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Kiani et al.

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(54) **PULSE OXIMETER PROBE-OFF DETECTION SYSTEM**

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(22) Filed: **Jun. 16, 2000**

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(51) **Int. Cl.**[7] **A61B 5/00**
(52) **U.S. Cl.** **600/322**; 600/344
(58) **Field of Search** 600/309–310, 600/322–324, 316, 344; 356/39–42

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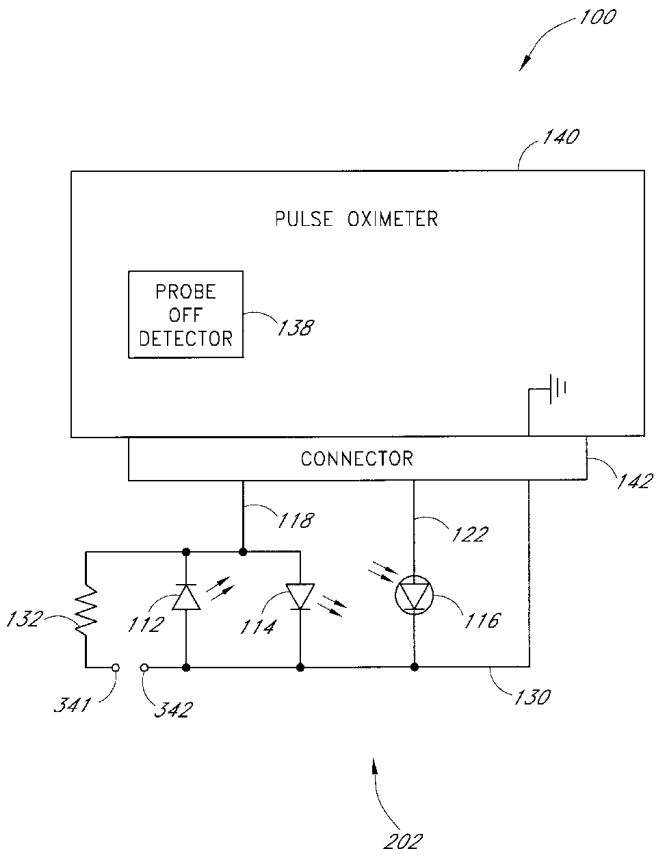
(57) **ABSTRACT**

The present invention provides a number of improvements that can be incorporated into a pulse oximeter probe to detect when a probe has become dislodged from a patient and/or to prevent a probe-off condition. A probe-off condition occurs when the optical probe becomes partially or completely dislodged from the patient, but continues to detect an AC signal within the operating region of the pulse oximeter. In one aspect, the present invention provides electrical contacts that contact the skin of a patient when the probe is properly attached. In another aspect, the present invention provides a number of louvers placed in front of the sensor's photodetector to filter out oblique light rays that do not originate from a point in front of the detector. Accordingly, if the emitter and photodetector are not properly aligned, the photodetector will not produce a signal within the valid operating range of the pulse oximeter. In accordance with a method of the present invention the pulse oximeter can sound an alarm or display a warning if it determines that the probe is not properly attached to the patient.

