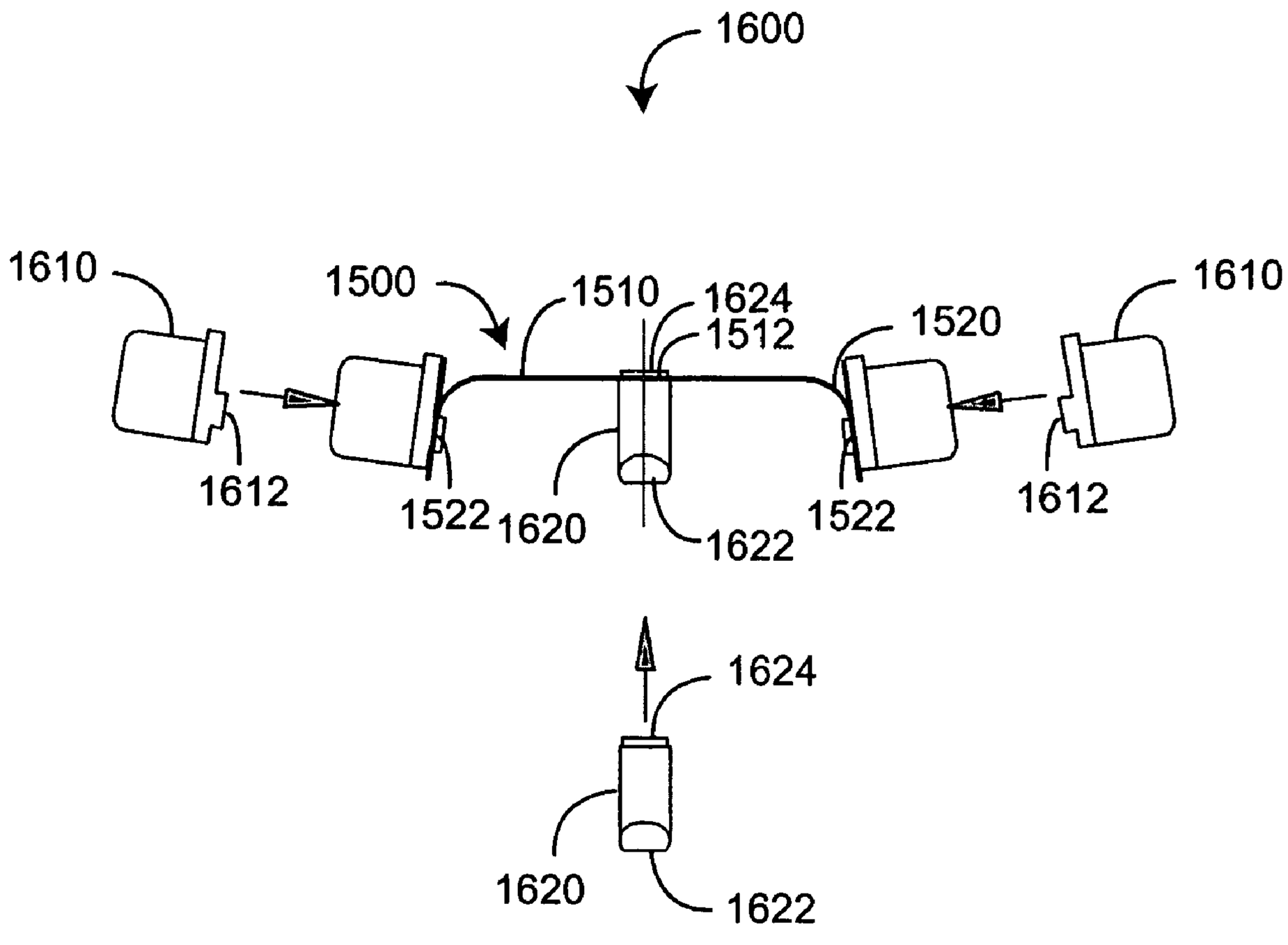

1600
1610
1500
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1622

FIG. 16

CONNECTOR SWITCH

CROSS-REFERENCE TO RELATED APPLICATIONS

This application relates to and claims the benefit of prior U.S. Provisional Application No. 60/546,531 entitled Connector Switch, filed Feb. 20, 2004 and incorporated by reference herein.

