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(54) **AUTOMATIC EXTERNAL DEFIBRILLATOR WITH ACTIVE STATUS INDICATOR**

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A61N 1/39 (2006.01)

(52) **U.S. Cl.**
USPC **607/5**; 607/7; 607/148

(58) **Field of Classification Search**
USPC 607/5, 142, 145, 148, 149, 29, 7
See application file for complete search history.

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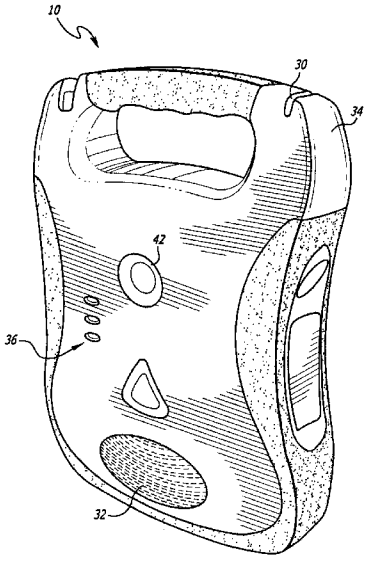
(57) **ABSTRACT**

An AED includes defibrillation circuitry housed within an enclosure, a first processor programmed to periodically test the operability of the defibrillation circuitry and a second processor in communication with the first processor. The AED further includes a visual indicator, such as a red/green LED, positioned at the exterior of the enclosure that is operatively connected to the second processor. The second processor is programmed to control the visual indicator in response to the periodic test results provided to it by the first processor.

7 Claims, 5 Drawing Sheets



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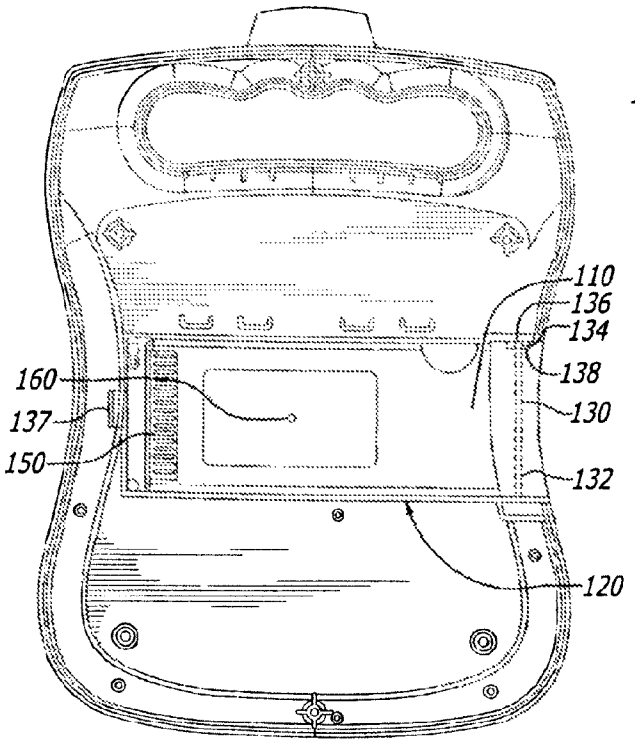


