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(54) **SYSTEMS AND METHODS FOR DETECTING CARDIAC ACTIVITY AND/OR INACTIVITY**

(71) Applicant: **Stryker Corporation**, Kalamazoo, MI (US)

(72) Inventor: **Marko N. Kostic**, Portage, MI (US)

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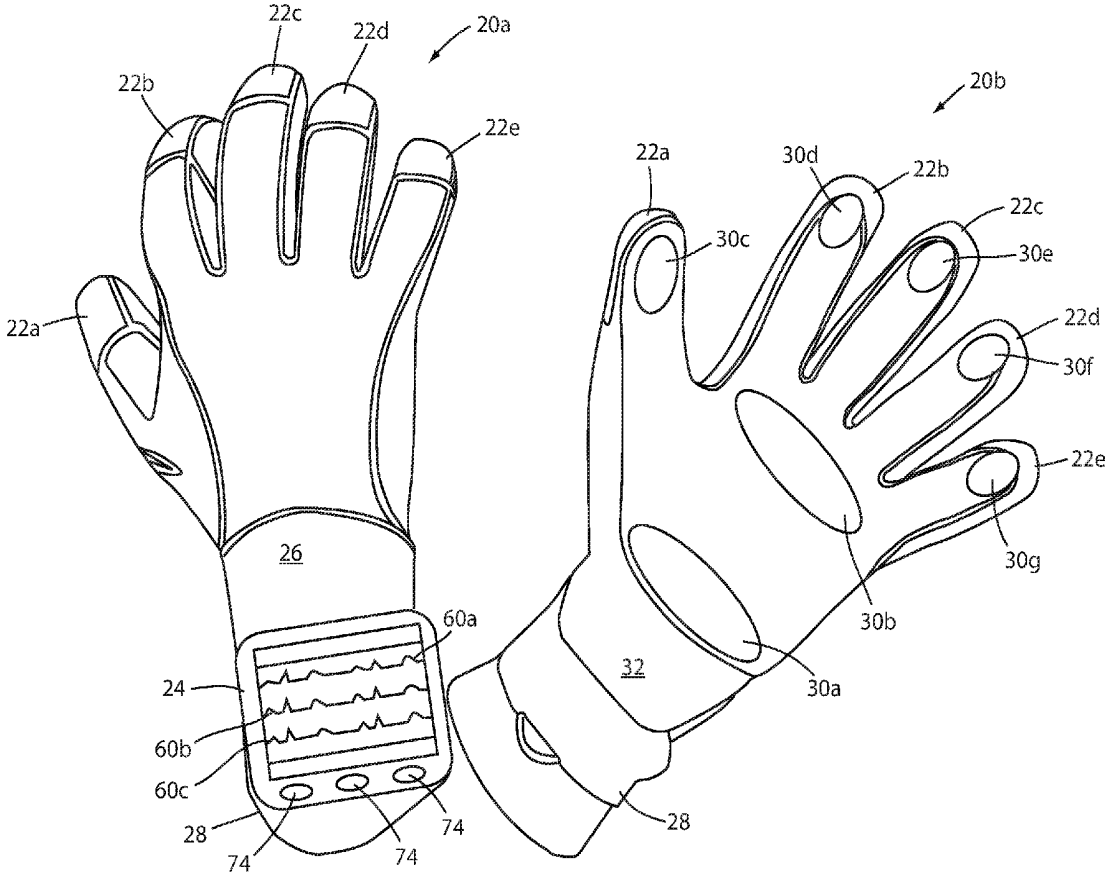
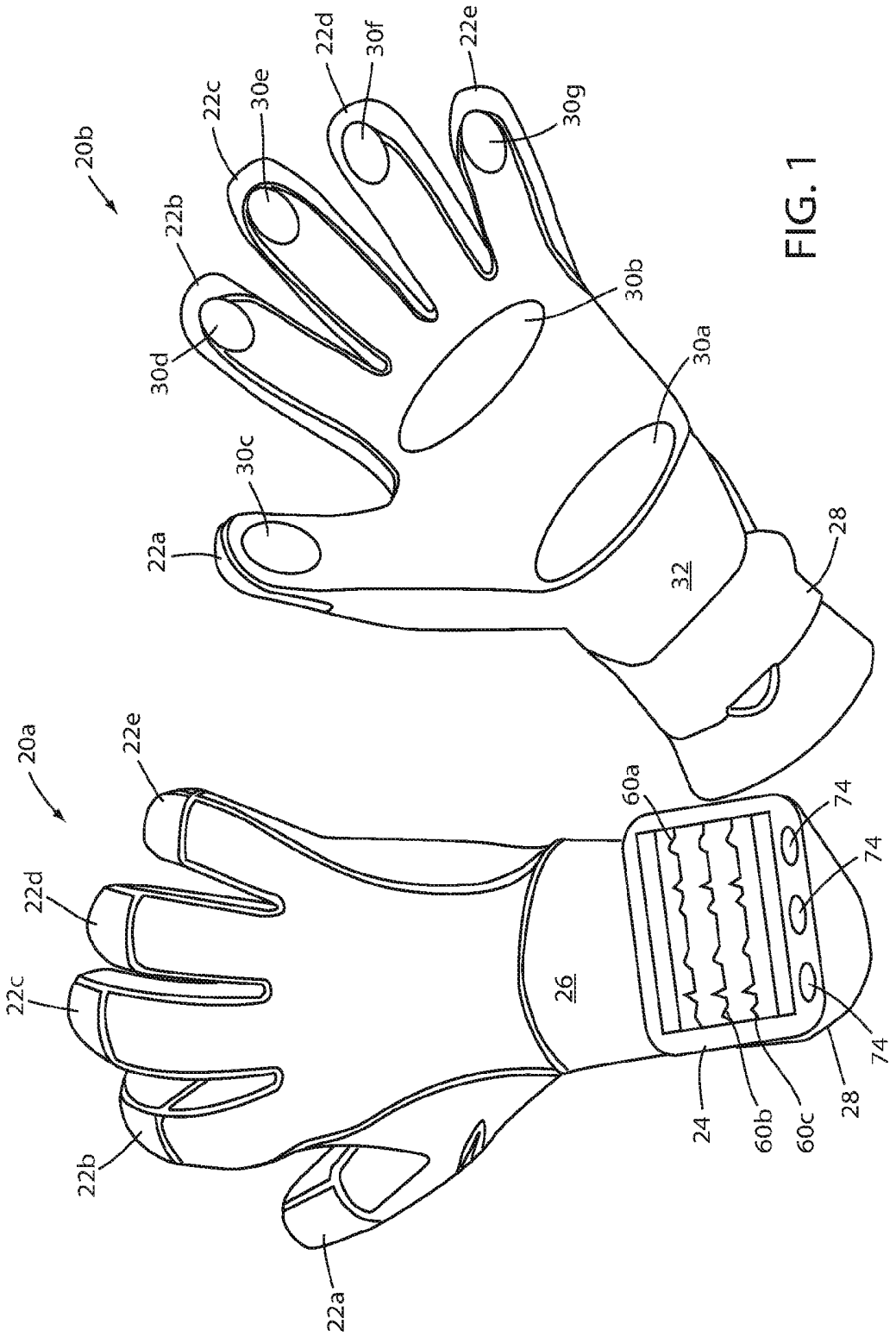
(57) **ABSTRACT**

A non-invasive sensor unit, such as a glove or pad, is adapted to be placed over the chest of an injured person who may be in need of CPR and/or AED. The sensor unit includes a plurality of electrodes for detecting one or more ECG voltages of the person. A controller processes the ECG voltages and displays them on a display, thereby enabling the user to assess whether CPR and/or AED is needed. The sensor unit is adapted to continue to provide ECG data while the user is applying chest compressions to the person. The sensor unit may include accelerometers for reducing artifacts from the ECG voltages that arise from the movement of the user while applying chest compressions. The electrodes are, in some embodiments, capacitive sensors that enable ECG voltages to be detected without requiring direct contact with the skin of the person.