BACKGROUND OF THE INVENTION

Pulse oximetry is a widely accepted noninvasive procedure for measuring arterial oxygen saturation, which provides early detection of hypoxia. FIG. **1** illustrates a pulse oximetry system **100** having a sensor **110** applied to a patient, a monitor **120**, and a patient cable **130** connecting the sensor **110** and the monitor **120**. The sensor **110** has emitters and a detector, which are attached to a tissue site, such as a finger as shown. The patient cable **130** transmits an emitter drive signal from the monitor **120** to the sensor **110** and a resulting detector signal from the sensor **110** to the monitor **120**. The monitor **120** processes the detector signal to provide a numerical readout of oxygen saturation and pulse rate.

FIGS. **2**A-B illustrate a pulse oximetry sensor **110**. As shown in FIG. **2**A, the sensor **110** has an adhesive wrap **205** that positions emitters **250** (not visible) proximate, for example, a finger nail and a detector **260** (not visible) proximate a finger pad. A sensor plug **200** inserts into a sensor connector **135** (FIG. **1**) so that plug contacts **201** are in electrical communications with the monitor **120** (FIG. **1**) via the patient cable **130** (FIG. **1**).

As shown in FIG. **2**B, a pulse oximetry sensor **110** has both red and infrared light emitting diode (LED) emitters **210**, **220** and a photodiode detector **230**. LED pinouts **250** on the plug contacts **201** (FIG. **2**A) connect the LEDs **210**, **220** to the monitor **120** (FIG. **1**). Detector pinouts **260** on the plug contacts **201** (FIG. **2**A) connect the photodiode **230** to the monitor **120** (FIG. **1**). The sensor **110** may also have an information element **240**, such as a resistor. The information element **240** may have various uses, such as an indicator of sensor type, depending on the manufacturer. A pulse oximetry sensor is described in U.S. Pat. No. 6,256,523 entitled Low Noise Optical Probes; a pulse oximetry monitor is described in U.S. Pat. No. 6,826,419 entitled Signal Processing Apparatus And Method; and an information element is described in U.S. Pat. No. 5,758,644 entitled Manual and Automatic Probe Calibration, all of which are assigned to Masimo Corporation, Irvine, Calif. and incorporated by reference herein.

SUMMARY OF THE INVENTION

A patient cable can be an adapter cable. That is, it can function to physically and electrically adapt a sensor to an otherwise incompatible monitor. For example, some monitors are configured to read a sensor information element. An adapter cable for a sensor that does not have an information element can incorporate that element in the adapter cable itself, such as within one of the adapter cable connectors. In some circumstances, however, removing the sensor from such an adapter cable can result in a monitor status message indicating a malfunctioning sensor rather than a disconnected sensor. This arises because the monitor is able to read the information element but is unable to receive a detector signal. A connector switch, however, advantageously electrically disconnects the information element from the monitor when the sensor is disconnected from the adapter cable. In that manner, the monitor will detect the absence of both a sensor and an information element and display a correct status message accordingly.

One aspect of a connector switch is an interconnection between a sensor and a monitor having a cable, an information element and a switch. The cable has conductors providing electrical communication between a sensor connector and a monitor connector. The information element is readable by the monitor and mounted in the sensor connector, the monitor connector or the cable. A switch is mounted in the sensor connector and is responsive to the sensor connecting to and disconnecting from the sensor connector so as to alter the readability of said information element.

Another aspect of a connector switch is an interconnection method that provides a cable configured to communicate drive signals from a physiological parameter monitor to a sensor and physiological signals from the sensor to the monitor. An information element is associated with the cable, where the information element is capable of conveying information regarding the sensor to the monitor. A switch is actuated in response to the sensor connecting and disconnecting to the cable so as to render the information element readable and unreadable by the monitor, respectively.

A further aspect of a connector switch is a sensor-monitor interconnection comprising a cable adapted to communicate signals between a physiological sensor and a physiological parameter monitor. An information element is capable of conveying information regarding the sensor to the monitor. A switch is associated with the cable and responsive to the physiological sensor connecting to and disconnecting from the cable so as to enable and disable the reading of the information element by the monitor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a pulse oximetry system;

FIGS. **2**A-B are a top view and a schematic diagram of a pulse oximetry sensor;

FIG. **3** is a perspective view of a patient cable;

FIG. **4** is a schematic diagram of a patient cable having a connector switch;

FIGS. **5**A-B are side views of unattached and attached sensor and patient cable connectors;