FIG. 1A

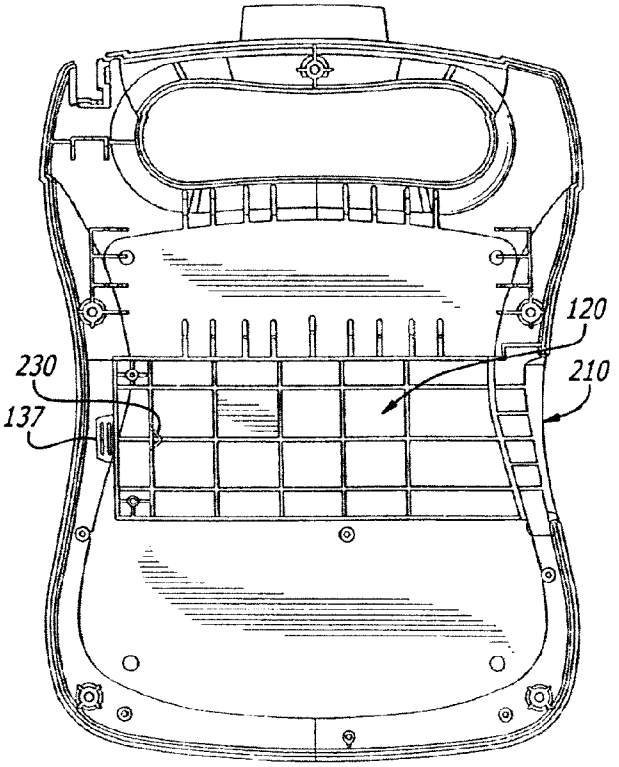


FIG. 1B

FIG. 2

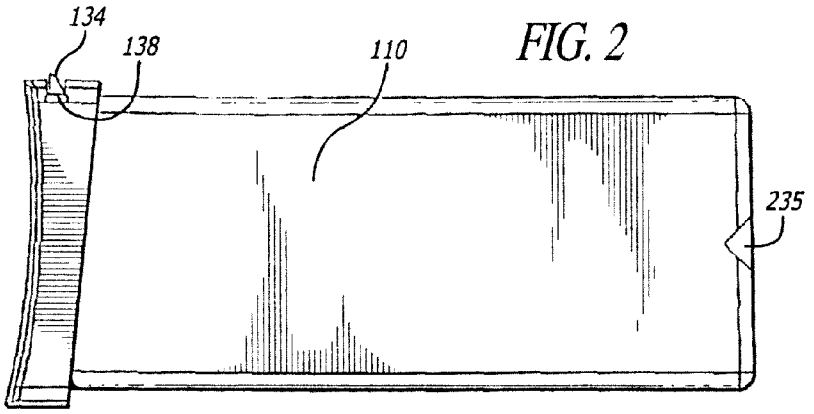


FIG. 3

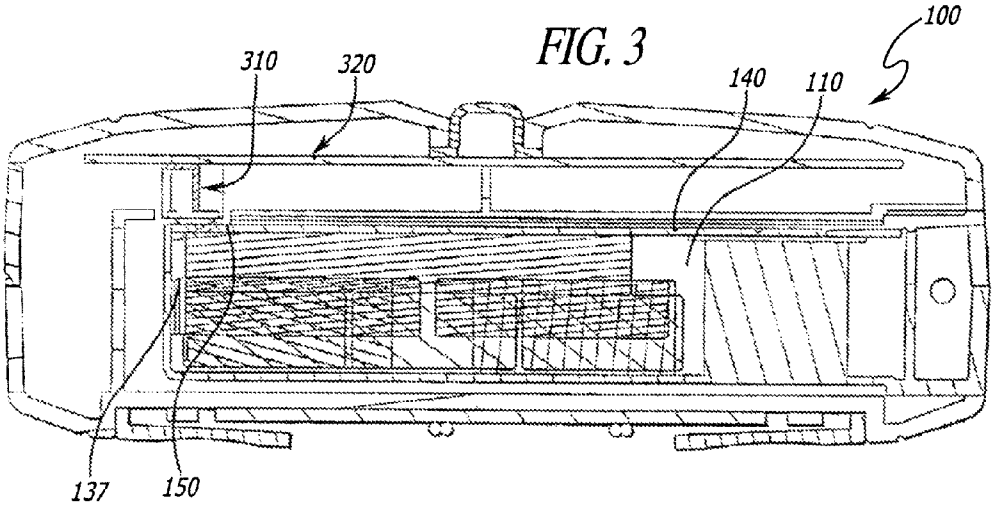


FIG. 4

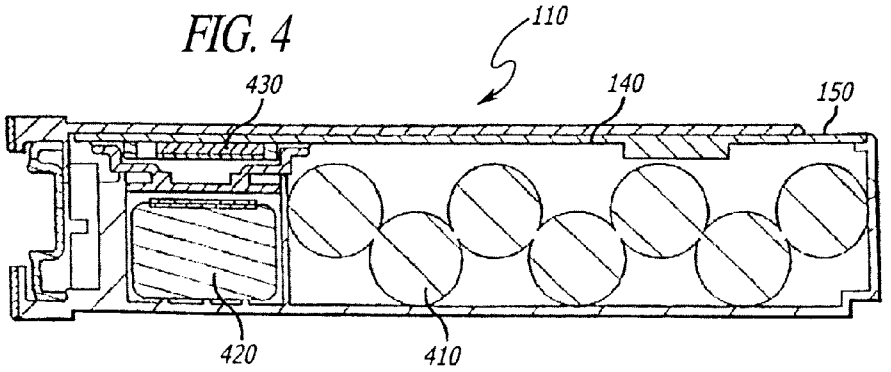
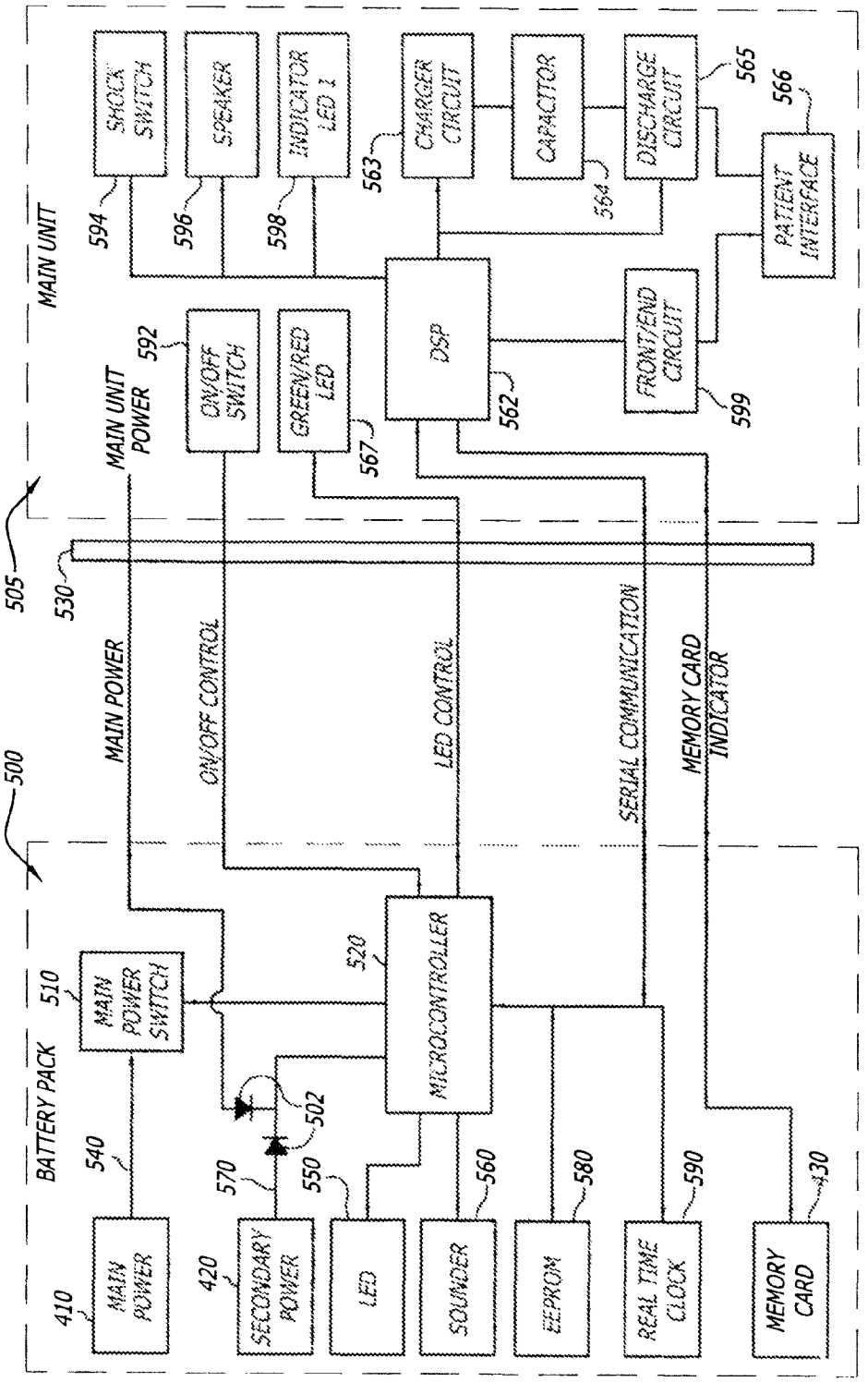