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32
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20a
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22c
22b
22a
60a
74
74
74
26
24
60b
60c
28

FIG. 1

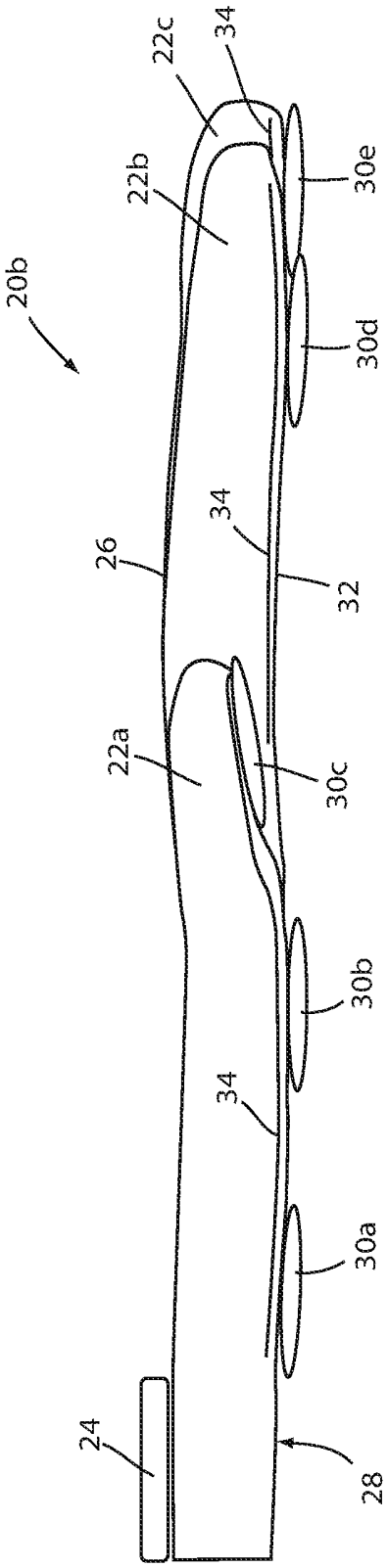

FIG. 2

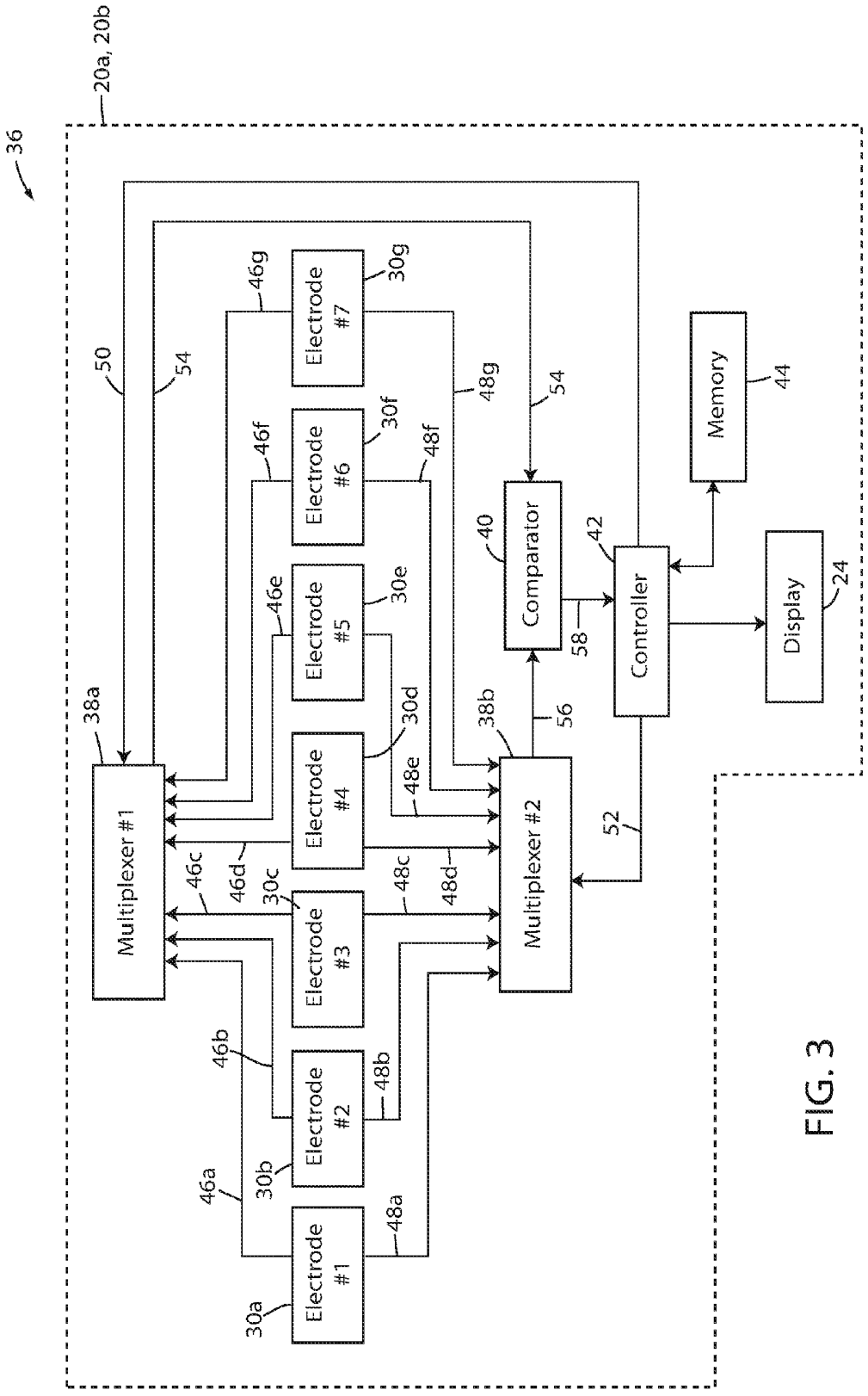
36
20a, 20b
50
54
Electrode #7
30g
46g
48g
54
Electrode #6
30f
46f
48f
Electrode #5
30e
46e
Electrode #4
30d
48e
Electrode #3
30c
46c
46d
48c
48d
Electrode #2
30b
46b
48b
Electrode #1
30a
46a
48a
38a
Multiplexer #1
38b
Multiplexer #2
52
56
40
Comparator
42
Controller
58
Memory
44
Display
24