47 Claims, 15 Drawing Sheets



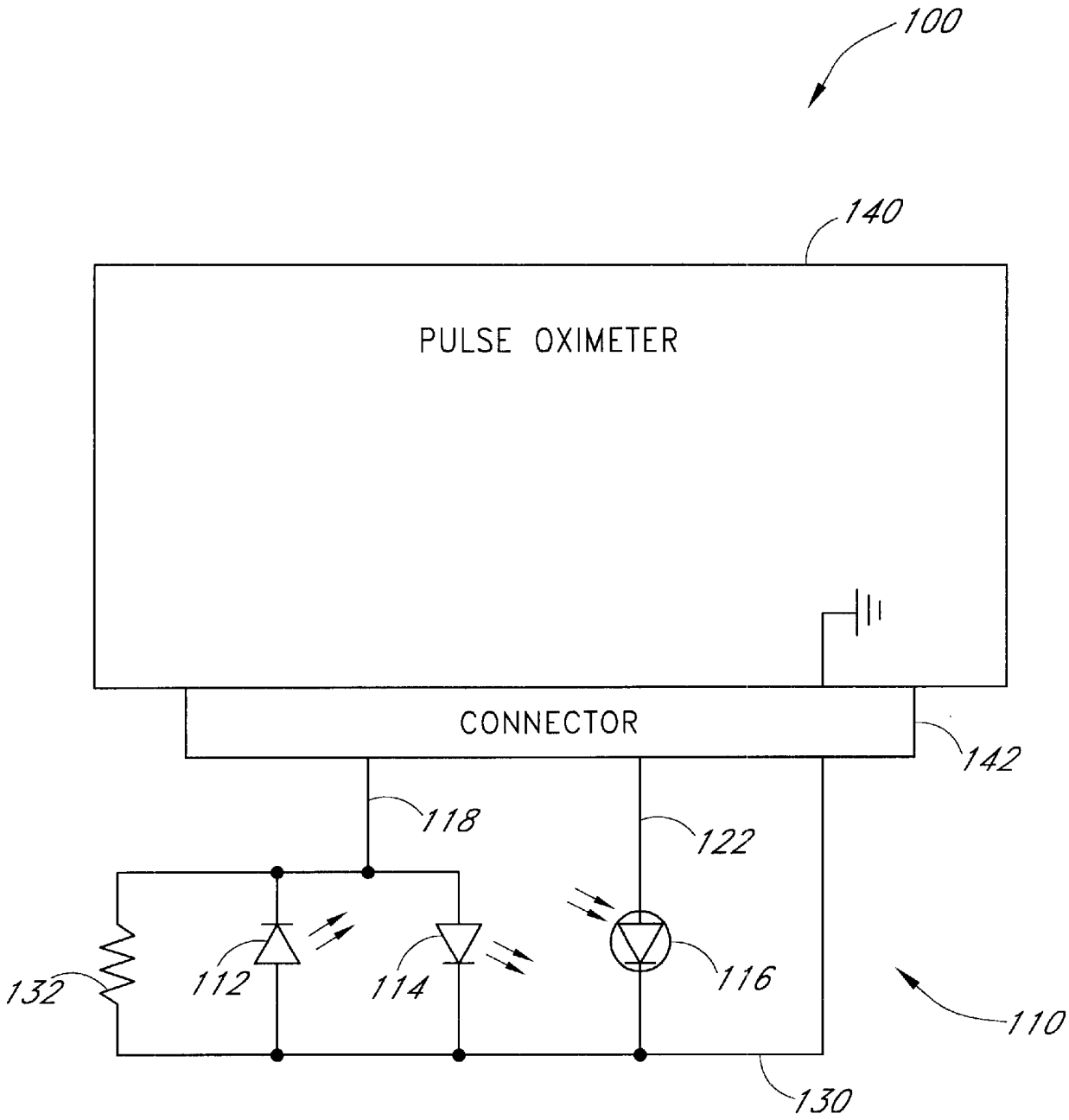

100
140
PULSE OXIMETER
CONNECTOR
142
118
122
132
112
114
116
110
130

FIG. 1

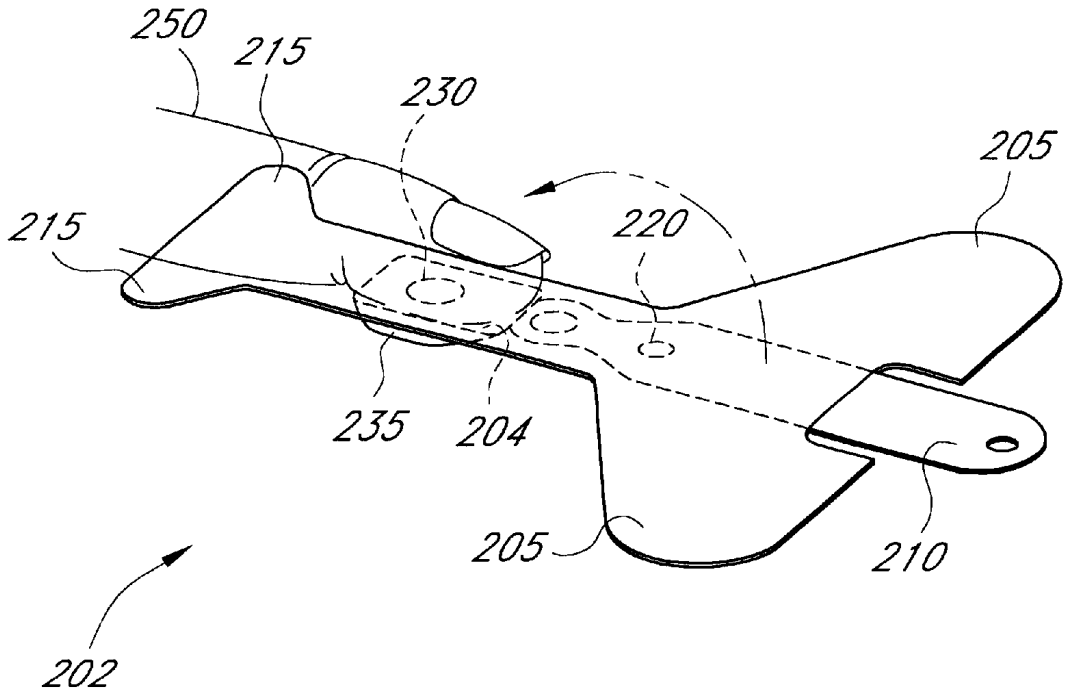

250
215
230
205
215
220
235
204
205
210
202

FIG. 2A

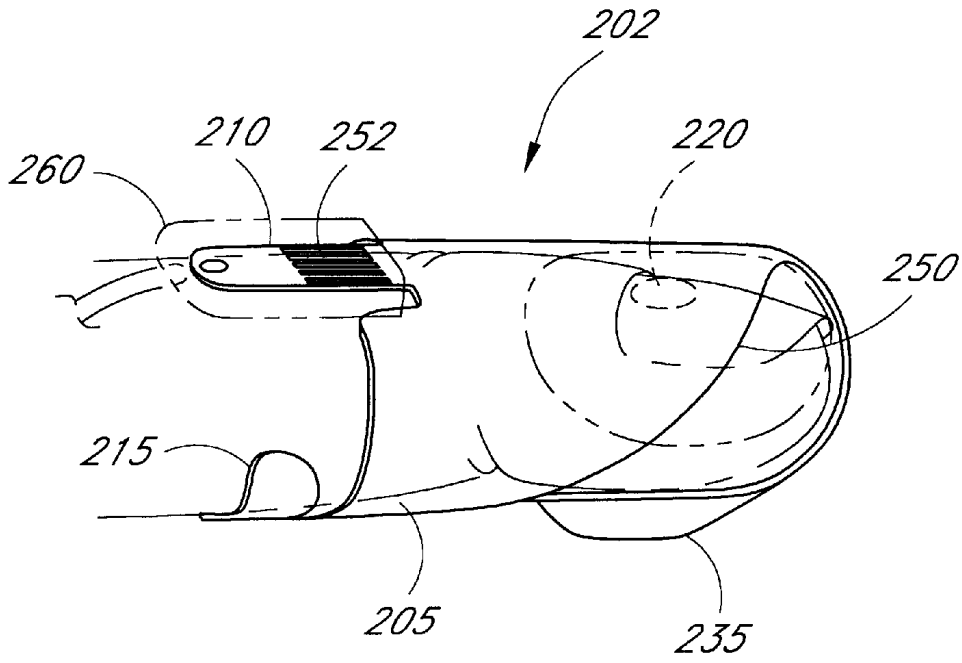

202
210
252
220
260
250
215
205
235

FIG. 2B

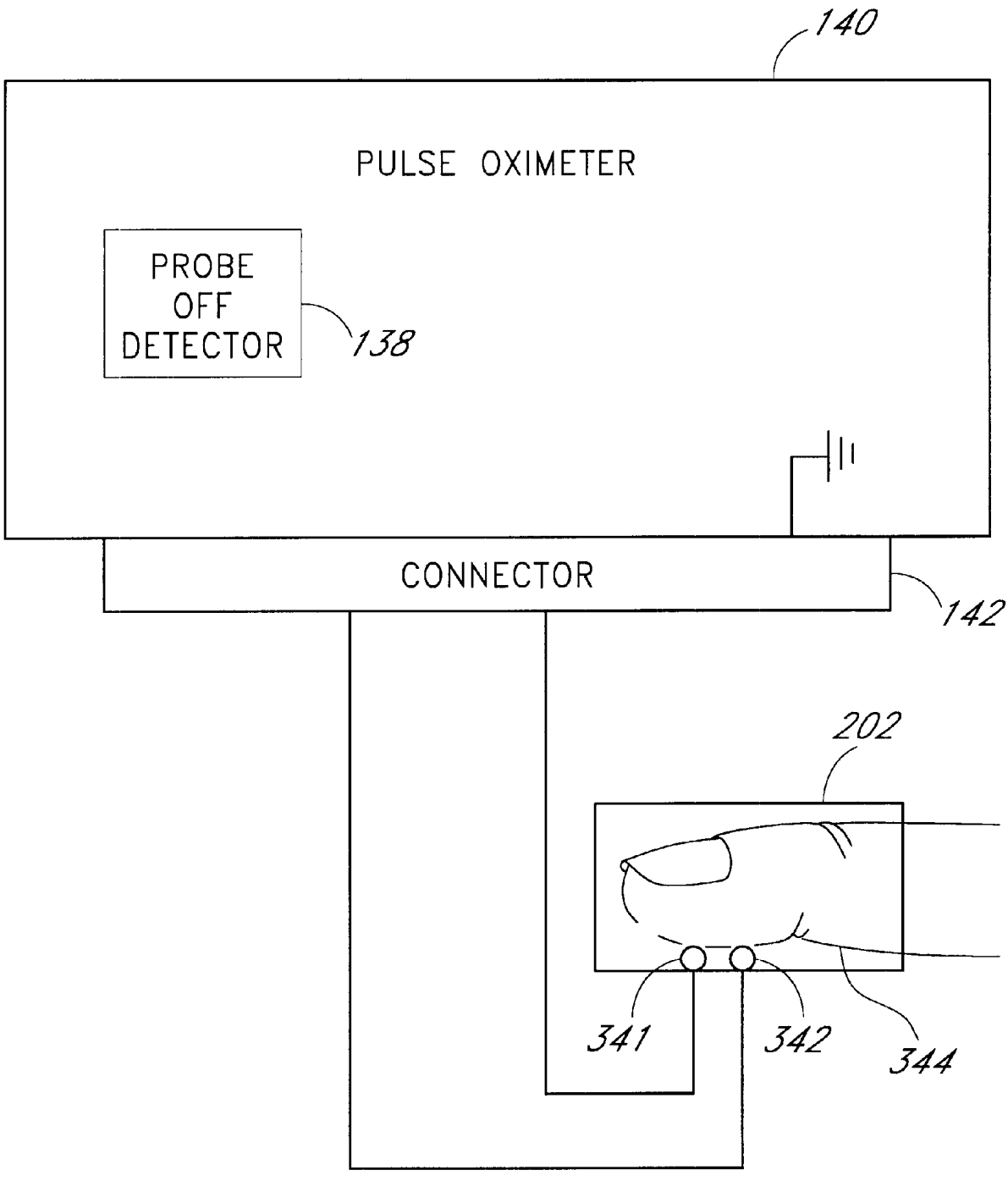

140
PULSE OXIMETER
PROBE OFF DETECTOR
138
CONNECTOR
142
202
341
342
344

FIG. 3A

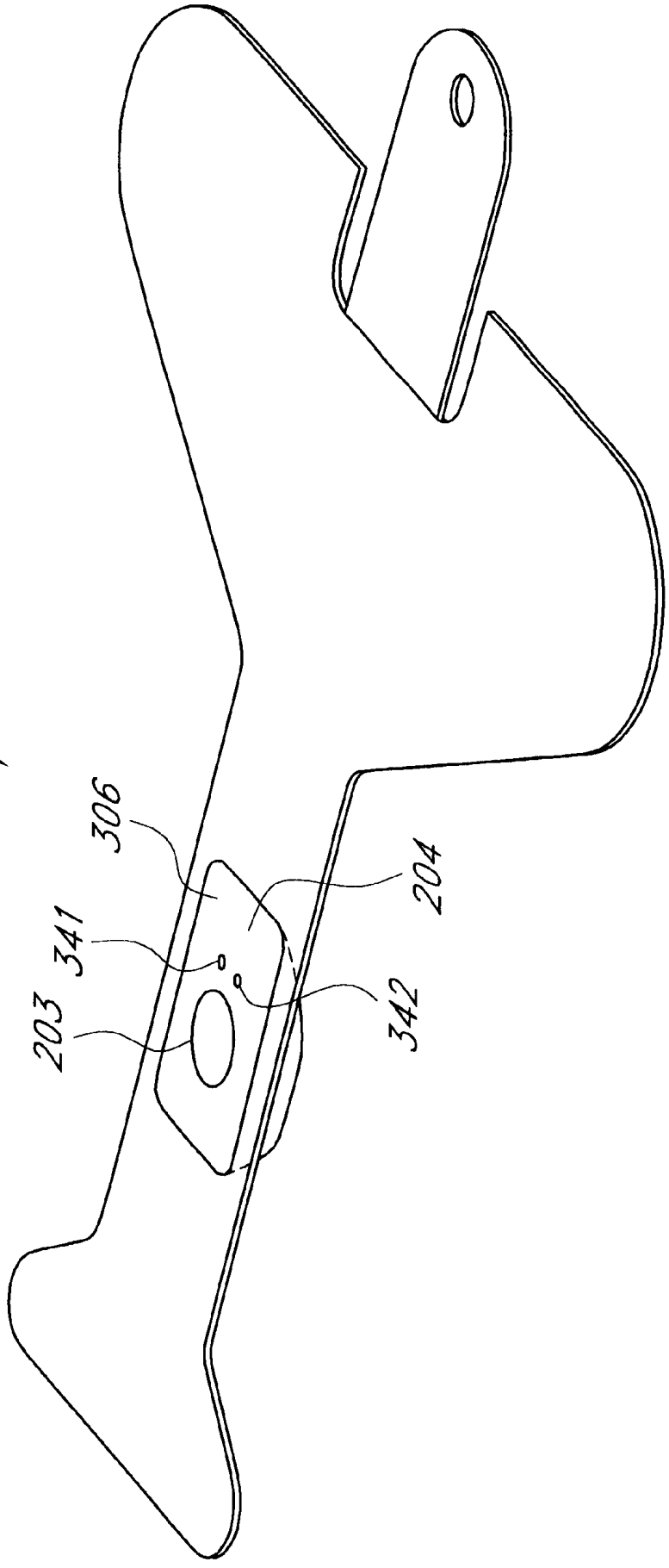


FIG. 3B

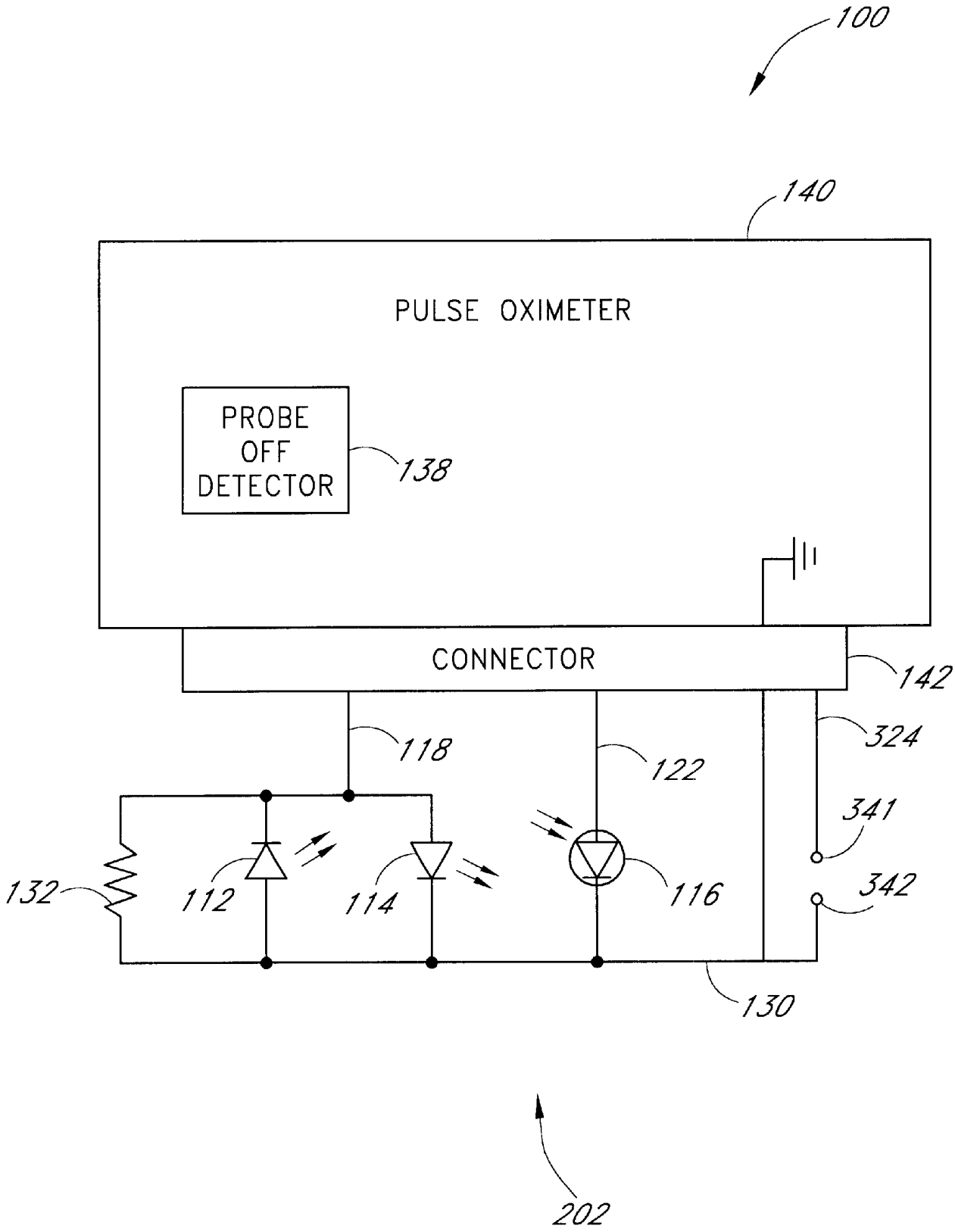

100
140
PULSE OXIMETER
PROBE OFF DETECTOR
138
CONNECTOR
142
118
122
324
341
342
132
112
114
116
130
202

FIG. 3C

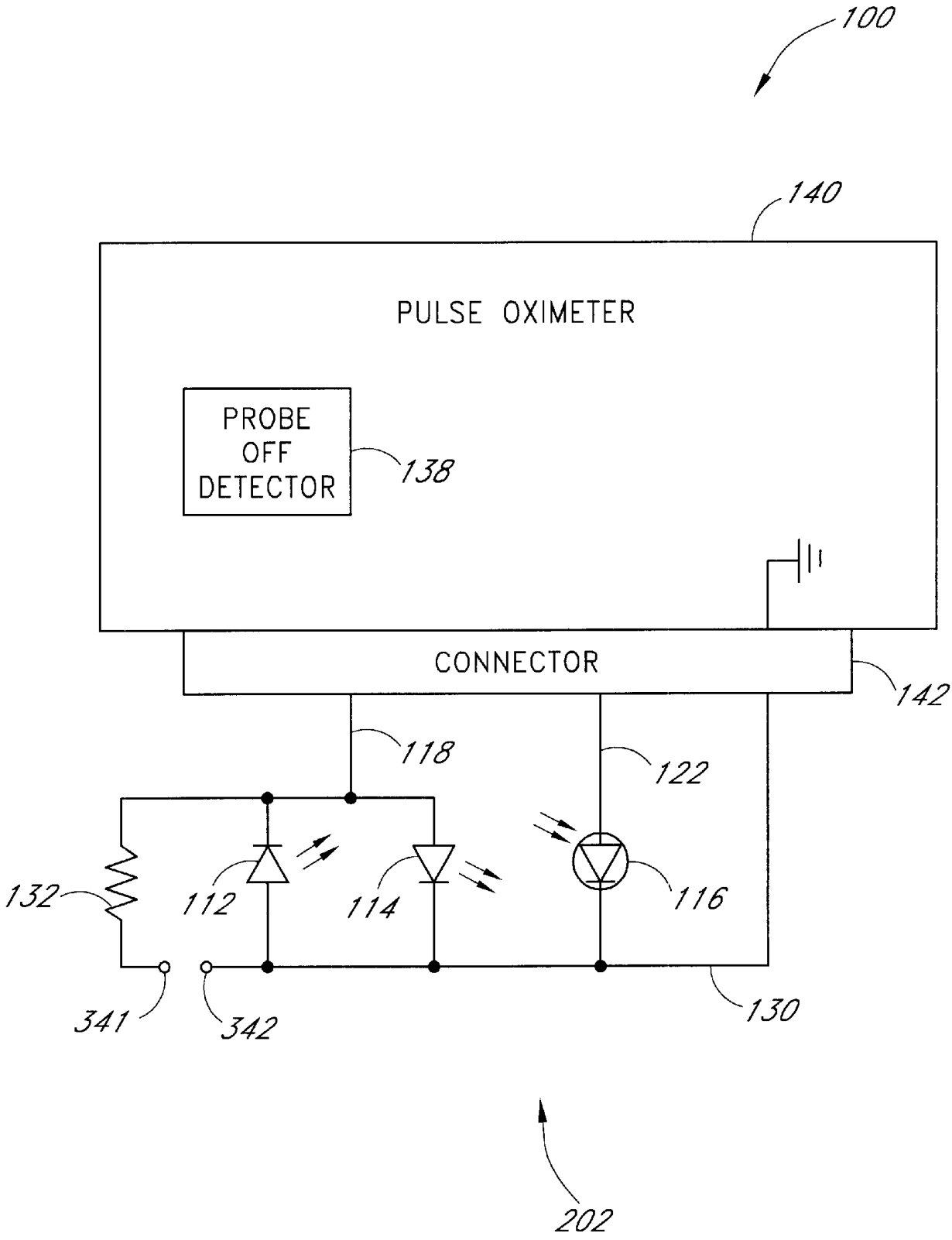

100
140
PULSE OXIMETER
PROBE OFF DETECTOR
138
CONNECTOR
142
118
122
132
112
114
116
341
342
130
202

FIG. 3D

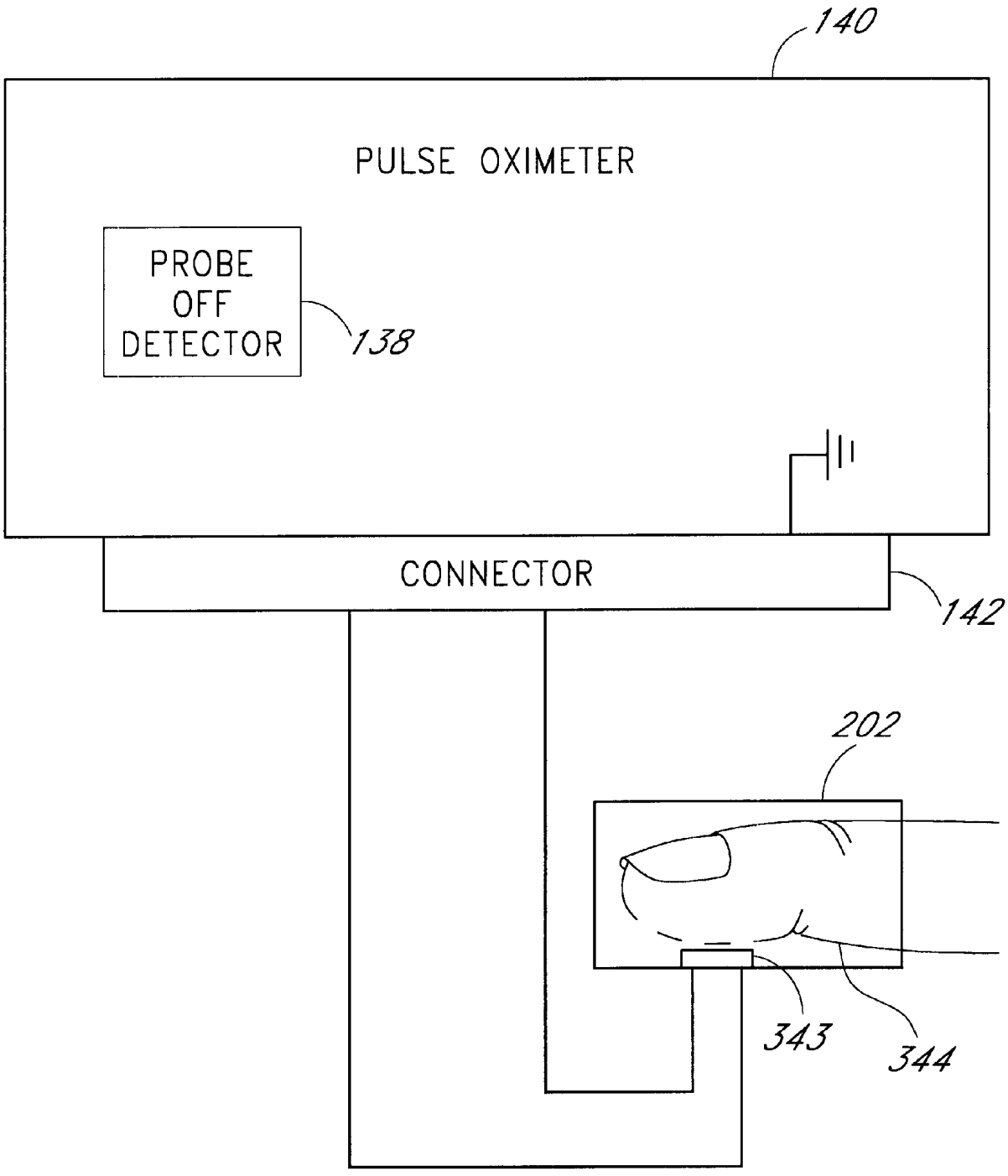

140
PULSE OXIMETER
PROBE OFF DETECTOR
138
CONNECTOR
142
202
343
344

FIG. 3E

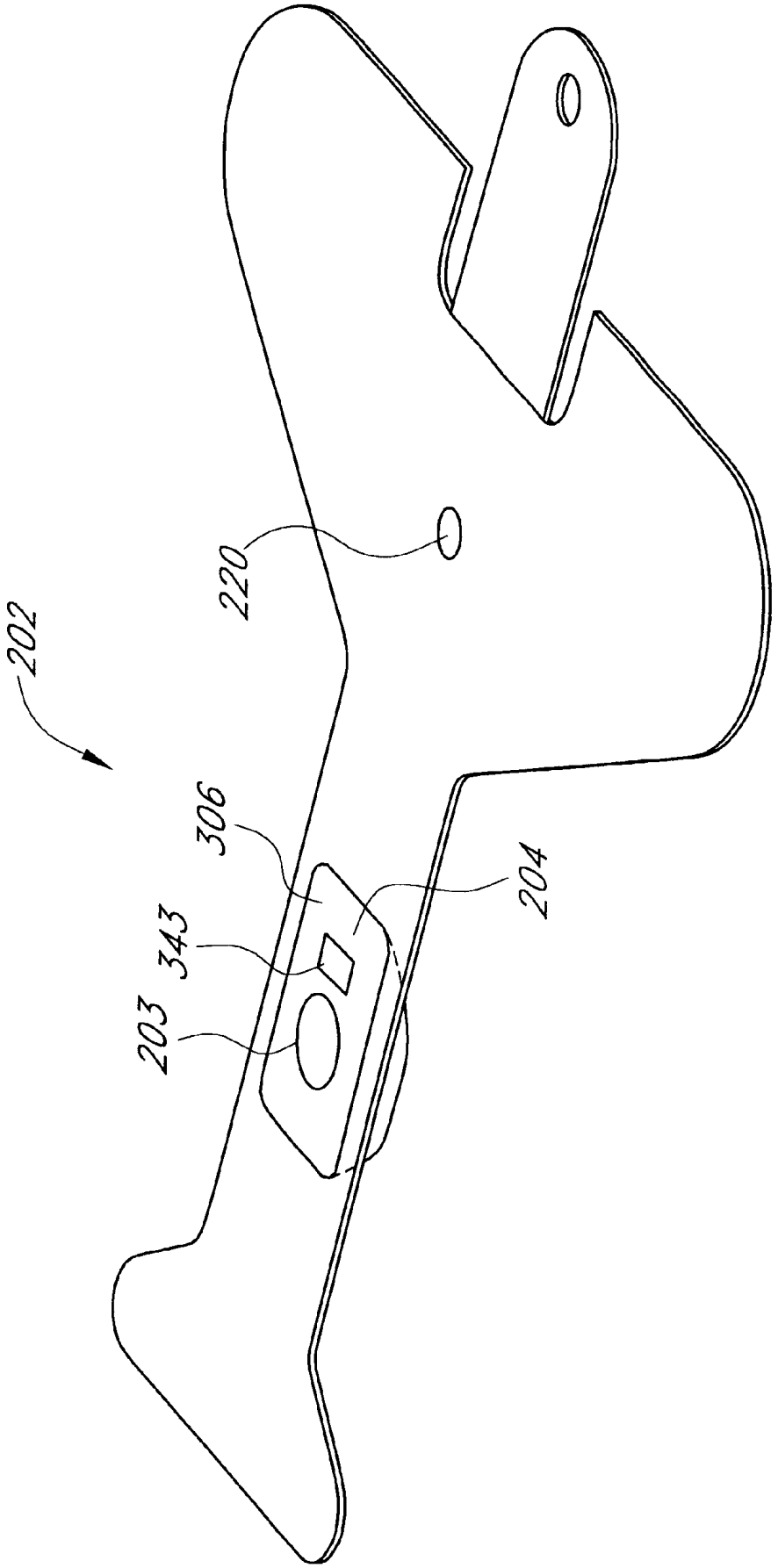