FIG. 5


500
BATTERY PACK
MAIN UNIT
505
530
MAIN POWER
ON/OFF CONTROL
LED CONTROL
SERIAL COMMUNICATION
MEMORY CARD INDICATOR
MAIN UNIT POWER
510
MAIN POWER SWITCH
520
MICROCONTROLLER
540
570
550
560
580
590
430
502
410
MAIN POWER
420
SECONDARY POWER
LED
SOUNDER
EEPROM
REAL TIME CLOCK
MEMORY CARD
592
ON/OFF SWITCH
GREEN/RED LED
567
DSP
562
FRONT/END CIRCUIT
599
594
SHOCK SWITCH
596
SPEAKER
598
INDICATOR LED 1
563
CHARGER CIRCUIT
564
CAPACITOR
565
DISCHARGE CIRCUIT
566
PATIENT INTERFACE

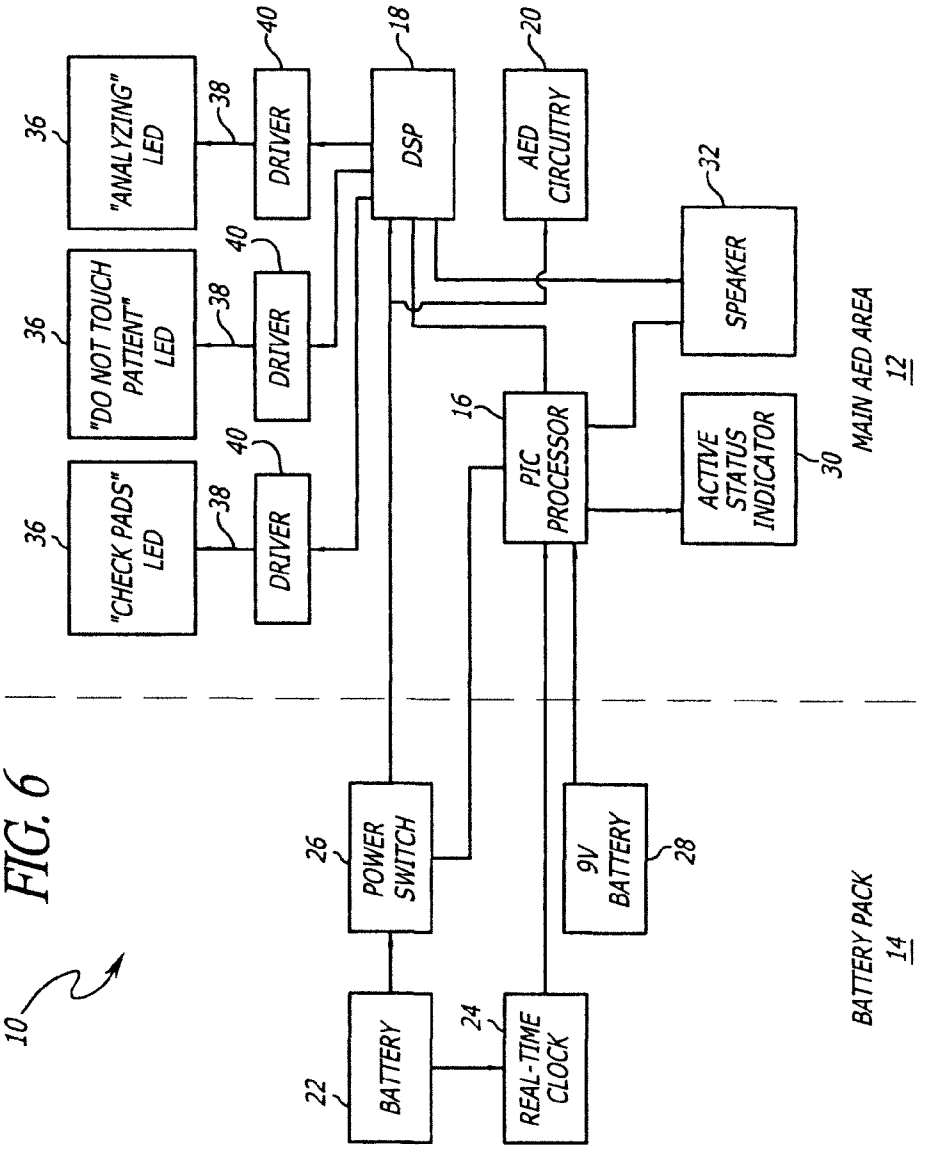
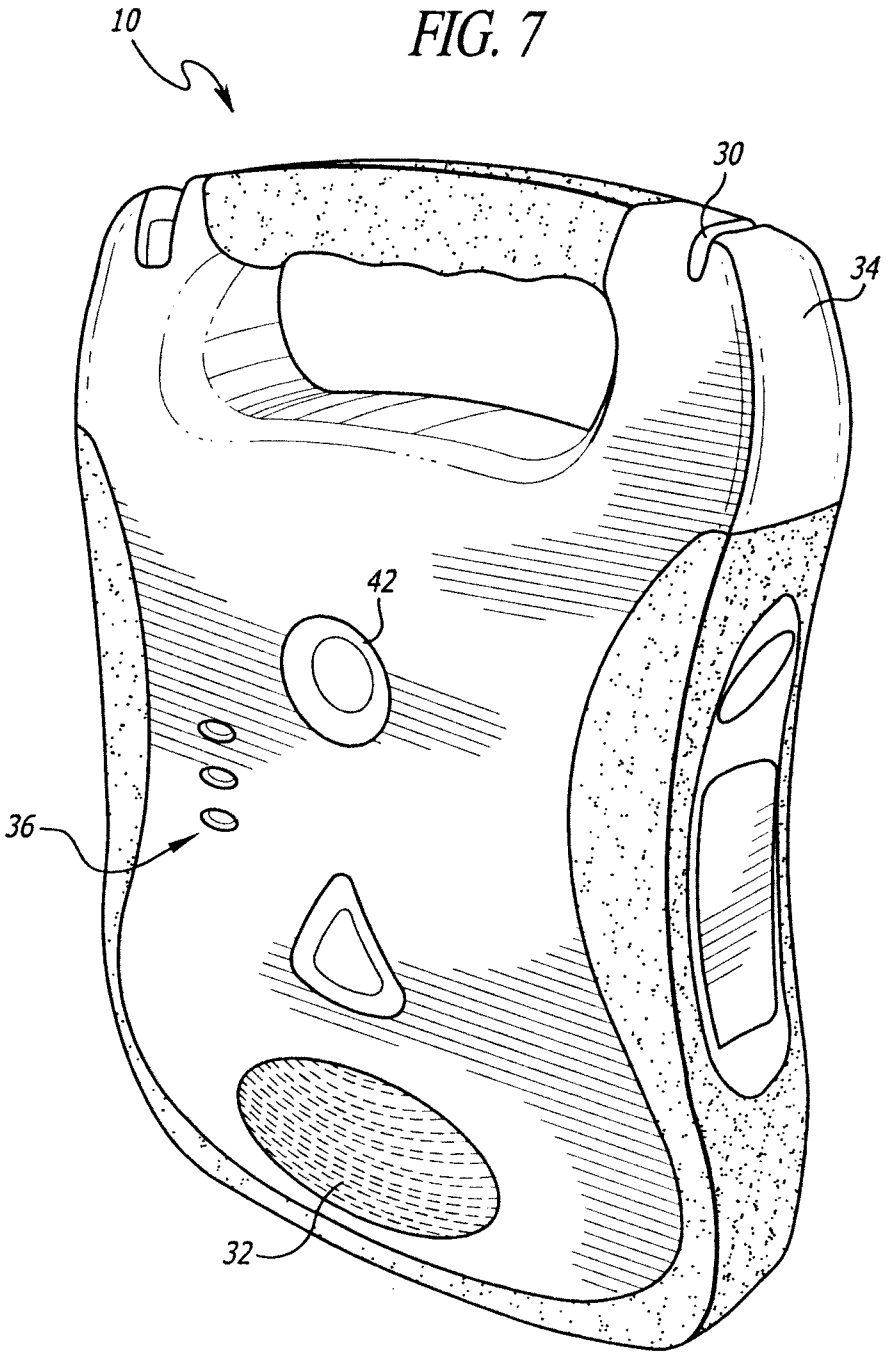