FIGS. **6**A-B are exploded bottom and top perspective views of a sensor connector;

FIGS. **7**A-C are bottom and side views of a spring assembly and a bottom view of a partial top shell assembly;

FIGS. **8**A-B are bottom views of a printed circuit board (PCB) and a top shell assembly;

FIGS. **9**A-C are exploded side, assembled side and assembled front views of a sensor connector;

FIG. **10** is a top view of a PCB;

FIGS. **11**A-D are exploded perspective, top, front and side views of a PCB assembly;

FIGS. **12**A-C are top, side, and detailed top views of a wired PCB assembly;

FIGS. **13**A-C are bottom, side and top views of a taped PCB assembly;

FIGS. **14**A-C are top, front, and side views of a shielded PCB assembly;

FIGS. **15**A-D are unfolded top, top, front, and side views of a connector spring; and

FIG. **16** is a side view of a spring and latch assembly.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. **3-4** illustrate an adapter patient cable **300** having a sensor connector **310** and a monitor connector **320** physically and electrically connected by a cable **330**. The sensor connector **310** has a resistor **410** (FIG. **4**) and a normally open (N.O.) switch **420** (FIG. **4**) in series with the resistor **410**. The resistor **410** functions as a sensor information element, as described above. The switch **420** is responsive to a sensor being attached or removed from the sensor connector **310**, as described below. Utilizing the switch **420** to connect and disconnect the resistor advantageously allows a connected monitor to indicate accurate status information regarding a sensor.

In particular, when a sensor is attached to the sensor connector **310**, the switch **420** moves to a closed position **522** (FIG. **5**B) connecting the resistor **410** to the monitor so that the monitor is able to read the resistor **410**. When a sensor is removed from the sensor connector **310**, the switch **420** returns to an open position **521** (FIG. **5**A) disconnecting the resistor **410** from the monitor so that the monitor is unable to read the resistor **410**. As such, the monitor is able to unambiguously detect when a sensor is attached or removed from the sensor connector **310** and, accordingly, the monitor indicates a removed sensor rather than a malfunctioning sensor.

FIGS. **5**A-B illustrate the mechanical details of inserting and removing a sensor plug **200** into the sensor connector **310**. In particular, when the plug **200** is inserted, plug contacts **201** electrically connect with the sensor connector contacts **1030**, and the tab **203** presses the switch **420** to a closed position **522**. When the plug **200** is removed, the tab **203** releases the switch **420**, which returns to its normally open position **521**.

FIGS. **6**A-B illustrate a sensor connector **310** having a cable assembly **610**, a spring assembly **620**, a top shell **630** and a bottom shell **640**. Construction of the sensor connector **310** is illustrated in detail with respect to FIGS. **7-9**. Construction of the cable assembly **610** is illustrated in detail with respect to FIGS. **10-14**. Construction of the spring assembly **620** is illustrated in detail with respect to FIGS. **15-16**.

Sensor Connector Construction

FIGS. **9**A-C illustrate a sensor connector **310** having a top shell assembly **700** and a bottom shell **640**. FIGS. **8**A-B illustrate the top shell assembly **700** having a cable assembly **610**, a spring assembly **620** and a top shell **630**. FIGS. **7**A-B illustrate the spring assembly **620** including a spring **1500**, a latch **1620** and buttons **1610** so as to secure and release the tab **203** (FIGS. **5**A-B) of a sensor plug **200** (FIGS. **5**A-B). FIG. **7**C shows the spring assembly **620** is inserted into the top shell **630** As shown in FIGS. **8**A-B, the cable assembly **610** is inserted into the top shell **630** over the spring assembly **620**. As shown in FIGS. **9**A-C, the top shell assembly **700** is attached to the bottom shell **640**. In one embodiment, the bottom shell **640** is ultrasonically welded to the top shell assembly **700**. As shown in FIGS. **9**B-C, the assembled sensor connector **310** has a front portion **910** and a back portion **920**. The front portion **910** has a socket **912** configured to removably accept a sensor plug **200** (FIGS. **5**A-B). The back portion **920** is fixedly attached to a patient cable **330** (FIG. **3**) electrically connecting the sensor to a monitor. Both sides of the sensor connector **310** have buttons **1610** adapted to release the sensor when pressed.