FIG. 3

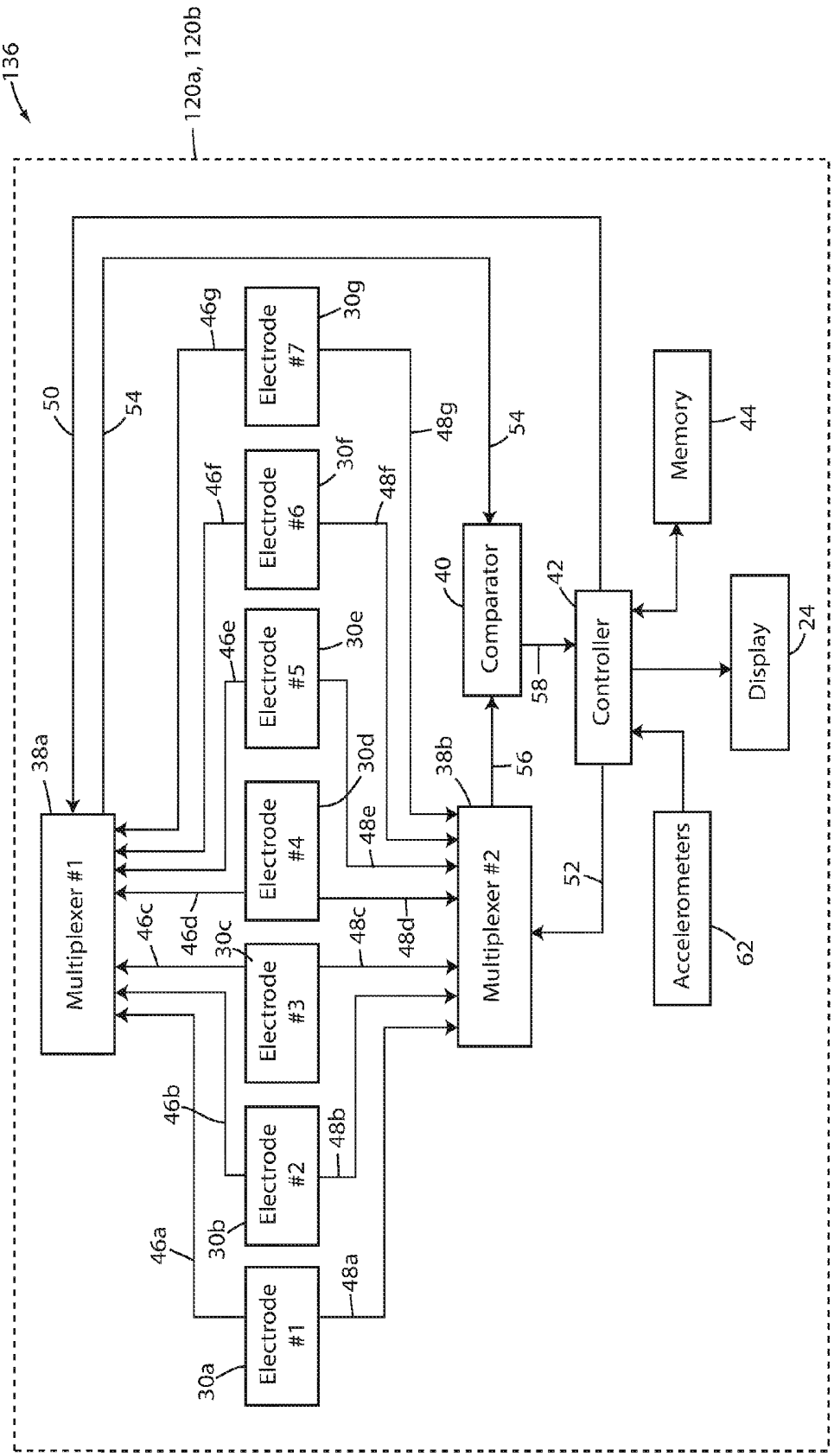
136
120a, 120b
50
54
38a
Multiplexer #1
46a
46b
46c
46d
46e
46f
46g
30a
30b
30c
30d
30e
30f
30g
Electrode #1
Electrode #2
Electrode #3
Electrode #4
Electrode #5
Electrode #6
Electrode #7
48a
48b
48c
48d
48e
48f
48g
38b
Multiplexer #2
52
56
40
Comparator
42
Controller
58
Memory
44
Display
24
Accelerometers
62

FIG. 4

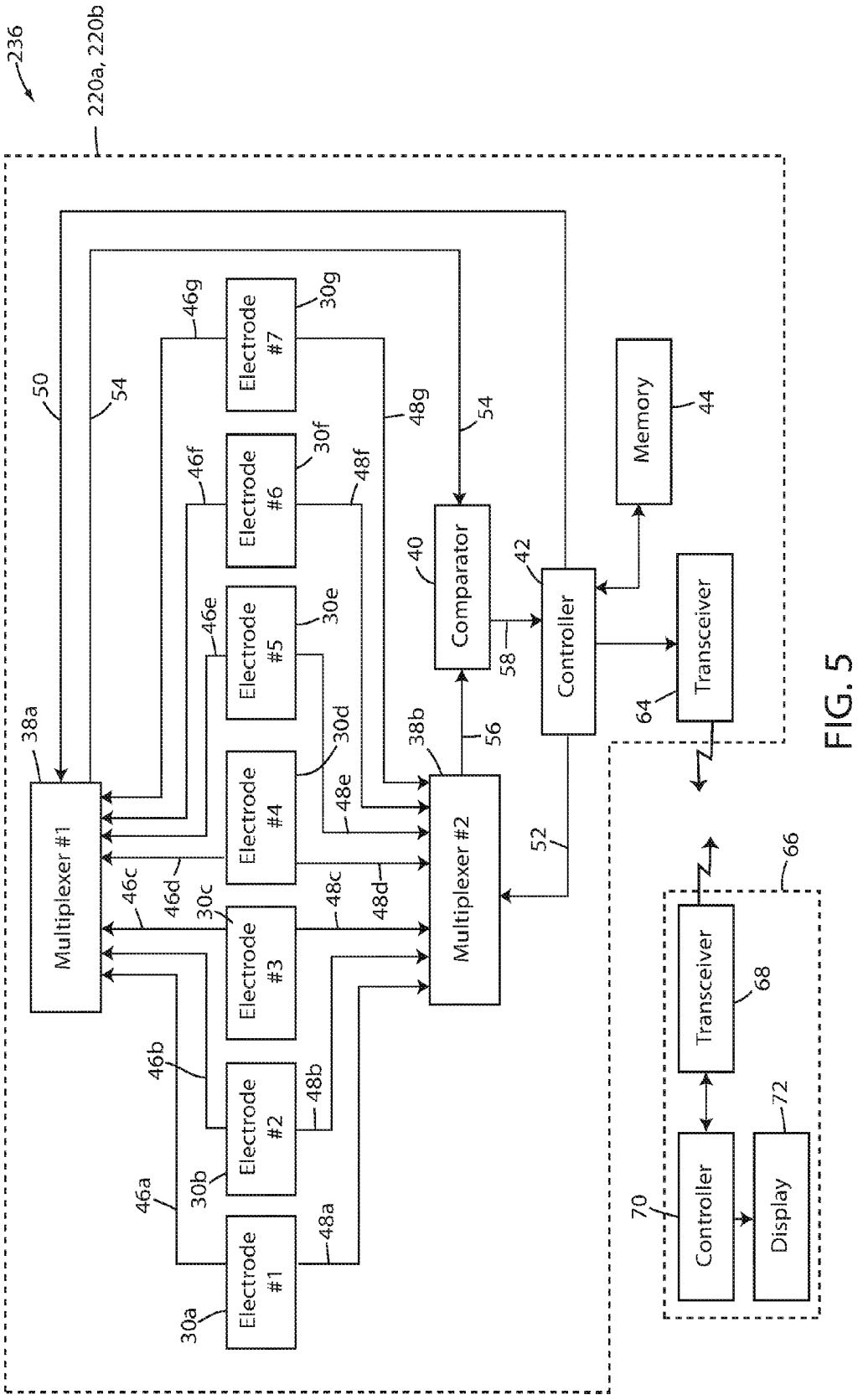
236
220a, 220b
Electrode #1
Electrode #2
Electrode #3
Electrode #4
Electrode #5
Electrode #6
Electrode #7
Multiplexer #1
Multiplexer #2
Comparator
Controller
Memory
Transceiver
Transceiver
Controller
Display
30a
30b
30c
30d
30e
30f
30g
38a
38b
40
42
44
46a
46b
46c
46d
46e
46f
46g
48a
48b
48c
48d
48e
48f
48g
50
52
54
56
58
64
66
68
70
72

FIG. 5

SYSTEMS AND METHODS FOR DETECTING CARDIAC ACTIVITY AND/OR INACTIVITY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. provisional patent application Ser. No. 62/349,158 filed Jun. 13, 2016, by inventor Marko Kostic and entitled SYSTEMS AND METHODS FOR DETECTING CARDIAC ACTIVITY AND/OR INACTIVITY, the complete disclosure of which is incorporated herein by reference.

BACKGROUND

[0002] The present disclosure relates to devices, systems, and methods for assisting a person prior to, during, and/or after performing cardio-pulmonary resuscitation (CPR) on a victim.

[0003] When performing CPR on a victim, it is typically necessary to occasionally pause during the application of chest compressions in order to determine whether the victim has reestablished his or her heart beat. Such pauses, however, interrupt the pumping of blood throughout the victim's body which is undesirable.

SUMMARY

[0004] According to one or more embodiments, an apparatus and method for providing useful information about the cardiac state of the CPR-victim to the rescuer while the rescuer is performing CPR is provided. In some embodiments, the apparatus includes a glove worn by the rescuer that has a plurality of electrocardiograph (ECG) electrodes built into it. These electrodes provide the rescuer with information about the rhythmic activity, or lack of rhythmic activity, of the victim's heart. Further, this information is provided without requiring the rescuer to stop applying chest compressions. In some embodiments, the information is provided regardless of whether or not the glove makes direct contact with the skin of the victim, thereby enabling the rescuer to use the apparatus without requiring him or her to remove clothing from the victim's chest area.