10
"ANALYZING" LED
"DO NOT TOUCH PATIENT" LED
"CHECK PADS" LED
36
38
40
DRIVER
DSP
18
AED CIRCUITRY
20
SPEAKER
32
PIC PROCESSOR
16
ACTIVE STATUS INDICATOR
30
MAIN AED AREA
12
POWER SWITCH
26
9V BATTERY
28
BATTERY
22
REAL-TIME CLOCK
24
BATTERY PACK
14

FIG. 6

FIG. 7



AUTOMATIC EXTERNAL DEFIBRILLATOR WITH ACTIVE STATUS INDICATOR

RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 10/678,593, entitled "Automatic External Defibrillator with Active Status Indicator," filed Oct. 2, 2003, now U.S. Pat. No. 7,930,023 which is a continuation-in-part of U.S. patent application Ser. No. 10/453,312, filed Jun. 3, 2003 (now U.S. Pat. No. 7,495,413), which is a continuation of U.S. patent application Ser. No. 09/960,859, filed Sep. 21, 2001 (now U.S. Pat. No. 6,577,102). The complete disclosure of each of the above-identified applications is hereby fully incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to external defibrillators, and more specifically to automatic external defibrillators (AED) having active status indicators that provide a continuous indication related to the operational readiness of the defibrillator. The invention further relates to AEDs having other operation indicators that provide indications related to the condition of the defibrillator during use.

2. Description of Related Art

Conventional AEDs perform periodic self-tests to determine the operational readiness of the defibrillator. Some defibrillators perform such self-tests automatically when they are turned on. Other defibrillators perform self-tests on a periodic basis regardless of the on/off state of the defibrillator. The results of these tests, however, may not be indicated until subsequent turn-on of the AED or may not be readily apparent to the user of the AED.

Hence, those skilled in the art have recognized a need for providing a continuous, active indication of the operational readiness of an external defibrillator regardless of the on/off state of the defibrillator. The need for additional indications of the condition of a defibrillator during use has also been recognized. The invention fulfills these needs and others.

SUMMARY OF THE INVENTION

Briefly, and in general terms, the invention is directed to an AED that provides a continuous, active indication of the operational readiness of the defibrillator. This active indication is provided by a visual indicator carried by the enclosure of the AED. The visual indicator may be a single LED capable of displaying different first and second colors, e.g., red and green. Alternatively the visual indicator may be two separate LEDs or may be a mechanical type indicator having different first and second positions, each having an associated color.

An AED incorporating aspects of the invention includes defibrillation circuitry housed within an enclosure, a first processor programmed to periodically test the operability of the defibrillation circuitry and a second processor in communication with the first processor. The AED further includes a visual indicator, as described above, positioned at the exterior of the enclosure that is operatively connected to the second processor. The second processor is programmed to control the visual indicator in response to the periodic test results provided to it by the first processor. Alternatively, the first and second processors may be combined into a single processor.