FIG. 3F

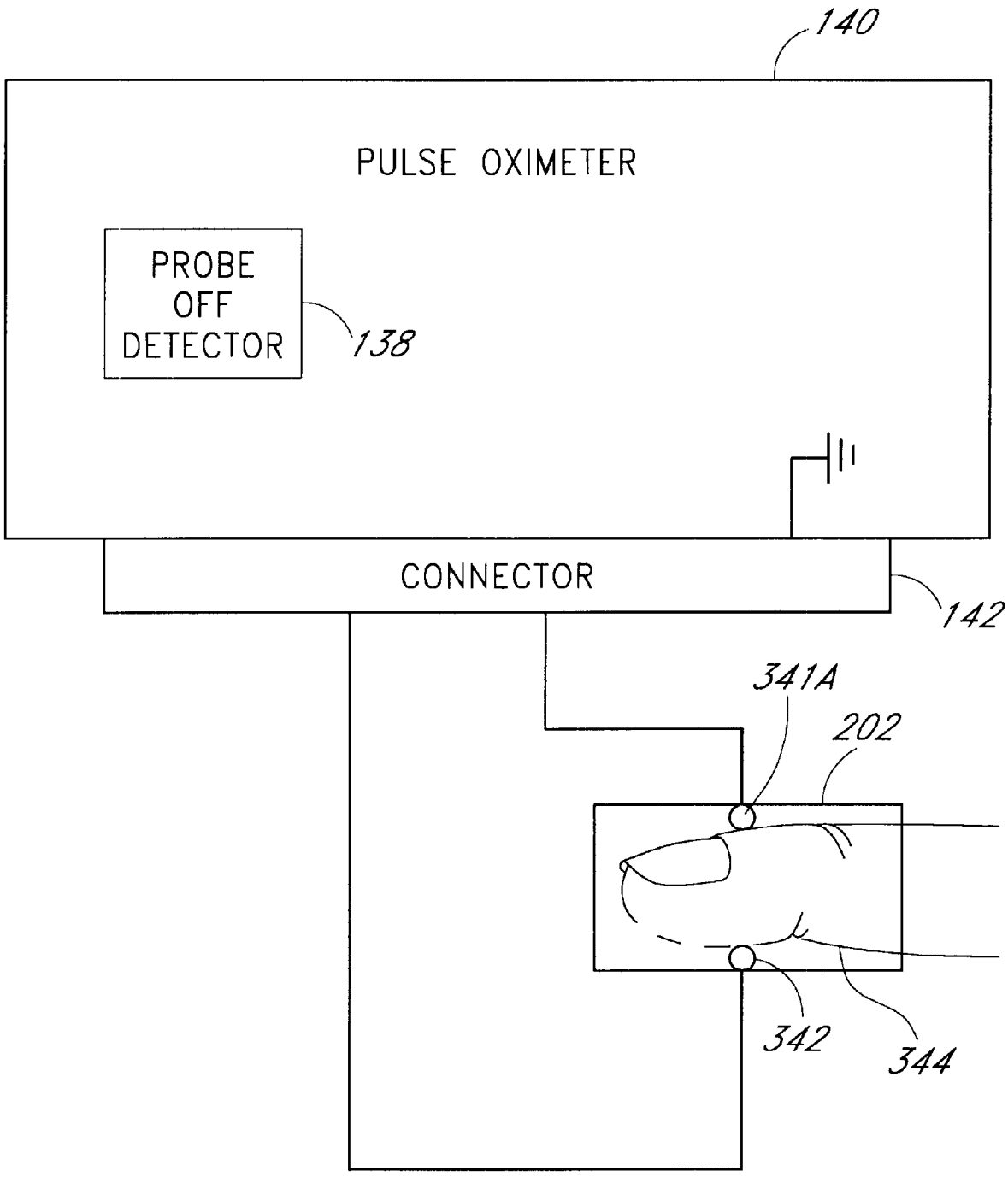

140
PULSE OXIMETER
PROBE OFF DETECTOR
138
CONNECTOR
142
341A
202
342
344

FIG. 3G

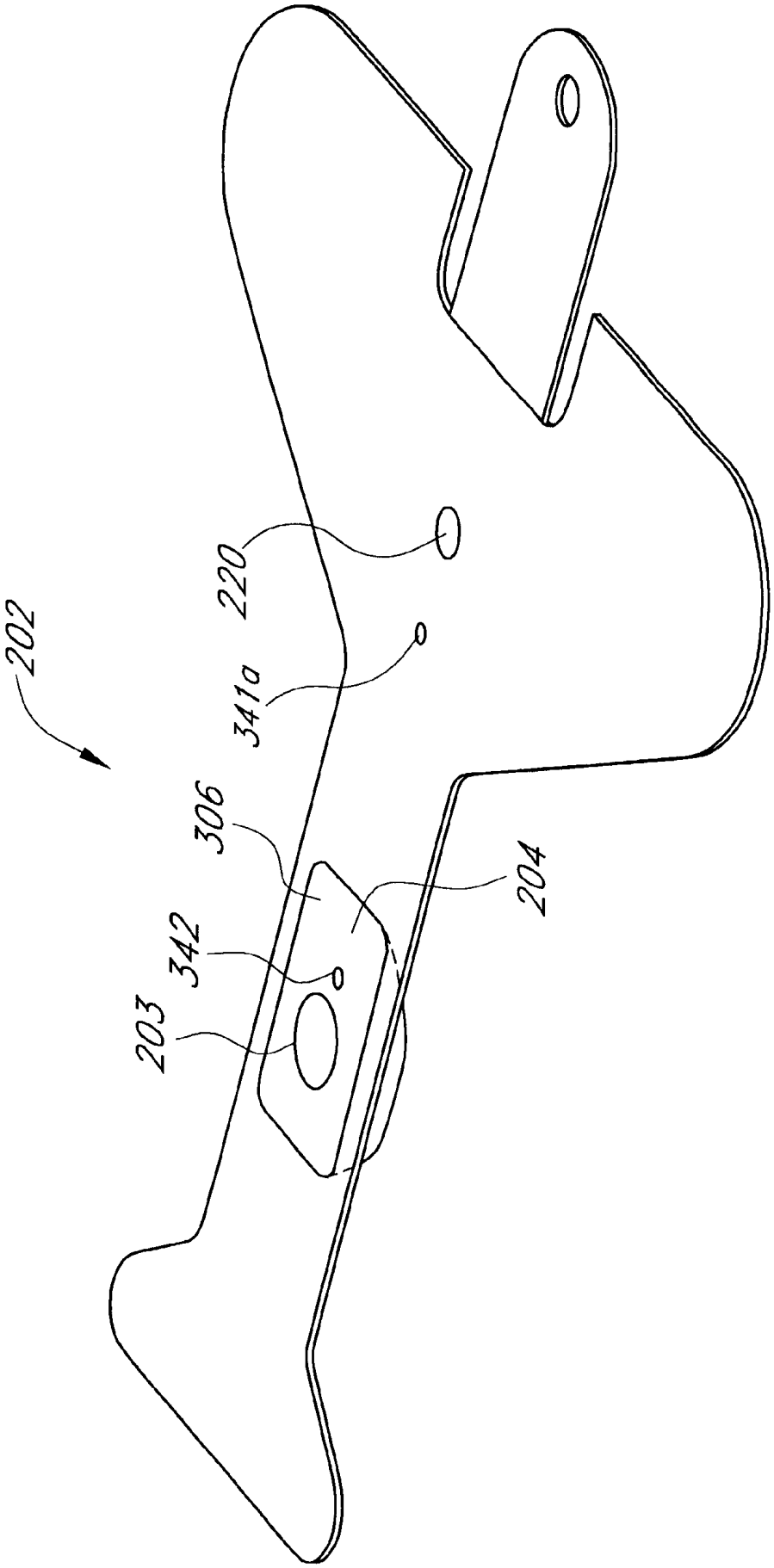


FIG. 3H

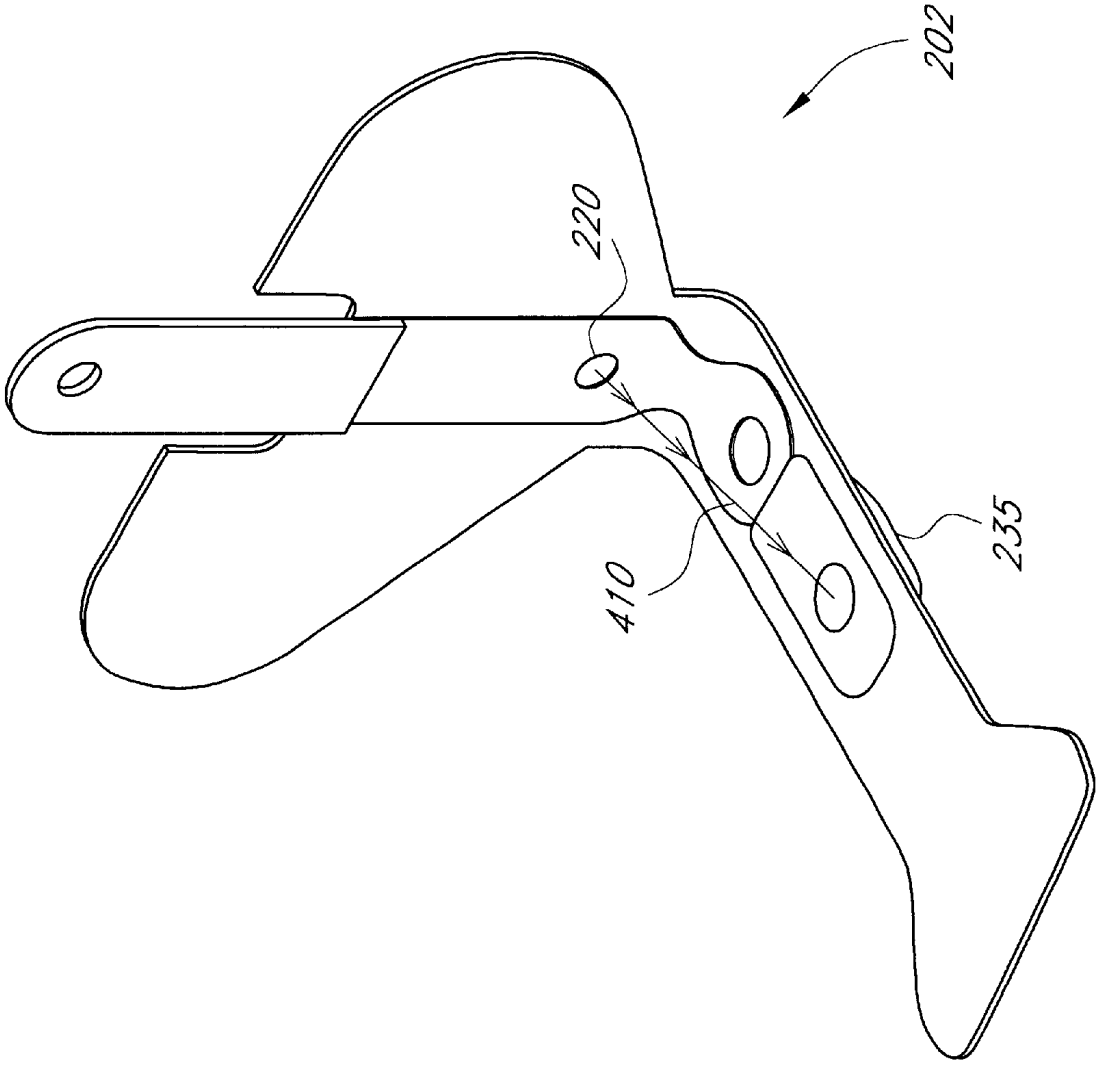


FIG. 4

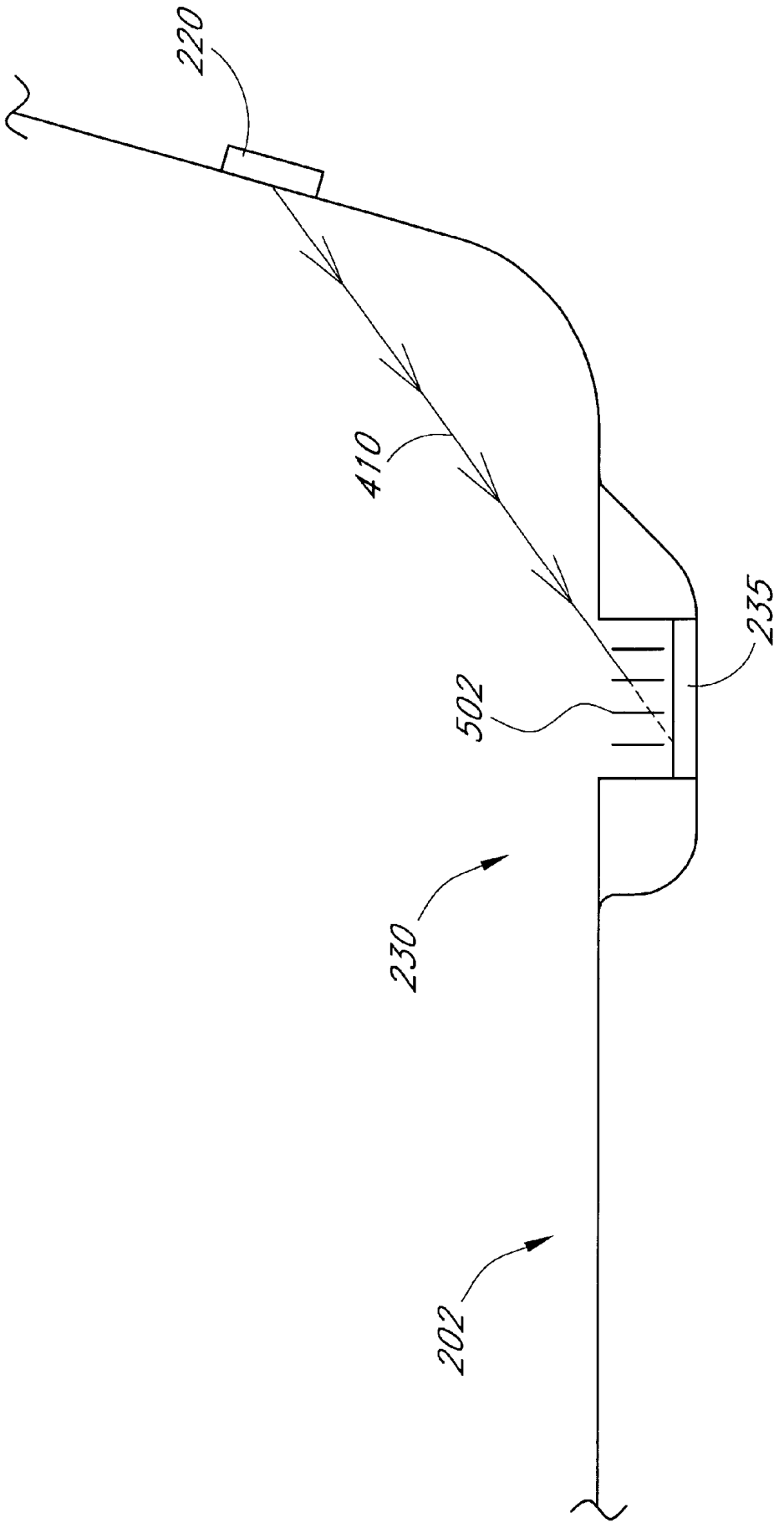


FIG. 5A

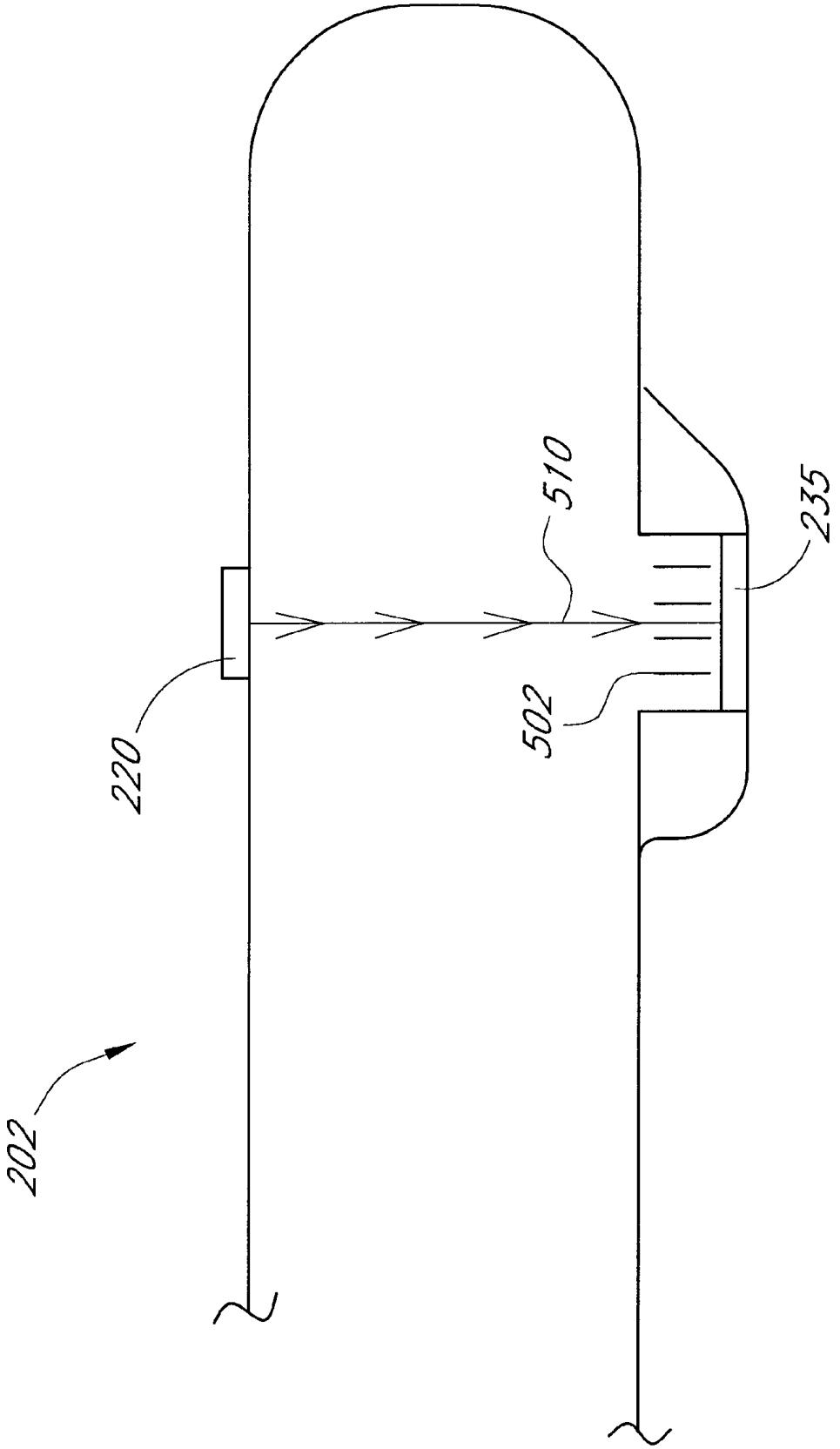


FIG. 5B

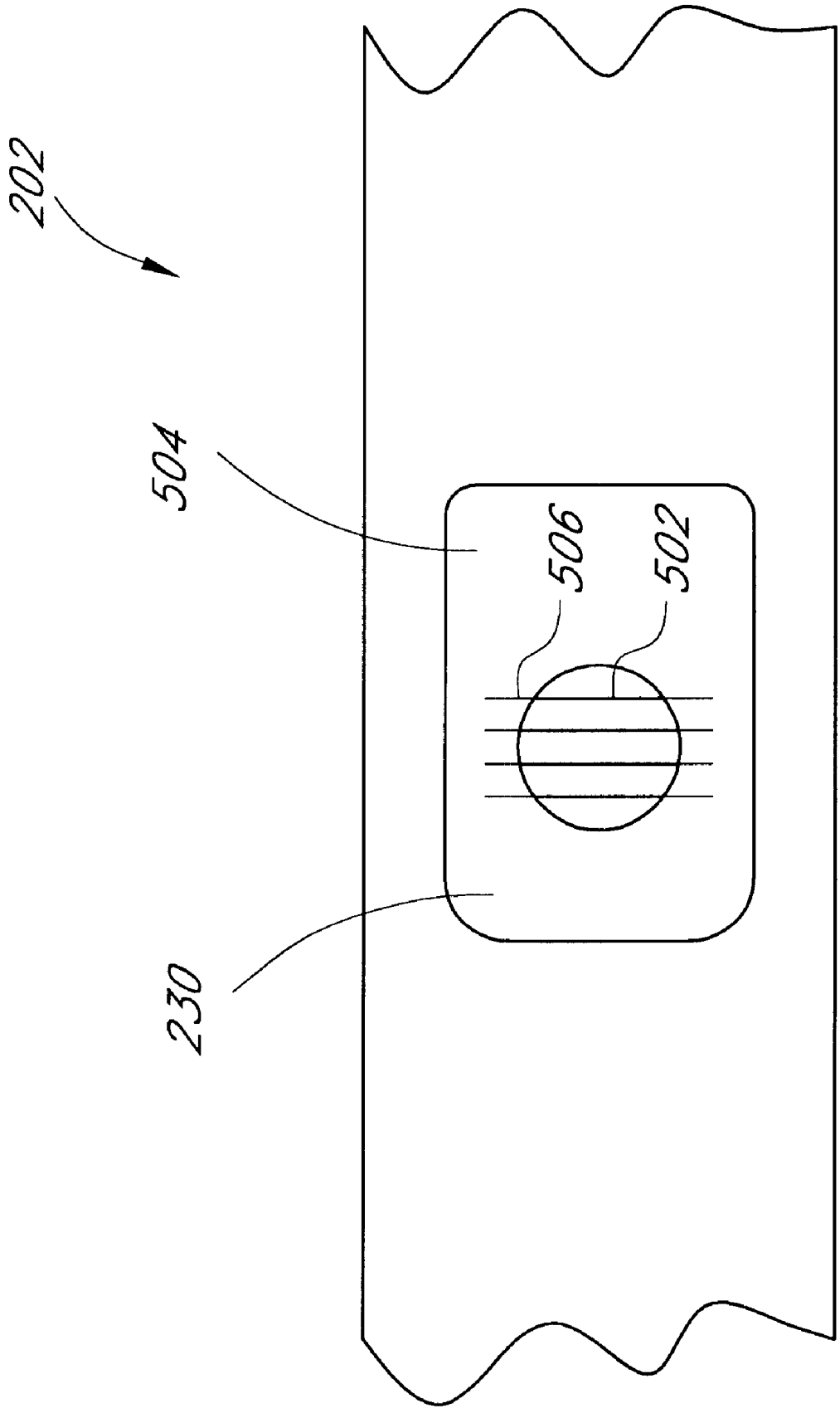


FIG. 5C

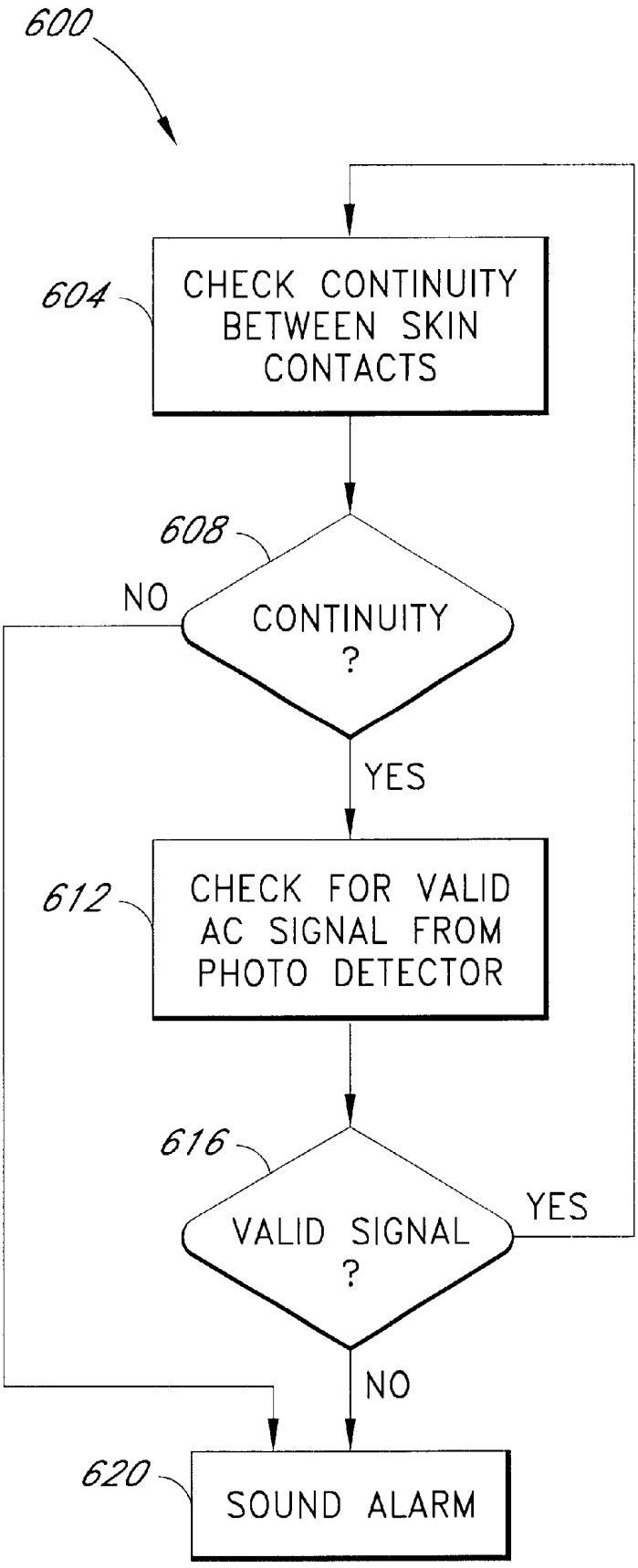

600
604
CHECK CONTINUITY BETWEEN SKIN CONTACTS
608
NO
CONTINUITY ?
YES
612
CHECK FOR VALID AC SIGNAL FROM PHOTO DETECTOR
616
VALID SIGNAL ?
YES
NO
620
SOUND ALARM

FIG. 6

PULSE OXIMETER PROBE-OFF DETECTION SYSTEM

Applicant claims priority to prior filed Provisional Application No. 60/140,000 filed Jun. 18, 1999.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to optical probes that can be attached to the finger, toe, or appendage of a patient. More particularly, the present invention relates to devices and methods for identifying when a probe has become dislodged from a patient.