[0005] According to one embodiment of the disclosure, a glove for use by a rescuer when performing CPR is provided. The glove includes a plurality of sheaths, first and second electrodes, and a controller. The sheaths are adapted to receive a plurality of digits (fingers and/or thumbs) of the rescuers hand. The first electrode is positioned adjacent a distal end of a first one of the sheaths and it is adapted to detect a first ECG voltage of the victim when the glove is worn by the rescuer and placed over the victim's chest. The second electrode is positioned away from the first electrode and it is adapted to detect a second ECG voltage of the victim when the glove is worn by the rescuer and placed over the victim's chest. The controller receives and processes the first and second ECG voltages and outputs a signal indicative of cardiac activity of the victim's heart based on the first and second ECG voltages.

[0006] According to another embodiment, a glove for use by a rescuer when performing CPR is provided. The glove includes a plurality of sheaths, first and second electrodes, a display, and a controller. The plurality of sheaths are adapted to receive a plurality of digits of the rescuer's hand. The first electrode is positioned adjacent a distal end of a first one of the sheaths and it is adapted to detect a first ECG voltage of the victim when the glove is worn by the rescuer and placed over the victim's chest. The second electrode is positioned away from the first electrode and it is adapted to detect a second ECG voltage of the victim when the glove is worn by the rescuer and placed over the victim's chest. The display is attached to a dorsal surface of the glove. The controller receives the first and second ECG voltages and displays data related to the first and second ECG voltages on the display.

[0007] According to yet another embodiment, a glove for use by a rescuer when performing CPR is provided. The glove includes at least four electrodes, an indicator, and a controller. The four or more electrodes are positioned on a ventral face of the glove at locations adapted to face the victim's chest when the glove is worn by the rescuer and used during chest compressions applied to the victim. The at least four electrodes are adapted to detect first, second, third, and fourth ECG voltages, respectively, when the glove is worn by the rescuer and placed over the victim's chest. The indicator is positioned on a dorsal face of the glove. The controller determines at least first, second, third and fourth signal-to-noise ratios (SNR) of the first, second, third, and fourth ECG voltages, respectively, and outputs a signal indicative of cardiac activity of the victim's heart based upon the ECG voltage with the highest SNR.

[0008] According to other aspects of the disclosure, the electrodes may be adapted to detect changes in capacitance due to electrical activity of the victim's heart. Such changes are detected due to the electrical activity of the victim's heart and are sensed by the electrodes without the electrodes needing to be placed in direct contact with the victim's skin.

[0009] In some embodiments, the second electrode is positioned on the glove at a location adjacent a palm of the rescuer's hand. In such embodiments, a third electrode may be placed on the glove at a location adjacent a distal end of a second one of the sheaths.

[0010] The indicator communicates with the controller and is adapted to provide at least one of an audio and visual indication to the rescuer of cardiac activity of the victim's heart. The indicator includes a graphical display, in some embodiments, that is adapted to display a graph derived from at least one of the first and second ECG voltages. In other embodiments, the indicator includes a Light Emitting Diode (LED) adapted to have its illumination state changed each time the victim's heart is detected to beat.

[0011] The glove further includes, in some embodiments, a wireless transceiver in communication with the controller. The controller uses the wireless transceiver to wirelessly transmit data regarding the first and second ECG voltages to a second device. In some of such embodiments, the controller wirelessly transmits data regarding the first and second ECG voltages to the second device while the rescuer is performing chest compressions on the victim.

[0012] In some embodiments, the glove includes a first accelerometer positioned adjacent the distal end of the first one of the sheaths and a second accelerometer positioned adjacent the distal end of a second one of the sheaths. The controller uses outputs from the first and second accelerometers to remove artifacts from the first and second ECG voltages that are due to movement of the rescuer when applying chest compressions to the victim.

[0013] The glove includes a first dielectric layer positioned between the first electrode and an interior of the first

one of the sheaths, in some embodiments. The first dielectric layer shields the first electrode from electrical interference caused by the rescuers hand.

[0014] In some embodiments, the controller displays a difference between the first and second ECG voltages on the display. The difference may be displayed on a graph with respect to an axis indicating time.

[0015] The display, in at least one embodiment, is a liquid crystal display, an AMOLED display, and/or an OLED display.

[0016] The controller, in some embodiments, outputs at least two signals indicative of cardiac activity of the victim's heart based upon the ECG voltages with the first and second highest SNRs. The controller graphically displays data derived from the voltages having the first and second highest SNRs.

[0017] In some embodiments, the glove includes at least four accelerometers. Each of the accelerometers is positioned adjacent a corresponding one of the electrodes. The controller uses outputs from the at least four accelerometers to remove artifacts from the first, second, third, and fourth ECG voltages that are due to movement of the rescuer when applying chest compressions to the victim. The controller may remove the artifacts from the first, second, third, and fourth ECG voltages prior to determining the ECG voltage with the highest SNR.

[0018] A first one of the electrodes is positioned adjacent a lower palm area, in some embodiments, and a second one of the electrodes is positioned adjacent a first fingertip of the glove. A third electrode may be positioned adjacent a second fingertip of the glove.

[0019] In some embodiments, one or more of the accelerometers are used to detect a depth of the chest compressions and provide an indication of the depth to the rescuer.

[0020] In those embodiments where a display is included on the glove, the display may be positioned outside of an opisthenar portion of the glove such that the rescuer is able to place his or her second hand (which may be gloved or non-gloved) over the opisthenar portion of the glove on the first hand while applying chest compressions. In one such embodiment, the display is positioned adjacent a wrist area of the glove.

[0021] In yet another embodiment, a system is provided for use by a rescuer when performing CPR compressions on a victim. The system includes first and second gloves. The first glove has a plurality of sheaths adapted to receive a plurality of digits of the rescuer's hand; first and second electrodes adapted to detect first and second ECG voltages, respectively, when the first glove is worn by the rescuer and placed over the victim's chest; and a first transceiver. The second glove has a second transceiver and a display attached to a dorsal surface of the glove. The second transceiver is adapted to receive data related to the first and second ECG voltages from the first transceiver and to use the received data to display ECG information about the victim on the display.

[0022] The first and second transceivers are adapted to communicate via a wire in one embodiment, and wirelessly in another embodiment.

[0023] In still another embodiment, a method of performing CPR on a victim is provided. The method includes placing a plurality of ECG electrodes over the victim's chest wherein the plurality of ECG electrodes produce a corresponding plurality of ECG voltages. The method further includes placing a first hand over at least one of the ECG electrodes; placing a second hand over the first hand; applying compressive forces to the victim's chest; determining which of the plurality of ECG voltages has the best signal-to-noise (SNR) ratio; and outputting a signal indicative of cardiac activity of the victim's heart based on the ECG voltage with the best SNR.

[0024] The plurality of ECG electrodes are incorporated into a glove, in a first embodiment. In another embodiment, the plurality of ECG electrodes are incorporated into a pad placed over the victim's chest.

[0025] Before the various embodiments disclosed herein are explained in detail, it is to be understood that the claims are not to be limited to the details of operation or to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The embodiments described herein are capable of being practiced or being carried out in alternative ways not expressly disclosed herein. Also, it is to be understood that the phraseology and terminology used herein are for the purpose of description and should not be regarded as limiting. The use of "including" and "comprising" and variations thereof is meant to encompass the items listed thereafter and equivalents thereof as well as additional items and equivalents thereof. Further, enumeration may be used in the description of various embodiments. Unless otherwise expressly stated, the use of enumeration should not be construed as limiting the claims to any specific order or number of components. Nor should the use of enumeration be construed as excluding from the scope of the claims any additional steps or components that might be combined with or into the enumerated steps or components.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] FIG. **1** is a perspective view of a pair of gloves according to a first embodiment of the disclosure;

[0027] FIG. **2** is a side elevation view of a left one of the gloves of FIG. **1**;

[0028] FIG. **3** is a block diagram of a control system for the gloves of FIG. **1**;

[0029] FIG. **4** is a block diagram of an alternative control system for one or more modified gloves according to a second embodiment of the disclosure; and

[0030] FIG. **5** is a block diagram of yet another alternative control system for one or more modified gloves according to a third embodiment of the disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0031] A first glove **20***a* and a second glove **20***b* according to a first embodiment of the disclosure are shown in FIG. **1**. First and second gloves **20***a* and **20***b* are each constructed in the same manner in this embodiment. First glove **20***a* is adapted to be worn on the right hand of a rescuer while second glove **20***b* is adapted to be worn on the left hand of the rescuer. Each glove **20***a* and **20***b* includes five sheaths **22***a-e* that are each adapted to receive one of the rescuers digits (fingers and/or thumb). More specifically, sheaths **22***a* are adapted to receive the rescuer's thumbs; sheaths **22***b* are adapted to receive the rescuer's index fingers; sheaths **22***c* are adapted to receive the rescuers middle fingers; sheaths **22***d* are adapted to receive the user's ring fingers, and sheaths **22***e* are adapted to receive the user's pinky fingers.