Cable Assembly Construction

FIGS. **14**A-B illustrate a cable assembly **610** having a printed circuit board (PCB) assembly **1100** (FIGS. **11**A-D), an attached cable **1210** (FIGS. **12**A-C) and tape **1310** (FIGS. **13**A-B). As shown in FIGS. **11**, the PCB assembly **1100** has a PCB **1000**, a bushing **1120** and contacts **1130**, a component side **1001** adapted to attach components and a plug side **1002** configured to accept a sensor plug **200** (FIGS. **5**A-B). As shown in FIGS. **10-11**A, the PCB **1000** has a bushing aperture **1012**, end slots **1014**, contact slots **1016**, and pads **1019**. The aperture **1012** is generally disposed off center of the PCB **1000** so as to accommodate the bushing **1120**. The slots **1014**, **1016** are disposed on one side of the aperture **1012** and adapted to receive the contacts **1130**. The pads **1019** are distributed on the other side of the aperture **1012** and configured for a solder connection of cable wires.

As shown in FIGS. **11**A-D, the bushing **1120** is generally cylindrical having a wide portion **1124** and a narrow portion **1126**. The wide portion **1124** accommodates a removable latch **1620** (FIGS. **16**A-B) that is configured to secure and release a sensor plug tab **203** (FIG. **2**A). The narrow portion **1126** is configured to fasten the bushing **1120** to the PCB **1000**. In particular, the bushing **1120** is inserted into the PCB **1000** on the component side **1101** so that the wide portion **1124** is seated flush with the PCB **1000** surface and the narrow portion **1126** fits inside the aperture **1012**.

Also shown in FIGS. **11**A-D, the contacts **1130** have first ends **1132** and second ends **1134** and extend through the contact slots **1016** (FIG. **10**) from the component side **1101** to the plug side **1102**. The first ends **1132** are soldered into mounting holes **1118**. A switch **420** mounted on the plug side **1102** has a mounted end **1142** soldered to the PCB assembly **1100** and a contact end **1144** movable between an open position **521** (FIG. **5**A) and a closed position **522** (FIG. **5**B), as described above.

FIGS. **12**A-C illustrate a wired PCB assembly **1200** having a PCB assembly **1100**, an attached cable **1210**, a resistor **410** and cords **1230**. Wires **1212** extend from the end of the cable **1210** and are soldered to corresponding pads **1019**. Cords **1230** are wrapped around and glued to the bushing **1120**. The resistor **410**, described above, is attached on the component side **1101**.

FIGS. **13**A-B illustrate a taped PCB assembly **1300** having a wired PCB assembly **1200** and a tape **1310** which covers the soldered ends **1132** (FIG. **11**A) of the contacts **1130** along the mounting pads **1118**. The tape **1310** has a first portion **1312** attached over the plug side **1102** and a second portion **1314** attached over the component side **1101**. In one embodiment, the tape is kapton.

FIGS. **14**A-C illustrate a cable assembly **610** having a taped PCB assembly **1300** and an EMI shield **1410**. The EMI shield **1410** has an aperture **1412** that accommodates the bushing **1120** and snaps into a bushing groove **1122**.

Spring Assembly Construction

FIGS. **15**A-D illustrate a connector spring **1500** which actuates a latch **1620** (FIG. **10**) to secure and release a sensor plug **200** (FIG. **2**A). The connector spring **1500** has a spring bar **1510** and foldable sides **1520**. The spring bar **1510** extends between the sides **1520** and has a centered aperture **1512** that accommodates a latch **1620** (FIG. **16**). The sides **1520** have mounting holes **1522** configured to attach buttons **1610** (FIG. **16**). The sides **1520** are bent so as to extend generally perpendicular to the spring bar **1510**.

FIG. **16** illustrates a spring assembly **1600** having a connector spring **1500**, buttons **1610** and a latch **1620**. The buttons **1610** have inserts **1612** that snap into the corresponding mounting holes **1522** so as to fasten the buttons **1610** to the connector spring **1500**. The latch **1620** has a inclined face **1622** and an opposite flat face **1624** and is

secured into the connector spring **1500** so that the flat face **1624** fits into the aperture **1512** and is secured with the connector spring **1500**. The latch **1620** is adapted to fit through the bushing **1120** (FIG. **11**A). When the buttons **1610** are pressed, the sides **1520** are compressed, flexing the spring bar **1510** so as to actuate the latch **1620**.