2. Description of the Related Art

Oximetry is the measurement of the oxygen status of blood. Early detection of low blood oxygen is critical in the medical field, for example in critical care and surgical applications, because an insufficient oxygen supply can result in brain damage and death in a matter of minutes. Pulse oximetry is a widely accepted noninvasive procedure for measuring the oxygen saturation level of arterial blood, an indicator of oxygen supply. A pulse oximetry system generally consists of a probe attached to a patient, a monitor, and a cable connecting the probe and monitor. Conventionally, a pulse oximetry probe has both red and infrared (IR) light-emitting diode (LED) emitters and a photodiode detector. The probe is typically attached to a patient's finger or toe, or a very young patient's foot. For a finger, the probe is configured so that the emitters project light through the fingernail, the arteries, vessels, capillaries, tissue and bone. The photodiode is positioned opposite the LED so as to detect the LED transmitted light as it emerges from the finger tissues.

The pulse oximetry monitor (pulse oximeter) determines oxygen saturation by analyzing the differential absorption by arterial blood of the two wavelengths emitted by the probe. The pulse oximeter alternately activates the probe LED emitters and reads the resulting current generated by the photodiode detector. This current is proportional to the intensity of the detected light. The pulse oximeter calculates a ratio of detected red and infrared intensities, and an arterial oxygen saturation value is empirically determined based on the ratio obtained. The pulse oximeter contains circuitry for controlling the probe, processing the probe signals and displaying the patient's oxygen saturation and pulse rate. A pulse oximeter is described in U.S. Pat. No. 5,632,272 assigned to the assignee of the present invention.

SUMMARY OF THE INVENTION

The present invention provides a number of improvements that can be incorporated into a pulse oximeter probe to detect when a probe has become dislodged from a patient and/or to prevent a probe-off condition. A probe-off condition occurs when the optical probe becomes partially or completely dislodged from the patient, but may continue to detect an AC signal within the operating region of the pulse oximeter.

In one aspect, the present invention provides a number of electrical contacts that contact the skin of a patient when the probe is properly attached. The pulse oximeter can check the continuity through the contacts to determine whether the probe is properly attached. If the probe is not properly attached, the pulse oximeter can identify a probe-off condition even though the oximeter measures an AC signal that appears like the probe is still attached.