[0032] Gloves **20***a* and **20***b* are intended to be worn by a rescuer while the rescuer is performing chest compressions on a victim whose heart has stopped beating. Gloves **20***a* and **20***b* are adapted to detect ECG activity of the victim's heart while the rescuer is performing chest compressions and to display one or more signals indicative of that activity (or inactivity as the case may be). More specifically, each glove **20***a* and **20***b* includes a display **24** coupled to a dorsal side **26** of the gloves **20***a* and **20***b* and positioned in a wrist area **28**. Display **24** displays information relating to the ECG voltages detected by the glove in a manner that allows the rescuer to see the displayed information while simultaneously applying chest compressions. The rescuer is therefore able to continue applying chest compressions without interruption while simultaneously receiving an indication of whether or not the victim's heart has regained any rhythmic activity or not. This avoids the need for the rescuer to periodically stop the chest compressions and manually check for cardiac activity, thereby also avoiding the cessation of blood being pumped to the victim's vital organs by way of the applied chest compressions.

[0033] Each glove **20***a*, **20***b* includes a plurality of electrodes **30** positioned on a ventral side **32** of the gloves. In the illustrated embodiment, each glove **20***a*, **20***b* includes a lower palm electrode **30***a*, an upper palm electrode **30***b*, a thumb electrode **30***c*, an index finger electrode **30***d*, a middle finger electrode **30***e*, a ring finger electrode **30***f*, and a pinky finger electrode **30***g*. The electrodes **30***c*-**30***g* are each placed adjacent the distal ends of the respective sheaths **22** to which they are attached. It will be understood by those skilled in the art that more or fewer numbers of electrodes **30** may be used in alternative embodiments, and that the position of one or more of the electrodes **30** may also be changed from that illustrated in FIG. **1**.

[0034] Each electrode **30** is made of a suitable metal and may be implemented either as a conductive electrode or a capacitive electrode. When implemented as conductive electrodes, gloves **20***a* and/or **20***b* are most effective at detecting cardiac voltages when the electrodes **30** are placed in direct contact with the victim's skin. When implemented as capacitive electrodes, gloves **20***a* and/or **20***b* are able to detect cardiac voltages without having to place the electrodes **30** in direct contact with the victim's skin. In this latter implementation, gloves **20***a* and **20***b* are therefore able to effectively operate without requiring the rescuer to remove clothing from the victim's chest area.

[0035] Electrodes **30**, whether implemented as resistive or capacitive electrodes, detect changes in electrical potential on or near the victim's skin due to the cardiac activity of the victim. These changes in electrical potential are sensed when the electrodes **30** positioned in contact with the victim's skin (if implemented as resistive electrodes), or when the electrodes **30** are positioned sufficiently close to the victim's heart so as to detect changes in electrical potential due to cardiac activity of the victim's heart (if implemented as capacitive electrodes). When one of gloves **20***a* or **20***b* is placed over the victim's chest and includes capacitive electrodes **30**, the electrodes **30** are sufficiently close to the victim's heart to sense such electrical potential changes, even if the victim still has clothing positioned on top of his or her chest and located between electrodes **30** and the victim's skin.

[0036] When electrodes **30** are implemented as capacitive sensors, gloves **20***a*, **20***b* are constructed, in at least one embodiment, to include a dielectric insulation layer **34** positioned between the electrodes **30** and the interior of the gloves **20***a*, **20***b*, as shown in FIG. **2**. Dielectric insulation layer **34** helps prevent changes being detected by electrodes **30** due to the pulse of the rescuer and/or physical movement of the rescuer's hands and/or fingers. Dielectric insulating layers **34** are positioned inside of each sheath **22**, as well as over a palm area of the gloves **20***a*, **20***b* such that each of the electrodes **30** is shielded from electrical activity of the rescuers hands.

[0037] One example of a control system **36** of gloves **20***a*, **20***b* is shown in diagram form in FIG. **3**. Control system **36** includes electrodes **30***a-g*, first and second multiplexers **38***a*, **38***b*, a comparator **40**, a controller **42**, a memory **44**, and display **24**. Control system **36** controls and carries out the detection, processing, and display of the voltages sensed by electrodes **30**. Controller **42** of control system **36** is a microcontroller in one embodiment of control system **36**. Controller **42** may alternatively be constructed of any electrical component, or group of electrical components, that are capable of carrying out the functions described herein. In other embodiments, controller **42** includes any one or more microprocessors, microcontrollers, field programmable gate arrays, systems on a chip, volatile or nonvolatile memory, discrete circuitry, and/or other hardware, software, or firmware that is capable of carrying out the functions described herein, as would be known to one of ordinary skill in the art. Such components can be physically configured in any suitable manner, such as by mounting them to one or more circuit boards, or arranging them in other manners, whether combined into a single unit or distributed across multiple units. The instructions followed by controller **42** in carrying out the functions described herein, as well as the data necessary for carrying out these functions are stored in memory **44**, which is accessible to controller **42**.

[0038] Electrodes **30***a-g* are coupled to first multiplexer **38***a* by first input lines **46***a-g*, respectively. Electrodes **30***a-g* are also coupled to second multiplexer **38***b* by second input lines **48***a-g*, respectively. The electrical potentials or voltages from each of electrodes **30***a-g* are therefore fed to both multiplexers **38***a* and **38***b*. Controller **42** is electrically coupled to first and second select lines **50** and **52**. First select line **50**, which is controlled by controller **42**, is coupled to first multiplexer **38***a* while second select line **52** is coupled to second multiplexer **38***b*. First select line **50** controls which one of input lines **46***a-g* multiplexer **38***a* outputs onto first output line **54**. Second select line **52** controls which one of input lines **46***a-g* multiplexer **38***b* outputs onto second output line **56**. First and second output lines **54** and **56** feed into comparator **40**. Comparator **40** includes an output line **58** that feeds back into controller **42**.

[0039] Controller **42** is programmed to use comparator **40** and multiplexers **38***a*, **38***b* to detect and record voltage differences between pairs of electrodes **30***a-g*. In one embodiment, controller **42** is programmed to output a control signal on first select line **50** that selects the input line **46***a* from first electrode **30***a*. This electrode **30***a* corresponds to the lower palm area of the rescuers hand. The result of this selection is to feed the output from electrode **30***a* to comparator **40**. Controller **42** is also programmed to output a control signal on second select line **52** that selects the input line **46***d* from fourth electrode **30***d*. This electrode **30***d* corresponds to the index finger of the rescuer's hand. The result of this latter selection is to feed the output from

electrode **30***d* to comparator **40**. Comparator **40** therefore compares the outputs from first and fourth electrodes **30***a* and **30***d* and feeds the result of the comparison to controller **42** via output line **58**. Controller **42** processes the result by determining a magnitude of the difference between the two voltages from electrodes **30***a* and **30***d*. This difference is stored in memory **44**.

[0040] After detecting and measuring the difference in voltages from electrodes **30***a* and **30***d*, controller **42** changes the values output on select lines **50** and **52** such that a comparison is made by comparator **40** between one or more other electrodes (for example, electrodes **30***a* and **30***e*). The result of this comparison is reported by comparator **40** to controller **42** via output line **58**, which measures the difference and stores the value. Controller **42** may then carry out one or more additional comparisons in a similar manner, including measuring and storing the difference in voltages resulting from the additional comparisons. As would be known to one of ordinary skill in the art, additional processing of the voltages detected by electrodes **30** may also be carried out by controller **42** to generate meaningful ECG voltages for display on display **24**. Such additional processing may include appropriate filtering and analysis of the raw voltages coming from electrodes **30**, as would be known to one of ordinary skill in the art. The processed data output by controller **42** may indicate the victim's heart rate (if any), the presence of arrhythmia, and/or other cardiac data.