In one configuration, the second processor is programmed to 1) cause the indicator to continuously present a first color, e.g., green, when the defibrillator is on and the periodic test result is that the defibrillation circuitry is operating normally; 2) cause the indicator to intermittently present the first color when the defibrillator is off and the periodic test result is that the defibrillation circuitry is ready to operate normally; 3) cause the indicator to continuously present a second color, e.g., red, when the defibrillator is on and the periodic test result has detected an error in the defibrillation circuitry and 4) cause the indicator to intermittently present the second color when the defibrillator is off and the periodic test result has detected an error in the defibrillation circuitry.

In another aspect, the invention is directed to an AED that provides visual and/or audible indications of the condition of a defibrillator during use. These indications relate to the operation of the AED in conjunction with the electrode pad assembly used to monitor a patient's heart activity and administer defibrillation shocks.

An AED related to this aspect of the invention includes defibrillation circuitry housed within an enclosure and an electrode pad assembly adapted for electrical communication with the defibrillation circuitry at one end and a patient at the other end. The AED further includes a processor programmed to monitor the operation of the defibrillation circuitry and electrode pad assembly and a visual indicator positioned at the exterior of the enclosure and operatively connected to the processor. The AED may also include a speaker. The processor is programmed to control the visual indicator and/or speaker in response to the results of the operation monitoring.

These and other aspects and advantages of the invention will become apparent from the following detailed description and the accompanying drawings which illustrate by way of example the features of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A illustrates a top sectional view of an AED with a battery pack installed;

FIG. **1**B illustrates a top sectional view of the AED with the battery pack removed;

FIG. **2** illustrates a bottom view of the battery pack;

FIG. **3** illustrates a side sectional view of the AED including the battery pack;

FIG. **4** illustrates a side sectional view of the battery pack including first and second battery units;

FIG. **5** illustrates a block diagram of one configuration of circuitry contained within the battery pack and the AED;

FIG. **6** illustrates a block diagram of another configuration of circuitry contained within the battery pack and the AED; and

FIG. **7** is a perspective view of an AED including an active status indicator.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1**A illustrates a top sectional view of the Semi-Automatic External Defibrillator ("AED") **100** that includes a battery system, for example battery pack **110**. The AED **100** is a device to treat cardiac arrest that is capable of recognizing the presence or absence of ventricular fibrillation or rapid ventricular tachycardia or other shockable cardiac arrhythmias, and is capable of determining, without intervention by an operator, whether defibrillation should be performed. Upon determining that defibrillation should be performed, the AED automatically charges and requests delivery of electrical energy to electrodes that attach to a patient to deliver the energy to the patient's heart.

The battery pack **110** provides power to components such as electronics and a charger located in the AED **100**. The charger charges a capacitor **564** (FIG. **5**) of the AED **100** that provides the electrical energy to the electrodes attached to the patient. The AED **100** includes a generally rectangular shaped battery well **120** that is constructed and arranged to house the battery pack **110**. The battery pack **110** is sized to slide in and out of the battery well **120** to releasably connect a power supply of the battery pack **110** to the AED **100**.

FIG. **1**B illustrates a top sectional view of the AED **100** and the battery well **120** with the battery pack **110** removed. An entrance **210** of the battery well **120** accommodates alignment of the battery pack **110** within the battery well **120**.

FIG. **2** illustrates a bottom view of the battery pack **110**. Referring to FIGS. **1**B and **2**, an opposite end of the battery well **120** includes a wedge-shaped feature **230** that corresponds to a wedge-shaped receptacle **235** located in the battery pack **110**. When inserting the removable battery pack **110** to the AED **100**, the battery pack **110** is guided along by the battery well **120** to the wedge-shaped feature **230**. The battery pack **110** is aligned at the end of its travel by the wedge shaped feature **230** in the battery well **120** via the corresponding wedge shaped receptacle **235** in the battery pack **110**.

Referring to FIG. **1**A, to maintain the battery pack **110** in a connected position relative to the AED **100**, the battery pack **110** includes a latch **130** that retains the battery pack **110** within the battery well **120** when the battery pack is fully inserted into the battery well **120**. An end of the latch **130** connects with a spring **132** to bias the latch in a normally extended position. In the normally extended position, a latching end **134** of the latch **130** extends to enter a corresponding slot **136** located in the AED **100**. The latch **130** is moveable in a plane parallel to the spring **132** to compress the spring **132** to release the latching end **134** from the slot **136**. When the latching end **134** is released from the slot **136**, an ejection spring **137** located on the AED **100** pushes on the battery pack **110** to eject the battery pack **110** from the battery well **120**. The battery pack **110** includes a slot **138** from which the latch **130** extends. Even in a fully contracted position, the latch **130** extends past the slot **138**.

The battery pack **110** also includes a printed circuit board (PCB) **140** including exposed electrical terminals **150** to connect the printed circuit board **140** to electrical circuitry contained in the AED **100**, as described in more detail below. The PCB **140** includes electrical components that connect to circuitry of the AED **100** when the battery pack **110** is installed in the AED **100**. The battery pack **110** includes a window **160** that is located proximate to a visual indicator, such as light emitting diode (LED) **550** (FIG. **5**). The window **160** allows an operator to view the LED **550** when the battery pack **110** is removed from the AED **100**. Thus, the operator can determine a status of at least one of the AED **100** and the battery pack **110** independent of the battery pack **110** being connected to the AED **100**. It should be appreciated that the AED **100** could also include a window located proximate to the battery pack window **160** so that an operator can view the LED **550** when the battery pack is inserted in the AED **100**.

FIG. **3** illustrates a side sectional view of the AED **100** including the battery pack **110**. The electrical terminals **150** of the PCB **140** contact a connector **310** located within the AED **100**, to electrically connect the battery pack PCB **140** with an AED PCB **320**.