In another aspect, the present invention provides a number of louvers placed in front of the probe's photodetector to filter out oblique light rays that do not originate from a point in front of the detector. If the probe becomes dislodged, the emitter will not likely remain in front of the photodetector. If the emitter and photodetector are not properly aligned, the photodetector will not produce a signal within the valid operating. range of the pulse oximeter. The louvers prevent light from an oblique angle from reaching the photodetector and creating a false signal that might be interpreted by the pulse oximeter as a physiological signal. Accordingly, the pulse oximeter can determine that a probe has become dislodged when the photodetector does not produce a valid signal. Furthermore, probe-off conditions can avoided since oblique light rays are not able to reach the photodetector to produce an apparently valid signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings in which like reference numbers represent corresponding components throughout:

FIG. **1** illustrates a schematic of one embodiment of a pulse oximeter system;

FIGS. **2**A–B depict an optical probe and the attachment of the optical probe on the fingertip of an adult patient;

FIG. **3**A illustrates a schematic of a pulse oximeter system that incorporates electrical contacts to the skin of a patient, in accordance with one embodiment of the present invention;

FIG. **3**B illustrates a perspective view of an optical probe incorporating electrical contacts to the skin of a patient;

FIG. **3**C illustrates a schematic of one embodiment of a pulse oximeter system that incorporates electrical contacts to the skin of a patient;

FIG. **3**D illustrates a schematic of a preferred embodiment of a pulse oximeter system that incorporates a number of electrical contacts to the skin of a patient;

FIG. **3**E depicts a generalized schematic of a pulse oximeter that incorporates another embodiment of a contact on a pulse oximeter probe;

FIG. **3**F depicts a perspective view an optical probe incorporating the embodiment of FIG. **3**E;

FIG. **3**G depicts a generalized schematic of a pulse oximeter system that incorporates another embodiment of a contact sensor in accordance with the present invention;

FIG. **3**H depicts a perspective view of an optical probe incorporating the contact sensor of FIG. **3**G;

FIG. **4** illustrates a probe that has become unfastened;

FIG. **5**A illustrates a probe wherein a number of louvers are placed in front of the detector assembly;

FIG. **5**B illustrates a properly attached probe wherein a number of louvers are placed in front of the detector assembly;

FIG. **5**C illustrates a top plan view of a preferred embodiment of a probe wherein a number of louvers are placed in front of the detector assembly

FIG. **6** illustrates a flow chart of the method of detecting a dislodged probe.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

To compute peripheral arterial oxygen saturation, denoted Sp_aO_2, pulse oximetry relies on the differential light absorption of oxygenated hemoglobin, HbO_2, and deoxygenated

hemoglobin, Hb. This differential absorption is measured at the red and infrared wavelengths of the probe. In addition, pulse oximetry relies on the pulsatile nature of arterial blood to differentiate hemoglobin absorption from absorption of other constituents in the surrounding tissues. Light absorption between systole and diastole varies due to the blood volume change from the inflow and outflow of arterial blood at a peripheral tissue site. The tissue site might also comprise skin, muscle, bone, venous blood, fat, pigment, etc., each of which absorbs light. Blood oxygen saturation measurements are based upon a ratio of the time-varying or AC portion of the detected red and infrared signals with respect to the time-invariant or DC portion. This AC/DC ratio normalizes the signals and accounts for variations in light pathlengths through the measured tissue.

As reproduced in FIG. **1**, a schematic of one embodiment of a pulse oximeter system **100** is disclosed in U.S. Pat. No. 5,758,644 (the '644 patent), assigned to the assignee of the present application and incorporated herein by reference. The system **100** comprises a pulse oximeter **140**, which is attached through a connector **142** to a probe **110**. The probe **110** comprises a first LED **112**, a second LED **114** and a photodetector **116**. The first and second LEDs **112** and **114** are connected back-to-back and share a common electrical connection **118**. The photodetector **116** has its own electrical connection **122**. Each of the LEDs **112** and **114** and the photodetector **116** are connected at their outputs to a common ground electrical connection **130**. The two LEDs **112** and **114** are preferably configured to produce different wavelengths of light, which pass through the flesh of a patient to be detected by the photodetector **116**. The oximeter **140** can select the LED to be driven by applying either a positive or negative voltage to the connection **118**. A coding resistor **132** has a resistance that can measured by the pulse oximeter **140** to determine the particular characteristics of the probe **110**. The coding resistor **132** is coupled in parallel with the first LED **112** or the second LED **114**. The resistor **132** can be used to indicate the operating wavelength of the first and second LEDs **112** and **114**, or to indicate the type of probe. In order to read the coding resistor **132**, the pulse oximeter **140** drives the first LED **112**/coding resistor **132** combination at a level that is low enough that the LED draws insignificant current. At this level, significantly all of the current flows through the coding resistor **132** and the pulse oximeter **140** can determine the value of the resistor in accordance with Ohm's law. By configuring the coding resistor **132** in parallel with one of the LEDs **112**, **114**, the added expense of an additional lead connecting the pulse oximeter **140** to the probe **110** can be saved.

One embodiment of a disposable probe for use with pulse oximetry systems is disclosed in U.S. Pat. No. 5,782,757, assigned to the assignee of the present application and incorporated herein by reference. FIGS. **2**A–B depict the optical probe **202** and the attachment of the optical probe **202** on the fingertip **250** of an adult patient. The disposable optical probe **202** is designed to fit comfortably onto a patient's fingertip. As illustrated in FIG. **2**A, the probe **202** includes a central portion **204**, a pair of adhesive flanges **205** extending from the central portion **204**, a connector portion **210** situated between the flanges **205**, and a pair of smaller adhesive flaps **215** extending from the central portion **204** on the end of the optical probe **202** opposite from a connector tab **210**. The probe **202** further includes an emitter aperture **220** with a number of emitters (e.g., a light-emitting diodes) positioned within the central portion **204** close to the connector portion **210**, and a detector aperture **230** which allows light to pass through the detector aperture **230** to a detector assembly **235**. An adult fingertip **250** is shown in phantom in FIG. **2**A to illustrate the position at which the fingertip **250** is placed when the probe **202** is to be fastened onto the fingertip **250** for use. Although not depicted specifically in FIGS. **2**A–**2**B, the probe **202** is typically fabricated from multiple layers.

FIG. **2**B illustrates the probe **202** fastened onto the fingertip **250**. As shown in FIG. **2**B, the probe **202** folds to conform to the very end of the fingertip. The adhesive flaps **205** fold downward (in the illustration of FIG. **2**B) to wrap around the fingertip **250** while the adhesive flaps **215** fold upward (in the illustration of FIG. **2**B) about a portion of the circumference of the fingertip **250** to provide support. As shown in FIG. **2**B, when the probe **202** is folded about the fingertip **250**, the emitters located within the probe are spaced opposite the detector assembly **235** such that light from the emitters passes through the emitter aperture **220**, through the finger **250** and is incident upon the detector assembly **235** through the detector aperture **230**.

FIG. **2**B depicts a receiving connector portion **260** which engages with contacts **252** on the connector **210** to provide an electrical connection between the optical probe **202** and the pulse oximeter **140**. Once the optical probe **202** is securely fastened to the fingertip **250** and the connector **210** provides an electrical connection between the optical probe **202** and digital signal processing circuitry, signals are detected from the detector **235** and transmitted to the processing circuitry via the connector **260**.

A probe-off condition occurs when the optical probe becomes partially or completely dislodged from the patient, but continues to detect an AC signal within the operating region of the pulse oximeter. Probe-off errors are serious because the pulse oximeter may display a normal saturation when, in fact, the probe is not properly attached to the patient, potentially leading to missed desaturation events. Failure to detect a probe-off condition is the result of the probe detector receiving light directly from the emitters without transmission through the patient's tissue.

As illustrated in the schematic of FIG. **3**A, a first aspect of the present invention involves an optical probe **202** which incorporates a number of electrical contacts **341** and **342** that make contact to the skin of the patient when the probe **202** is properly secured. In order to detect a probe-off condition, a probe-off detector module **138** of the pulse oximeter **140** periodically applies a voltage across the contacts **341** and **342** or drives a current. A non-zero current indicates that the patient's skin **344** has closed the circuit between the contacts **341** and **342** and the probe **202** is properly secured. If the probe becomes dislodged, the patient's skin **344** is no longer be in contact with the contacts **341** and **342**, resulting in an open circuit.

FIG. **3**B illustrates one preferred embodiment of an optical probe **202** incorporating one embodiment of the present invention. The present embodiment incorporates a first electrical contact **341** and a second electrical contact **342** in the surface **306** of the central portion **204** of the probe **202**. The electrical contacts **341** and **342** are positioned in a location such that contact to a finger or flesh portion of the patient is ensured when the probe **202** is properly attached. In the illustrated embodiment, the contacts **341** and **342** are located proximate the detector aperture **203**. In another embodiment, contacts **341** and **342** are on opposite sides of the detector aperture **203**. The optical probe **202** also has an emitter aperture **220** through which light of at least two wavelengths passes from LEDs.

As illustrated in the schematic diagram of FIG. **3**C, the pulse oximeter system **100** of FIG. **1** can be modified to

incorporate the first aspect of the present invention by extending an additional lead **324** through the connector **142** to the probe **202**. The additional lead can be connected to one contact **341** while the second contact **342** can be wired to the common ground lead **130**.

A schematic diagram of another embodiment of the present invention is illustrated in FIG. **3**D. The contacts **341** and **342** can be installed in line within the path of the coding resistor **132**. When the patient's skin **344** is in contact with the contacts **341** and **342**, the circuit through the coding resistor **132** will be closed; when the patient's skin **344** is not in contact with the contacts **341** and **342**, the circuit through the coding resistor **132** will be open. The skin **344** will have some finite resistance between the contacts **341** and **342** that will affect the measured resistance of the coding resistor. As the contacts **341** and **342** are installed in series with the coding resistor **132**, any resistance across the contacts **341** and **342** will be added to the resistance of the coding resistor **132** when the pulse oximeter **140** attempts to measure the resistance of the coding resistor **132**. The resistance of the skin **344** can effectively be ignored in the measurement of the coding resistor **132**, however, by choosing the value of the coding resistor **132** to be substantially larger than the resistance of a patient's skin **344** between the contacts **341** and **342**. Alternatively, the acceptable resistance for the coding resistor can be specified as in a range that includes the likely added resistance of the skin in the circuit. In the present configuration, the probe-off detector module **138** of the pulse oximeter **140** can verify that the optical probe **202** is properly secured simultaneously with checking the resistance of the coding resistor **132**. An open circuit indicates that the probe has become dislodged, whereas a valid resistance of a coding resistor **132** indicates a proper attachment of the probe **202**. If the probe has become dislodged, the pulse oximeter **140** can sound an alarm, display a warning message, or both.

The pulse oximeter **140** is particularly vulnerable to probe-off errors when operating at its highest sensitivity, where even small induced variations in light directly detected from the emitters have sufficient signal strength to be processed as a physiological signal. In a probe-off condition, a detector AC signal can be induced by slight changes in the direct light path between the emitters and the detector. For example, small amounts of patient motion, such as chest movement from breathing, can induce a probe-off AC signal. As another example, "creep" in the probe configuration, such as a folded probe gradually returning to its original unfolded shape after becoming dislodged can also induce a probe-off AC signal.

FIGS. **3**E and **3**F depict a generalized embodiment of the present invention with the same features as described in **3**A and **3**B, except that the electrical contacts **341**, **342** are replaced with a contact sensor **343**. The electrical contacts **341** and **342** comprise a specialized case of a contact sensor **343** where skin is involved. The contact sensor **343** may also comprise a piezoelectric sensor, a conductive contact sensor, or any other contact sensors which detect the contact of the tissue material.

FIGS. **3**G and **3**H depict yet another embodiment of the electrical contact based contact sensor of FIGS. **3**A and **3**B. FIG. **3**G depicts a schematic form with a pulse oximeter **140** and a probe off detector module. FIG. **3**H depicts a perspective view of the optical pulse oximeter probe having optical emitters and at least one detector. However, in this embodiment, electrical contact **341**A and electrical contact **342** are positioned opposite each other. The electrical contact **341**A is positioned near the emitter aperture **220**, so as to contact the portion of the tissue material near the emitter **220**. The electrical contact **342** is positioned near the detector aperture **203**. Similarly, other contact sensors could be positioned, one near the emitter aperture **220** and one near the detector aperture **203**.

In one embodiment the electrical contacts **341**, **342**, **341**A are metallic. In another embodiment, these contacts comprise conductive adhesive, or gel based contacts.