[0041] After comparing and processing the voltages from at least two pairs of electrodes **30**, controller **42** is programmed to select the pair of electrodes having the greatest difference between their respective voltages. Controller **42** thereafter displays the outputs from that pair of voltages on display **24**.

[0042] The output from that pair of voltages is indicative of the electrical activity of the victim's heart (if any), and provides a signal to the rescuer as to whether or not the victim's heart has started beating again.

[0043] In some embodiments, controller **42** is programmed to display multiple voltages. The multiple voltages are generated from the differences between different pairs of electrodes **30**. For example, in the embodiment shown in FIG. **1**, controller **42** is programmed to display three different output voltages **60***a*, **60***b*, and **60***c*. The selection of which electrode pairs are used to generate these three different output voltages **60***a*-**60***c* is preprogrammed and fixed, in some embodiments. In other embodiments, the selection of the electrode pairs that are used to generate these three different output voltages **60***a*-**60***c* is preprogrammed, but may be changed by the user utilizing one or more buttons (e.g. buttons **74**) coupled to display **24**. In still other embodiments, the selection of the electrode pairs that are used to generate these different output voltages **60***a*-**60***c* is dynamic. When programmed to be dynamic, controller **42** may run comparisons between multiple pairs of electrodes **30** and choose the three pairs having the highest differences. Alternatively, when programmed to be dynamic, controller **42** may run comparisons between multiple pairs of electrodes **30** and choose the pairs having the three highest signal-to-noise (SNR) ratios. Still other methods of choosing which voltages to display are possible. Further, the number of voltages **60** displayed on display **24** may vary from that shown in FIG. **1**.

[0044] The ECG output voltages that are displayed on display **24** need not be of the type that are clinically accurate enough to provide detailed cardiac information, such as one might find from a standard 12-lead electrocardiogram. Instead, the ECG voltages that are displayed on display **24** need only provide an indication of cardiac activity or inactivity. In some embodiments, the output ECG voltages will only provide an indication of the QRS complex of the victim's cardiac activity. In other embodiments, the output ECG voltages will provide an indication of the PQRST complex of the victim's cardiac activity. Indeed, in some embodiments, display **24** is replaced by a non-graphical indicator that merely provides a flashing light (such as an LED) and/or a beeping sound whenever a heartbeat is detected by control system **36**. In such embodiments, control system **36** doesn't provide any morphological data about the ECG voltages, but instead merely provides an indication whenever a heartbeat is detected. This allows the rescuer to determine not only whether the victim's heart is beating or not, but also the frequency of the heart beats. Further, in some embodiments, the brightness of the visual indicator and/or the volume of the aural indicator may be tied to the strength of the detected heart beat so that the rescuer is given feedback as to the strength of the victim's cardiac activity.

[0045] Due to the fact that gloves **20***a* and/or **20***b* are intended, in some embodiments, to provide indications of the presence or absence of cardiac activity, but not necessarily details about the morphology of the ECG waves, it is not necessary for a rescuer to place his or her hand that contacts the victim in a specific orientation or location with respect to the victim. That is, the electrodes **30** do not need to align with any of the locations that electrodes are conventionally placed on the victim's body when a standard 12-lead electrocardiogram is obtained. The rescuer therefore does not need to be concerned with proper position or orientation while using gloves **20***a*, **20***b*, but can instead focus his or her energies on applying chest compressions.

[0046] Regardless of the manner in which control system **36** conveys the ECG data to the rescuer (e.g. via display **24** or one or more non-graphical indicators), control system **36** repetitively analyzes the outputs of electrode pairs multiple times a second. Control system **36** is therefore able to detect cardiac activity in real time and to output, as appropriate, voltages corresponding to the detected cardiac activity in real time, using either display **24** or one or more non-graphical indicators.

[0047] It will be understood by those skilled in the art that the circuitry of control system **36** may be varied substantially from that shown in FIG. **3**. For example, although not shown in FIG. **3**, it will be understood by those skilled in the art that one or more analog-to-digital converters (ADC) may be added to the circuitry for converting the analog outputs from electrodes **30** into digital signals for processing by controller **42**. As another example, additional circuitry and/or programming of controller **42** may be added that looks for signal-to-noise (SNR) ratios between pairs of electrodes **30**. In some of such embodiments, controller **42** displays the ECG voltages that are generated from the pair of electrodes **30** having the highest SNR. In other of such embodiments, controller **42** displays the ECG voltages that are generated from several of the pairs of electrodes having the highest SNRs. In still other embodiments, the outputs from one or more pairs of electrodes are combined together with the outputs from one or more other pairs of electrodes **30**. Still other manners may be used for detecting ECG voltages from electrodes **30**.

[0048] As shown in FIG. **1**, display **24** is positioned outside of an opisthenar region (the back side of the palm) of the gloves **20***a*, **20***b*. This allows the rescuer to place a first one of his or her hands in direct contact with the victim and then place the second one of or his or her hands directly on top of the opisthenar region of the first hand in the standard manner recommended for performing chest compressions. Because displays **24** are positioned outside of this opisthenar region, the placement of the second hand on top of the first hand does not visually obscure the display coupled to the glove **20***a*, **20***b* of the first hand, thereby enabling the rescuer to view the presence or absence of cardiac activity while maintaining his or her hands on top of each other and applying chest compressions. In other words, the placement of display **24** on gloves **20***a*, **20***b* of the embodiment of FIG. **1** enables the display to be seen while the rescuer performs CPR in the conventional manner with one hand on top of the other.

[0049] In a modified embodiment, only a single one of the gloves **20***a*, **20***b* includes a display **24**. In this modified embodiment, the glove with the display **24** is first positioned by the rescuer on top of the victim's chest and the glove without the display is then placed on top of the glove with the display. In this manner, the glove with the display has its electrodes placed in contact with the victim, while the glove without the display is not necessarily making any contact between its electrodes and the victim. Indeed, in this embodiment, the glove without the display does not need to include any electrodes **30** at all as it does not include any structure for displaying the output of the voltages sensed by electrodes **30**. The glove without the display **24** therefore may omit all of the control system **36** components whatsoever, if desired. Alternatively, the rescuer can omit using a second glove and can instead place his or her gloved hand in contact with the victim and then place his or her non-gloved hand on top of the gloved hand. Thereafter, chest compressions can be applied using both hands.

[0050] FIG. **4** illustrates a modified control system **136** that may be used in one or more modified gloves **120***a* and/or **120***b*. Modified control system **136** includes a plurality of components that are the same as the components of control system **36**. Those common components are labeled with the same reference number as used with control system **36**. New components are labeled with a new reference number. Further, unless explicitly stated otherwise below, those components of control system **136** that are common to control system **36** operate in the same manner as previously described.

[0051] Control system **136** differs from control system **36** in that it also includes one or more accelerometers **62**. Control system **136** includes, in at least one embodiment, at least one accelerometer for each digit of the rescuers hand. In other embodiments, fewer or greater numbers of accelerometers **62** may be used. Regardless of the specific number of accelerometers included within control system **136**, each accelerometer **62** is coupled to controller **42** and outputs signals indicative of the acceleration of portions of gloves **120***a*, **120***b*. Controller **42** uses these signals to reduce artifacts in the ECG voltages from electrodes **30** that may be otherwise introduced due to the movement of the rescuers hands during chest compressions. That is, accelerometers **62** sense the acceleration of the rescuer's hands and/or fingers while the rescuer is applying chest compressions to the victim. These outputs are forwarded to controller **42**, which is programmed to use these outputs, to filter disturbances in the ECG voltages that arise from the movement of the rescuer's hands. In this manner, the presence of ECG voltages is not falsely reported due to electrical disturbances caused by the rescuers hand motion. The accuracy of the reported ECG voltages is also increased.

[0052] Controller **42** of control system **136** may also be programmed, in one embodiment, to additionally detect the depth of the rescuer's chest compressions using the outputs of accelerometers **62**. In one of these modified embodiments, controller **42** displays the depth on display **24**. In another of these modified embodiments, controller **42** displays a target depth simultaneously with the actually measured depth so that the rescuer can visually see if he or she is under-compressing or over-compressing the victim's chest. In still another one of these modified embodiments, controller **42** provides an aural signal indicative of the chest compression depth, either in addition to, or in lieu of, the visual display of the chest compression depth. The aural signal may comprise a sound of varying pitch wherein a first pitch corresponds to compressions that are too shallow, a second pitch corresponds to compressions that are too deep, and a third pitch corresponds to compressions that are acceptable.