A connector switch was described above with respect to a patient cable interconnecting a disposable finger sensor and a pulse oximetry monitor. A connector switch, however, is applicable to an interconnection between any physiological sensor for attachment to various tissue sites and any corresponding monitor for measuring various physiological parameters, such as other hemoglobin species and blood glucose to name a few. Also, a connector switch was described above in terms of a switch employing a mechanical mechanism that is physically actuated to perform an electrical connection and disconnection function. Other connector switch embodiments include a switch or switches employing, for example, electrical, electromechanical, optoelectrical or electromagnetic mechanisms, to name a few, that are physically, electrically, magnetically or optically actuated to perform an electrical connection and disconnection function. Examples include, but are not limited to, transistor, optical and proximity switches and relays among others.

Further, a connector switch was described in terms of a single pole, single throw switch connecting and disconnecting a resistor between cable conductors. Other connector switch embodiments include multiple switches or multiple pole, multiple throw switches capable of selecting and deselecting or otherwise enabling and disenabling or switching between multiple information elements, including passive components, active components and various memory devices. In addition, although a connector switch was described above in terms a normally open switch, a connector switch includes a normally closed switch or switches, or a combination of normally open and normally closed switches.

A connector switch has been disclosed in detail in connection with various embodiments. These embodiments are disclosed by way of examples only and are not to limit the scope of the claims that follow. One of ordinary skill in art will appreciate many variations and modifications.

What is claimed is:

1. An interconnection between a noninvasive optical sensor and a monitor configured to receive one or more signals from said sensor indicative of light attenuated by body tissue, the monitor also configured to determine measurements for one or more physiological parameters based on the received one or more signals, the interconnection comprising:

a cable having a plurality of conductors providing electrical communication between a sensor connector and a monitor connector;

an information element readable by said monitor to determine information about a type of said sensor and to configure said monitor in its determination of said one or more physiological parameters based on said type, and mounted in one of said sensor connector, said monitor connector and said cable; and

a switch mounted in said sensor connector responsive to said sensor connecting to and disconnecting from said sensor connector so as to alter the readability of said information element.

2. The interconnection according to claim **1** wherein said switch has a closed position enabling said information element to be readable by said monitor and an open position disabling said information element from being readable by said monitor.

3. The interconnection according to claim **2** wherein said switch is normally in said open position and moves from said open position to said closed position as said sensor is connected to said sensor connector.

4. The interconnection according to claim **3** wherein said information element is a resistor and said switch electrically connects said resistor between a pair of said conductors so as to enable said monitor to determine a value for said resistor.

5. An interconnection method comprising the steps of:

providing a cable configured to communicate drive signals from a physiological parameter monitor to a noninvasive optical sensor capable of outputting a signal indicative of light attenuated by body tissue, and to communicate physiological signals from said sensor to said monitor;

associating an information element with said cable, said information element capable of conveying information regarding said sensor to said monitor; and

actuating a switch in response to said sensor connecting and disconnecting to said cable so as to render said information element readable and unreadable by said monitor, respectively.

6. The interconnection method according to claim **5** wherein said associating step comprises a substep of mounting said information element in a connector attached to said cable.

7. The interconnection method according to claim **6** wherein said actuating step comprising a substep of mechanically moving said switch with a portion of said sensor.

8. The interconnection method according to claim **7** wherein said actuating step comprising a substep of electrically connecting said information element to a conductor of said cable.

9. A sensor-monitor interconnection comprising:

a cable capable of communicate signals between a physiological sensor and a physiological parameter monitor;

an information element capable of conveying information regarding said sensor to said monitor; and

a switch associated with said cable and responsive to said physiological sensor connecting to and disconnecting from said cable so as to enable and disable access to said information element by said monitor.

10. The sensor-monitor interconnection according to claim **9** further comprising:

a sensor connector attached to said cable capable of electrically and mechanically connecting said sensor to said cable; and

a monitor connector attached to said cable capable of electrically and mechanically connecting said cable to said monitor,

wherein said information element is mounted within at least one of said sensor connector and said monitor connector.

11. The sensor-monitor interconnection according to claim **10** further comprising a plurality of conductors disposed within said cable, wherein said switch is adapted to connect and disconnect said information element to at least one of said conductors.

12. The sensor-monitor interconnection according to claim **11** further comprising a sensor portion configured to actuate said switch as said sensor is connected to said sensor connector.

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