FIG. **4** illustrates a probe **202** that has become unfastened. The illustrated probe **202** is shown in a partially unfolded shape that provides an oblique path **410** from the emitter aperture **220** to the detector assembly **235**. As a patient moves, or as the probe **202** unfolds, rays of light travelling along the oblique light path **410** may generate an AC signal that could be interpreted by the pulse oximeter **140** as a physiological signal.

As illustrated in the cross section of FIG. **5**A, a number of louvers **502** are placed in front of the detector assembly **235** within the detector aperture **203** in accordance with a second aspect of the present invention. The louvers **502** block light rays travelling along an oblique path **410** (i.e., light that does not originate from in front of the detector assembly **235**). As illustrated in FIG. **5**B, if the probe **202** is properly attached, the emitter aperture **220** will be directly in front of the detector assembly **235** and light rays will pass directly through the louvers **502** along a direct path **510**.

FIG. **5**C illustrates a top plan view of a preferred embodiment of this aspect of the present invention. The detector aperture **203** is formed in a plastic body **504** having slots **506** to hold the louvers **502** in place across the detector aperture **203**. In a preferred embodiment of the present aspect, the louvers **502** can be created from commercially available "3M Light Control Film."

The louvers **502** of the present aspect advantageously provide a separate or improved method for the pulse oximeter **140** to determine when a probe has become dislodged through monitoring the signal produced by the photodetector **116**. If the probe **202** becomes improperly secured, the emitter aperture will likely move from its proper location directly above the detector assembly **235**, which will cause any oblique light rays to be blocked by the louvers **502**. With no light rays reaching the detector assembly **235**, the detector will produce no signal. The probe-off detector **138** of the pulse oximeter **140** can detect the lack of signal and sound an alarm. The louvers **502** also advantageously block oblique light rays that might create a false signal that could be interpreted by the pulse oximeter **140** to be a physiological signal. Accordingly, the louvers **502** reduce or eliminate the possibility of a probe-off condition. The louvers **502** may be used alone or in combination with the contacts described herein.

FIG. **6** illustrates one embodiment of a method **600** by which a pulse oximeter **140** detects a dislodged probe and/or a probe-off condition. At a step **604**, the probe off detector module **138** checks for continuity between the skin contacts **341** and **342**. If, at a step **608**, there is continuity between the contacts **341** and **342**, the oximeter **140** passes control to a step **612**. If, on the other hand, there is no continuity at the step **608**, the oximeter **140** passes control to a step **620**. At step **620** the oximeter **140** sounds an alarm to alert a condition necessitating attention. At the step **612**, the oximeter **140** checks for a valid AC signal from the photodetector. If, at a step **616**, there is a valid signal, the oximeter **140** passes control back to the step **604** to start the cycle over again. If, on the other hand, there is no valid AC signal at the step **616** the oximeter sounds an alarm at the step **620**.

Accordingly, the pulse oximeter checks for and detects dislodgment of a probe and/or a probe-off condition.

While certain exemplary preferred embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention. Further, it is to be understood that this invention shall not be limited to the specific construction and arrangements shown and described since various modifications or changes may occur without departing from the spirit and scope of the invention as claimed. It is intended that the scope of the invention be limited not by this detailed description but by the claims appended hereto.

What is claimed is:

1. A method for verifying attachment of an optical probe to a patient, the method comprising:

providing an optical probe, the optical probe having at least two contacts configured to contact a patient's skin when the optical probe is properly attached;

applying a voltage across the at least two contacts; and

determining, based upon a measured resistance of a coding resistor, whether the at least two contacts are in contact with the patient's skin.

2. The method of claim **1**, wherein the at least two contacts comprise metallic contacts.

3. The method of claim **1**, wherein the at least two contacts comprise conductive adhesive contacts.

4. The method of claim **1**, wherein the at least two contacts comprise gel-based contacts.

5. The method of claim **1**, wherein the at least two contacts are positioned on the patient's skin proximate to a detector aperture in the optical probe.

6. The method of claim **1**, wherein the at least two contacts are positioned on the patient's skin proximate to an emitter aperture in the optical probe.

7. The method of claim **1**, wherein one of the at least two contacts is positioned on the patient's skin proximate to a detector aperture in the optical probe and the other of the at least two contacts is positioned on the patient's skin proximate to an emitter aperture in the optical probe.

8. The method of claim **1**, further comprising generating a visual alarm when the at least two contacts are not in contact with the patient's skin.

9. The method of claim **1**, further comprising generating a audible alarm when the at least two contacts are not in contact with the patient's skin.

10. The method of claim **1**, further comprising generating at least one of a visual or audible indicator when the at least two contacts are in contact with the patient's skin.

11. A method of detecting that a pulse oximetry probe may not be properly attached to a tissue site, the method comprising:

providing a pulse oximetry probe having a light emitter, a light detector configured to detect light from the light emitter when the pulse oximetry probe is properly attached, and at least two contacts configured to make contact to a patient's skin when the pulse oximetry probe is properly attached;

emitting light from the light emitter;

checking for continuity across the at least two contacts by measuring a resistance of a coding resistor;

checking for a valid signal from the light detector; and

determining whether the pulse oximetry probe is properly attached based upon the continuity check and the valid signal check.

12. The method of claim **11**, wherein the light detector further includes at least one louver.

13. The method of claim **11**, wherein the measuring the resistance of the coding resistor includes measuring the resistance of the patient's skin.

14. The method of claim **11**, wherein the measuring the resistance of the coding resistor does not include measuring the resistance of the patient's skin.

15. The method of claim **11**, wherein the at least two contacts comprise metallic contacts.

16. The method of claim **11**, wherein the at least two contacts comprise conductive adhesive contacts.

17. The method of claim **11**, wherein the at least two contacts comprise gel-based contacts.

18. The method of claim **11** wherein the at least two contacts are positioned on the patient's skin proximate to the light detector.

19. The method of claim **11**, wherein the at least two contacts are positioned on the patient's skin proximate to the light emitter.

20. The method of claim **11**, wherein one of the at least two contacts is positioned on the patient's skin proximate to the light detector and the other of the at least two contacts is positioned on the patient's skin proximate to the light emitter.

21. The method of claim **11**, further comprising generating a visual alarm when the pulse oximetry probe is not properly attached.

22. The method of claim **11**, further comprising generating a audible alarm when the pulse oximetry probe is not properly attached.

23. The method of claim **11**, further comprising generating at least one of a visual or audible indicator when the pulse oximetry probe is properly attached.

24. A pulse oximetry system comprising:

a pulse oximeter base unit;

an optical probe configured to be affixed to a body member of a patient;

at least two electrical contacts located on the optical probe, the electrical contacts configured to make contact to the body member of the patient when the optical probe is properly affixed to the patient; and

a probe-off detector module configured to check for acceptable continuity across the electrical contacts by measuring a resistance of a coding resistor, thereby determining whether the optical probe is properly affixed to the patient.

25. The pulse oximetry system of claim **24**, wherein the coding resistor is in parallel with an emitter of the optical probe.

26. The pulse oximetry system of claim **24**, wherein the coding resistor is not in parallel with an emitter of the optical probe.

27. The pulse oximetry system of claim **24**, further comprising an indicator for indicating when the optical probe is not properly affixed to the patient.

28. The pulse oximetry system of claim **27**, wherein the indicator comprises at least one of an audible or visual alarm.

29. The pulse oximetry system of claim **24**, further comprising an indicator for indicating when the optical probe is properly affixed to the patient.

30. The pulse oximetry system of claim **24**, wherein the at least two electrical contacts are positioned on the body member proximate to a detector of the optical probe.

31. The pulse oximetry system of claim **24**, wherein the at least two electrical contacts are positioned on the body member proximate to an emitter of the optical probe.

32. The pulse oximetry system of claim **24**, wherein one of the at least two electrical contacts is positioned on the

body member proximate to a detector of t he optical probe and the other of the at least two electrical contacts is positioned on the body member proximate to an emitter of the optical probe.

33. The pulse oximetry system of claim **24**, wherein the at least two electrical contacts comprise metallic contacts.

34. The pulse oximetry system of claim **24**, wherein the at least two electrical contacts comprise conductive adhesive contacts.

35. The pulse oximetry system of claim **24**, wherein the at least two electrical contacts comprise gel-based contacts.

36. A pulse oximeter system for determining proper attachment of a sensor, the pulse oximeter system comprising:

an oximeter base unit; and

a probe-off detector module configured to verify proper attachment of a pulse oximetry sensor to a measurement site of a patient by measuring a resistance associated with a coding resistor and a probe-off circuit of the pulse oximetry sensor.

37. The pulse oximetry system of claim **36**, wherein the probe-off circuit comprises a contact sensor.

38. The pulse oximetry system of claim **37**, wherein the contact sensor comprises a piezoelectric sensor.

39. The pulse oximetry system of claim **36**, wherein the coding resistor is in parallel with an emitter of the pulse oximetry sensor.

40. The pulse oximetry system of claim **36**, wherein the coding resistor is not in parallel with an emitter of the pulse oximetry sensor.

41. The pulse oximetry system of claim **36**, further comprising an indicator for indicating when the pulse oximetry sensor is not properly affixed to the measurement site.

42. The pulse oximetry system of claim **41**, wherein the indicator comprises at least one of an audible or visual alarm.

43. The pulse oximetry system of claim **16**, further comprising an indicator for indicating when the pulse oximetry sensor is properly affixed to the measurement site.

44. The pulse oximetry system of claim **16**, wherein the probe-off circuit comprises two contacts.

45. The pulse oximetry system of claim **44**, wherein the two contacts are positioned on the measurement site proximate to a detector of the pulse oximetry sensor.

46. The pulse oximetry system of claim **44**, wherein the two contacts are positioned on the measurement site proximate to an emitter of the pulse oximetry sensor.

47. The pulse oximetry system of claim **44**, wherein one of the two contacts is positioned on the measurement site proximate to a detector of the pulse oximetry sensor and the other of the two contacts is positioned on the measurement site proximate to an emitter of the pulse oximetry sensor.

* * * * *

专利名称(译)	脉搏血氧仪探测器检测系统		
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摘要(译)

本发明提供了许多改进，这些改进可以结合到脉搏血氧计探针中以检测探针何时从患者体内移出和/或防止探针断开状态。当光学探针部分或完全从患者体内移出时发生探测关闭状态，但是继续检测脉冲血氧计的操作区域内的AC信号。在一个方面，本发明提供了当探针正确连接时接触患者皮肤的电触点。在另一方面，本发明提供了多个放置在传感器的光电探测器前面的百叶窗，以滤除不是源自探测器前面的点的倾斜光线。因此，如果发射器和光电探测器未正确对准，则光电探测器将不会在脉冲血氧计的有效操作范围内产生信号。根据本发明的方法，如果脉搏血氧计确定探头没有正确地连接到患者，则它可以发出警报或显示警告。