[0053] In still another modified embodiment, controller **42** only uses the outputs of accelerometers **62** for detecting the depth of the applied compressions, and does not use accelerometers **62** for removing artifacts from the ECG voltages.

[0054] FIG. **5** illustrates a second modified control system **236** that may be used in one or more modified gloves **220***a* and/or **220***b*. Modified control system **236** includes a plurality of components that are the same as the components of control system **36**. Those common components are labeled with the same reference number as used with control system **36**. New components are labeled with a new reference number. Further, unless explicitly stated otherwise below, those components of control system **236** that are common to control system **36** operate in the same manner as previously described.

[0055] Control system **236** differs from control systems **36** and **136** in that it includes a transceiver **64** instead of a display **24**. Control system **236** operates in the same manner as control system **36** except that instead of displaying one or more ECG waveforms and/or other data on display **24**, transceiver **64** transmits the data that would otherwise be displayed to another device **66**. In one embodiment, transceiver **64** is a Bluetooth transceiver (e.g. IEEE 8020.15.1). In other embodiments, transceiver **64** is a WiFi transceiver (e.g. IEEE 802.11) or a ZigBee transmitter (e.g. IEEE 802.15.4). In still other embodiments, transceiver **64** is a wired transceiver, such as, but not limited to, a Universal Serial Bus (USB) transceiver.

[0056] The other device **66** may vary. In some embodiments, the other device **66** is any one of a defibrillator/monitor (such as, but not limited to, a LifePak defibrillator marketed by Physio-Control of Redmond, Washington), a smart phone, a wristband monitor, a tablet, a personal computer, a server, a pair of smart glasses (e.g. Google Glass), a network, or a smart watch, such as the iWatch marketed by Apple Inc. of Cupertino, Calif. The other device **66** includes a transceiver **68**, a controller **70**, and a display **72**. Transceiver **68** is adapted to communicate with transceiver **64**. Controller **70** may be a microcontroller, microprocessor, or other set of circuitry capable of processing the

data received from transceiver **68** and displaying it on display **72**. Display **72** may be the same type of display as display **24**, or it may be different.

[0057] When the other device **66** is a watch worn by the rescuer, or a nearby tablet, smart phone, or other device, the rescuer can see the cardiac rhythm information displayed on the watch, tablet, or other device, while simultaneously performing chest compressions. The rescuer therefore does not need to stop the chest compressions to assess the cardiac status of the victim.

[0058] It will be understood by those skilled in the art that, although control system **236** does not include any accelerometers **62**, it could be modified to include one or more accelerometers in order to perform either or both of the previously described functions: (1) removing motion-induced artifacts from the ECG voltages; and/or (2) measuring the depth of the chest compressions and reporting the depth in a meaningful manner to the rescuer.

[0059] It will also be understood by those skilled in the art that control system **236** may be additionally or alternatively modified to include both a display **24** and transceiver **64**. By including both display **24** and transceiver **64**, the glove **220***a*, **220***b* is able to display the ECG data locally as well as transmit it to the other device **66**. The other device **66** may also display the data and/or it may store the data in a memory (not shown).

[0060] Still further, it will be understood that in another modified embodiment, a first one of gloves **220***a* and **220***b* includes transceiver **64** but no display **24**, while a second one of gloves **220***a* and **220***b* includes both a transceiver **64** and a display **24**. In this modified embodiment, if the rescuer places the first glove on the victim and positions the second glove on top of the first glove, the first glove transmits the ECG data to the second glove for display on display **24**. On the other hand, if the rescuer places the second glove on the victim and positions the first glove on top of the second glove, the second glove displays the ECG data on its display. In this embodiment, the pair of gloves **220***a* and **220***b* need only include a single display. Further, regardless of which order the rescuer stacks his or her hands on top of the victim's chest, the ECG data will be automatically displayed on the display **24** of the one glove that includes display **24**.

[0061] In still other embodiments, any of the control systems **36**, **136**, and/or **236** disclosed herein may be incorporated into a pad that, instead of being worn by the rescuer, is placed on top of the victim's chest in the area of the victim's heart. The rescuer then pushes down on the pad while applying chest compressions to the victim. A display is either coupled to the pad or attached to another device **66** that receives the ECG data from the pad. In these pad embodiments, the rescuer does not need to put on any gloves when applying chest compressions to the victim, but still is able to receive information about the presence of absence of the victim's cardiac activity while applying the chest compressions.

[0062] As yet another alternative embodiment, either the pads or any of the gloves **20**, **120**, and/or **220** may be modified to include one or more additional sensors. For example, in some embodiments, one of these pads and/or gloves includes a saturated oxygen sensor that reports its data on display **24** and/or display **72**. One such saturated oxygen sensor that may be combined with gloves **20**, **120**, **220**, and/or the pads is disclosed in commonly assigned U.S. patent publication 2015/0327777, filed by inventors Marko Kostic, et al. and entitled TISSUE MONITORING APPARATUS AND SYSTEM, the complete disclosure of which is incorporated herein by reference. Other types of saturated oxygen sensors may also be used.

[0063] Another type of sensor that may be incorporated into any of the gloves **20**, **120**, **220**, and/or pads is a pulse wave velocity sensor. One such pulse wave velocity sensor suitable for this purpose is disclosed in commonly assigned U.S. patent publication 2016/0120411, filed by inventors Sean Hadley et al. and entitled SYSTEMS AND METHODS FOR DETECTING PULSE WAVE VELOCITY, the complete disclosure of which is incorporated herein by reference. Other types of pulse wave velocity sensors may also be used. Regardless of the type of pulse wave velocity sensor utilized, the processed outputs from the sensor are displayed on displays **24** and/or **72**.

[0064] Although gloves **20**, **120**, and **220**, as well as the pads, have all been described herein as being used for providing cardiac information to the rescuer while the rescuer is applying chest compressions, it will be understood by those skilled in the art that these devices may alternatively or additionally be used to provide a quick assessment of the victim's cardiac activity either before or after applying chest compressions. For example, one of these devices may be placed over the victim's chest prior to performing chest compressions to first determine whether CPR or AED (automated external defibrillator) treatments are needed or not. Also, if the chest compressions, or other treatment, are successful at restarting the victim's heart, the gloves or pads may be used to thereafter monitor the victim's cardiac rhythms.

[0065] Either of both of displays **24** and **72** are Liquid Crystal Displays (LCD) in one embodiment. In another embodiment, either or both of displays **24** and **72** are Active Matrix Organic Light Emitting Diode (AMOLED) displays. In still another embodiment, either or both of displays **24** and **72** are Organic Light Emitting Diode (OLED) displays. Still other display technology may incorporated into displays **24** and/or **72**, such as, but not limited to, Organic Light Emitting Transistor (OLET) displays, Surface-Conduction Electron-Emitter (SED) displays, Field Emission (FED) displays, Quantum Dot (QD-LED) displays, Ferro Liquid Crystal Displays (FLCD), and/or Thick-Film Dielectric Electroluminescent Technology (TDEL) displays.

[0066] Various additional alterations and changes beyond those already mentioned herein can be made to the above-described embodiments. This disclosure is presented for illustrative purposes and should not be interpreted as an exhaustive description of all embodiments or to limit the scope of the claims to the specific elements illustrated or described in connection with these embodiments. For example, and without limitation, any individual element(s) of the described embodiments may be replaced by alternative elements that provide substantially similar functionality or otherwise provide adequate operation. This includes, for example, presently known alternative elements, such as those that might be currently known to one skilled in the art, and alternative elements that may be developed in the future, such as those that one skilled in the art might, upon development, recognize as an alternative. Any reference to claim elements in the singular, for example, using the articles "a," "an," "the" or "said," is not to be construed as limiting the element to the singular.