FIG. **4** illustrates a side sectional view of the battery pack **110**. The battery pack **110** includes a first power supply, such as battery unit **410**. The battery unit **410** powers essential power needs of the AED during a main operating mode, for example when the AED is powered on. An essential power need includes, for example, the power necessary to charge the capacitor **564** to delivery energy to the patient. The battery unit **410** is preferably not being drained of power when the AED is powered off.

The battery unit **410** includes one or more battery cells, or other power supplies, that are electrically connected together. The power supply may include other forms of energy storage, for example based on chemical or kinetic principles, such as a flywheel storage device. The battery cells can include, for example, ⅔ A size batteries and/or C size batteries. The number of batteries used varies depending on a particular application but typically includes five or ten ⅔ A size batteries or four C size batteries. The five ⅔ A size batteries or four C size batteries are connected in series. Also, two sets connected in parallel of five ⅔ A batteries connected in series can be used for the battery unit **410**. The battery unit **410** preferably powers electronics and a charger located in the AED **100**.

The battery pack **110** also includes a secondary power supply, such as secondary battery **420**. The secondary battery **420** powers at least a portion of at least one of the AED and the battery pack **110** in an alternate mode, such as when at least a portion of the AED is powered off. Those skilled in the art will appreciate that the secondary battery **420** could also be used to power the AED during other modes, such as a sleep mode or when the AED is powered on. The secondary battery **420** typically includes a single 9 Volt battery, but other power supplies could be used, such as other sized batteries or other forms of energy storage. In a preferred embodiment, the battery pack **110** accommodates replacement of the secondary battery **420**. The secondary battery **420** can be sized smaller than the battery unit **410** and contain energy sufficient to power, for example, electric circuitry of the AED **100** and the battery PCB **140**.

The secondary battery **420** can be used to power circuitry exclusive of a state of the battery unit **410** and without draining power from the battery unit. Diodes **502** (FIG. **5**) electrically isolate the battery unit **410** from the secondary battery **420**. Electric circuitry of the battery pack PCB **140** is described in more detail below with regard to FIG. **5**. Such circuitry includes a socket to removably receive a memory device (FIG. **4**), such as a memory card **430** or a multi-media card (MMC).

When the AED **100** is powered on and attached to the patient, the memory card **430** records the patient's electrocardiogram (ECG) signals, audio signals received from a microphone located on the AED **100**, and other operational information such as results of an analysis done on the patient by software of the AED **100**. The memory card **430** may also hold files that may be used to upgrade the software of the AED **100** or to provide user training mode software for the AED.

FIG. **5** shows a block diagram illustrating battery pack circuitry **500** contained with the battery pack **110**, for example, on the battery pack PCB **140**, and main unit circuitry **505**. The circuitry **500** includes a main power switch **510**. The main power switch **510** connects with a digital logic, such as micro-controller **520**, that turns the main power switch **510** on and off and controls other circuitry **500** of the battery pack PCB **140**. In addition to or in place of the micro-controller **520**, the digital logic can also include a microprocessor, a programmable logic device (PLD), a gate array and a custom integrated circuit. Other digital logic could also be used such as a Programmable Interface Controller (PIC) manufactured by Microchip Technologies, located in Chandler, Ariz.

The micro-controller **520** connects with a main AED connector **530** that connects circuitry of the battery pack PCB **140** to circuitry of the AED **100**. When the operator engages a

power switch **592** located on the AED **100**, the micro-controller **520** receives a signal from the main unit connector **530** indicating that the power switch has been engaged. Thereafter, the micro-controller **520** enables the main power switch **510** to provide an electrical power between the battery unit **410** of battery pack **110** and the electronics of the AED **100**. The battery pack PCB **140** also includes a main battery connector **540** to connect the battery unit **410** to the main unit connector **530** and other circuitry of the battery pack PCB **140**.

The micro-controller **520** also controls a visual indicator, such as LED **550** and an audio indicator, such as sounder **560** that are used to automatically communicate information to the operator. For example, when the AED **100** fails a self-test, the operator is notified by a chirping sound from the sounder **560**. Moreover, the LED **550** blinks green to indicate that a status of components of the AED **100** is within an acceptable operating range. Those skilled in the art can appreciate the opposite could be true, i.e., that a blinking light indicates a fault condition. According to a preferred embodiment, if the LED **550** is not blinking an error exists, for example, in the circuitry **500**, or the battery unit **410** or secondary battery **420** are depleted. The micro-controller **520** monitors a signal of a comparator connected to secondary battery **420** to monitor a status of the secondary battery **420**, for example, to determine whether or not power of the secondary battery **420** is low or depleted.

Regarding the main unit circuitry **505**, a digital signal processor (DSP) **562** processes instructions and data of the AED **100**. The DSP **562** connects with a charger circuit **563** and discharger circuit **565** to control the charging and discharging of main unit capacitor **564**. The capacitor charger **563** connects the battery unit **410** to the capacitor **564**. The capacitor **564** connects to a discharge circuit **565** that connects to patient interface **566** to deliver shocks to the patient.

The micro-controller **520** also controls an active status indicator (ASI), which in one embodiment is a red and green LED **567** located on the AED **100**. In an alternate embodiment the ASI may include two separate LEDs, a red LED and a green LED. The micro-controller **520** connects to the red and green LED **567**, for example, via pins of the main unit connector **530**. The micro-controller **520** causes the LED **567** to blink green when the AED **100** is operating properly and causes the LED **567** to blink red when components of the AED are not within the acceptable operating range, for example, a component of the AED **100** failed during a self-test procedure. If the LED **567** is not blinking when the battery pack **110** is installed into the AED **100**, components of the AED **100** and the battery pack **110** should be checked. The operation of the AED self-test procedures and the ASI are described further below. The battery pack LED **550** is preferably disabled when the battery pack **110** is installed.

The secondary battery **420** powers the micro-controller **520**, the LED **550** and the LED **567**, which helps to maintain the integrity of the battery unit **410** that provides power to electronics and the capacitor charger located in the AED **100**. A secondary battery connector **570** connects the secondary battery **420** to the circuitry of the battery pack PCB **140**.