What is claimed is:

1. A glove for use by a rescuer when performing Cardio Pulmonary Resuscitation (CPR) compressions on a victim, the glove comprising:

a plurality of sheaths adapted to receive a plurality of digits of the rescuer's hand;

a first electrode positioned adjacent a distal end of a first one of the sheaths, the first electrode adapted to detect a first ECG voltage of the victim when the glove is worn by the rescuer and placed over the victim's chest;

a second electrode positioned away from the first electrode, the second electrode adapted to detect a second ECG voltage of the victim when the glove is worn by the rescuer and placed over the victim's chest; and

a controller adapted to receive and process the first and second ECG voltages, the controller adapted to output a signal indicative of cardiac activity of the victim's heart based on the first and second ECG voltages.

2. The glove of claim **1** further comprising:

a third electrode positioned away from the first and second electrodes, the third electrode adapted to detect a third ECG voltage of the victim when the glove is worn by the rescuer and placed over the victim's chest; and

wherein the controller is further adapted to receive the third ECG voltage and to process the third ECG voltage in conjunction with at least one of the first and second ECG voltages when outputting the signal indicative of cardiac activity of the victim's heart.

3. The glove of claim **1** wherein the first and second electrodes are adapted to detect changes in capacitance due to electrical activity of the victim's heart.

4. The glove of claim **3** wherein the first and second electrodes detect changes in capacitance due to the electrical activity of the victim's heart without needing to be placed in direct contact with the victim's skin.

5. The glove of claim **1** wherein the second electrode is positioned on the glove at a location adjacent a palm of the rescuers hand.

6. The glove of claim **2** wherein the second electrode is positioned on the glove at a location adjacent a palm of the rescuers hand, and the third electrode is positioned on the glove at a location adjacent a distal end of a second one of the sheaths.

7. The glove of claim **1** further comprising an indicator attached to a dorsal surface of the glove, the indicator in communication with the controller and adapted to provide at least one of an audio and visual indication to the rescuer of cardiac activity of the victim's heart.

8. The glove of claim **1** further comprising a wireless transceiver in communication with the controller, the controller adapted to use the wireless transceiver to wirelessly transmit data regarding the first and second ECG voltages to a second device.

9. The glove of claim **8** wherein the controller is adapted to wirelessly transmit data regarding the first and second ECG voltages to the second device while the rescuer is performing chest compressions on the victim.

10. The glove of claim **1** further comprising:

a first accelerometer positioned adjacent the distal end of the first one of the sheaths;

a second accelerometer positioned adjacent the distal end of a second one of the sheaths; and

wherein the controller is further adapted to use outputs from the first and second accelerometers to remove artifacts from the first and second ECG voltages that are due to movement of the rescuer when applying chest compressions to the victim.

11. The glove of claim **3** further including a first dielectric layer positioned between the first electrode and an interior of the first one of the sheaths, the first dielectric layer adapted to shield the first electrode from electrical interference caused by the rescuer's hand.

12. The glove of claim **2** wherein the controller is further adapted to determine first, second, and third signal-to-noise ratios (SNR) of the first, second, and third ECG voltages, respectively, compare the ECG voltage with the highest SNR to the ECG voltage with the second highest SNR, and to output the signal indicative of cardiac activity of the victim's heart based on the comparison.

13. A glove for use by a rescuer when performing Cardio Pulmonary Resuscitation (CPR) compressions on a victim, the glove comprising:

a plurality of sheaths adapted to receive a plurality of digits of the rescuer's hand;

a first electrode positioned adjacent a distal end of a first one of the sheaths, the first electrode adapted to detect a first ECG voltage of the victim when the glove is worn by the rescuer and placed over the victim's chest;

a second electrode positioned away from the first electrode, the second electrode adapted to detect a second ECG voltage of the victim when the glove is worn by the rescuer and placed over the victim's chest;

a display attached to a dorsal surface of the glove; and

a controller adapted to receive the first and second ECG voltages and to display data related to the first and second ECG voltages on the display.

14. The glove of claim **13** wherein the controller is adapted to display a difference between the first and second ECG voltages on the display.

15. The glove of claim **14** wherein the controller displays a graph of the difference between the first and second ECG voltages with respect to a time axis on the display.

16. The glove of claim **13** further comprising:

a first accelerometer positioned adjacent the distal end of the first one of the sheaths;

a second accelerometer positioned adjacent the distal end of a second one of the sheaths; and

wherein the controller is further adapted to use outputs from the first and second accelerometers to remove artifacts from the first and second ECG voltages that are due to movement of the rescuer when applying chest compressions to the victim, the controller removing the artifacts prior to displaying the data related to the first and second ECG voltages on the display.

17. The glove of claim **13** wherein the first and second electrodes are adapted to detect changes in capacitance due to electrical activity of the victim's heart.

18. The glove of claim **17** wherein the first and second electrodes detect changes in capacitance due to the electrical activity of the victim's heart without needing to be placed in direct contact with the victim's skin.

19. A glove for use by a rescuer when performing Cardio Pulmonary Resuscitation (CPR) compressions on a victim, the glove comprising:

at least four electrodes positioned on a ventral face of the glove at locations adapted to face the victim's chest

when the glove is worn by the rescuer while applying chest compressions to the victim, the at least four electrodes adapted to detect first, second, third, and fourth ECG voltages, respectively, when the glove is worn by the rescuer and placed over the victim's chest;

an indicator positioned on a dorsal face of the glove; and

a controller adapted to determine at least first, second, third and fourth signal-to-noise ratios (SNR) of the first, second, third, and fourth ECG voltages, respectively, and to output a signal indicative of cardiac activity of the victim's heart based upon the ECG voltage with the highest SNR.

20. The glove of claim **19** wherein the controller is further adapted to output a signal indicative of cardiac activity of the victim's heart based upon the ECG voltage with the second highest SNR.

21. The glove of claim **19** wherein the indicator is a graphical display adapted to display a first graph derived from the ECG voltage with the highest SNR and a second graph derived from the ECG voltage with the second highest SNR.

22. The glove of claim **19** wherein the indicator includes a Light Emitting Diode (LED) adapted to have its illumination state changed each time the victim's heart is detected to beat.

23. The glove of claim **19** further including at least four accelerometers, each of the accelerometers positioned adjacent a corresponding one of the four electrodes, wherein the controller is further adapted to use outputs from the at least four accelerometers to remove artifacts from the first, second, third, and fourth ECG voltages that are due to movement of the rescuer when applying chest compressions to the victim.

24. The glove of claim **19** wherein a first one of the electrodes is positioned adjacent a lower palm area, a second one of the electrodes is positioned adjacent a first fingertip of the glove; and a third one of the electrodes is positioned adjacent a second fingertip of the glove.

25. The glove of claim **23** wherein the controller is further adapted to detect a depth of the chest compressions using outputs from at least one of the four accelerometers.

26. The glove of claim **21** wherein the graphical display is positioned outside of an opisthenar portion of the glove such that the rescuer is able to place his or her non-gloved hand over the opisthenar portion of the glove while applying chest compressions.

27. The glove of claim **26** wherein the graphical display is positioned adjacent a wrist area of the glove.

* * * * *

专利名称(译)	用于检测心脏活动和/或不活动的系统和方法		
公开(公告)号	US20170354373A1	公开(公告)日	2017-12-14
申请号	US15/620254	申请日	2017-06-12
[标]申请(专利权)人(译)	史赛克公司		
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当前申请(专利权)人(译)	史赛克公司		
[标]发明人	KOSTIC MARKO N		
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IPC分类号	A61B5/00 A61B5/0404 A61B5/044 A61B5/0408		
CPC分类号	A61B5/6806 A61B5/0404 A61B5/04085 A61B5/044 A61B2505/01 A61B5/7415 A61B5/742 A61B2562/0219 A61B5/721 A61B5/0006 A61B5/0205 A61B5/0428 A61B5/0816 A61B5/4848		
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摘要(译)

诸如手套或垫的非侵入性传感器单元适于放置在可能需要CPR和/或AED的受伤人员的胸部上方。传感器单元包括多个电极，用于检测人的一个或多个ECG电压。控制器处理ECG电压并将其显示在显示器上，从而使用户能够评估是否需要CPR和/或AED。传感器单元适于在用户向人施加胸部按压时继续提供ECG数据。传感器单元可以包括加速度计，用于减少在施加胸部按压时由用户的运动引起的ECG电压的伪影。在一些实施例中，电极是能够检测ECG电压而不需要与人的皮肤直接接触的电容传感器。