The battery pack circuitry **500** also includes an electrically erasable programmable read only memory (EEPROM) **580** connected to the micro-controller **520** and the main unit connector **530**. The EEPROM **580** stores information that may be relevant to an owner, service person or operator of the AED **100**. The EEPROM **580** stores information regarding, for example, the number of shocks the battery unit **410** has been used for, that the AED **100** has been activated, the date of manufacture of the battery pack **110** and status information regarding a status of components of the battery pack **110** and the AED **100**. The DSP **562** of the AED **100** connects to a bus that connects to a real time clock (RTC) **590**, the EEPROM **580** and the micro-controller **520**. Typically once per power up of the AED **100**, the DSP accesses the RTC **590** to set a main unit clock of the AED **100** that is located in the DSP.

The main unit circuitry **505** also includes a switch **592**, such as an ON/OFF switch, that connects to the micro-controller **520** via the main unit connector **530**. A shock switch **594** connects to the DSP **562** to allow an operator to administer a shock to the patient. A speaker **596** and indicator LEDs **598** connect to the DSP **562** to supply instructions or other information to the operator. Front end circuitry **599** connects between the DSP **562** and the patient interface **566** to process and/or provide the DSP **562** with information from the patient.

With reference to FIG. **6**, in another configuration, the AED **10** consists of a main AED **12** and a removable battery pack **14**. The main AED **12** includes a PIC processor **16**, which is used to control power to the AED, a digital signal processor (DSP) **18**, which is the main processor for the AED, and AED circuitry **20**, which consists of the remainder of the AED circuitry. For a description of additional AED circuitry including the high-voltage circuitry used to generate and deliver defibrillation shock, see U.S. Pat. Nos. 5,607,454 and 5,645,571, the disclosures of which are hereby incorporated by reference. Alternate circuitry, within the purview of one of ordinary skill in the art, may be developed and employed. Thus, the scope of this invention is not intended to be limited to the circuitry described in the incorporated references.

The battery pack **14** is similar to that previously described with reference to FIG. **5**, except that some components, including the micro-controller **520** (FIG. **5**), i.e., the PIC processor, have been moved to the main AED **12** (FIG. **6**). The battery pack **14** includes a battery **22**, which contains multiple battery cells, a real-time clock **24**, which keeps time and can generate an output signal on a regular basis, a power switch **26**, which is used to couple the battery **22** to the main AED **12**, and a 9V battery **20** used to provide power to the PIC processor **16** during the times that the power switch **26** is off.

The DSP **18** is configured to run a number of self-tests that check the operation of the DSP **18** and the AED circuitry **20** on a periodic basis to ensure that the AED is fully operational. When the main AED **12** is powered off, the PIC **16** is placed in a standby mode. The real-time clock **24**, which is permanently powered from the battery **22**, issues a periodic signal, typically every five seconds. This signal is routed to the PIC **16** and causes the PIC to "wake up" from standby mode. At that time, the PIC **16** flashes an ASI **30** to indicate AED status and also decrements a count of the number of times that it has been woken up since the count was last set. When this count reaches zero, indicating that approximately 24 hours have elapsed since the count was last set, the PIC **16** turns the power switch **26** on which applies power to the AED causing the DSP **18** to execute startup code.

During the startup sequence, the DSP **18** communicates with the PIC **16** to determine the reason for the power-up. Typical reasons are that the user pressed the on/off button on the AED or that the PIC **16** has initiated a self-test. If the reason is a self-test, the DSP **18** executes self-test code which tests a portion or a majority of the AED circuitry **20**. The results of the self-test are communicated to the PIC **16** which then displays the AED status by blinking the ASI **30**. The PIC may also be configured to sound a sounder, e.g., speaker **32**. When the test is complete, the DSP **18** sets the wake-up counter to a value which will cause the PIC **16** to wake up the DSP **18** approximately 24 hours later and initiates main AED

12 shut-down. The PIC **16** then turns off power to the main AED **12** by switching off the power switch **26**. In this manner the AED is tested on a regular basis.

A typical testing schedule is to do the following self-tests at the intervals indicated:

Every day: basic circuitry tests.

Once a week: basic circuitry tests, basic battery tests and basic high voltage circuit tests,

Once a month: basic circuitry tests, additional battery tests and comprehensive high voltage circuit tests, including a partial-voltage internal shock.

Once every three months: basic circuitry tests, additional battery tests and comprehensive high voltage circuit tests, including a full-voltage internal shock.

Tests are performed in a "silent mode" where no user interface elements are exercised and the user is not able to tell that the tests are being executed. The user may also independently initiate a self-test by holding down the on/off button **42** (FIG. **7**) on the AED for five seconds while turning the unit on. This will cause an extended self-test, similar in scope to the "once every three months" test, to execute.

With reference to FIG. **7**, the ASI **30** is located on the upper right side of the AED enclosure **34**. The status indications provided by the ASI are as follows:

Steady-on green: the AED is on and operating normally.

Blinking green: the AED is off (in the stand-by mode) and is ready to operate normally.

Steady-On red: the AED is on and has detected an error.

Blinking red: the AED is off (in the stand-by mode) and the AED or battery pack needs servicing.

Off: battery pack not installed, AED defective, or the 9V battery is discharged.

Regarding the "blinking red" status, anytime the ASI **30** blinks red, the PIC **16** causes the speaker **32** to beep periodically to call attention to the AED. The ASI **30** is powered by the replaceable 9V battery **28** in the battery pack **14**. If the 9V battery **28** has discharged, active status indication will not be available. In this case, the 9V battery **28** should be replaced. Once the 9V battery **28** has been replaced, the ASI **30** will once again flash a status indication. If the 9V battery **28** is depleted, the AED will still be fully functional and can be used in the on-state normally.

When the ASI **30** is blinking red, additional indications of the reasons for the blinking may be obtained by turning the AED on through the on/off button **42**. These additional indications are provided by voice prompts programmed into the DSP **18** and output over the speaker **32**. These voice prompts include:

"Power on self-test failed, error 'xxx'"—indicates that the AED has failed the power-on self-test and is non-operational and needs servicing. The code number xxx indicates the type of problem that the unit is experiencing.

"Battery pack self-test failed, error 'xxx'"—indicates that the AED's battery pack is non-operational and needs servicing. The code number xxx indicates the type of problem that the unit is experiencing.

"Error 'xxx', service required"—indicates that the AED has detected an internal error, is non-operational and needs servicing. The code number xxx indicates the type of problem that the unit is experiencing.

"Battery pack low"—indicates that the battery pack capacity is low and should be replaced soon. The AED will still be able to deliver at least a minimum of six defibrillation shocks the first time this message is spoken.

"Replace battery pack"—indicates that the battery pack is almost discharged and that the AED may not be able to deliver defibrillation shocks. The battery pack should be immediately replaced.

"Replace 9V battery"—indicates that the 9V battery in the battery pack needs to be replaced. The unit may not provide active status indication during standby mode in this condition, but the AED is still fully functional when turned on and may be used to treat patients. The 9V battery should be replaced as soon as possible.

As previously indicated with reference to FIG. **5**, a speaker **596** and indicator LEDs **598** are connected to the DSP **562** to supply instructions or other information to the operator. With further reference to FIG. **7**, in one configuration of the AED, these indicators **36** are located on the front panel of the enclosure **34** and include a red "check pads" LED, a red "do not touch patient" LED and a green "analyzing" LED.

As shown in FIG. **6**, the indicator LEDs **36** are directly controlled by the DSP **18**. Each LED **36** has a separate control line **38** and driver circuit **40**. When the control line **38** is active the LED **36** is powered and lights up. The DSP **18** determines when to enable an LED **36** based on system state, i.e., connecting, motion, analyzing. The LED **36** can blink under software control by enabling and disabling the control line **38** at timed intervals.

The DSP **18** enables an LED **36** under the following conditions. The "check pads" LED blinks when the DSP **18** detects that the patient electrodes are not properly applied. The "do not touch patient" LED blinks when the DSP **18** detects patient motion and at times when the operator should stay clear of the patient. The "analyzing" LED blinks when the DSP **18** is analyzing the patient's ECG Signal. The process of determining conditions that activate these LEDs is described below within the context of additional indications provided by voice prompts.

In addition to the indications provided by the blinking LEDs **36**, the DSP **18** is programmed to output voice prompts over the speaker **32** in association with certain conditions. Voice prompts associated with the "check pads" LED include "connect pads" and "check pads". "Connect pads" indicates that the DSP **18** has determined that the pads are not properly connected to the unit or not placed on the patient. This determination may be made by measuring the impedance across the pads. A high impedance is an indication that the pads are either not connected to the unit or not placed on the patient while a low impedance serves as an indication that the pads may be shorted together. What is considered "high" or "low" impedance is dependent on the electrical characteristics of electrode pad assembly and the internal defibrillator circuitry. "Check pads" indicates that the pads are making improper contact with the patient and that the impedance is out of range, i.e., either too high or too low, for proper ECG analysis and shock delivery.

Voice prompts associated with the "do not touch patient" LED include "do not touch patient", "stop motion" and "stop interference". "Do not touch patient" indicates that the DSP **18** is in the process of analyzing the patient's heart rhythm and that the operator should not touch the patient. The DSP **18** is programmed to analyze ECG signals once it has determined that the electrode pads are making good connection to the patient. The "do not touch patient" message is spoken at the beginning of the ECG analysis period and also if motion or interference has been detected. "Stop motion" indicates that the DSP **18** has detected motion in the patient, such as may occur during the administering of CPR. "Stop interference" indicates that the DSP **18** has detected interference on the ECG signal. In each of these cases, the DSP **18** monitors

the characteristics of the ECG signals for indications of patient motion, e.g., an unexpected spike in the signal, and signal interference, e.g., a signal pattern containing noise or a signal of weak amplitude.

Voice prompts associated with the "analyzing" LED include "analyzing heart rhythm" and "analyzing interrupted". "Analyzing heart rhythm" indicates that the DSP **18** is actively analyzing the patient's ECG signal. The DSP **18** will continue analyzing until it has determined whether a rhythm is shockable or non-shockable or analyzing is interrupted for some reason. "Analyzing interrupted" indicates that the DSP **18** has determined that accurate ECG analysis is not possible and has ceased analyzing. The DSP **18** determines this condition by monitoring the ECG signal as previously described with respect to patient motion, signal interference and check pads. While the other LEDs may blink during this process, the "analyzing" LED will not be lit during this message.

While the invention has been described above by reference to various embodiments, it will be understood that many changes and modifications can be made without departing from the scope of the invention. It is therefore intended that the foregoing detailed description be understood as an illustration of the presently preferred embodiments of the invention, and not as a definition of the invention. It is only the following claims, including all equivalents, which are intended to define the scope of this invention.

What is claimed is:

1. An external defibrillator, comprising:

a battery;

defibrillation circuitry, the defibrillation circuitry powered by the battery and including

a micro-controller programmed to conduct a self-test and programmed to perform a rescue by executing a program stored thereon, the self-test including at least some portion of the defibrillation circuitry, the self-test being capable of determining an operational status of the external defibrillator; and

an active status indicator comprising a first light source that illuminates, the first light source operated by the programming running on the micro-controller, wherein when the most recent self-test has determined that the defibrillator operational status is normal, the first light source illuminates to indicate that the defibrillator is ready for use

wherein the self-test is conducted with the defibrillator being OFF from the perspective of a user.

2. The external defibrillator of claim **1**, wherein the self-test is autonomous and recurring.

3. The external defibrillator of claim **2**, wherein the self-test is selected from a group of self-tests of varying degrees.

4. The external defibrillator of claim **1**, wherein the illuminated first light source blinks frequently.

5. An external defibrillator, comprising:

a battery;

defibrillation circuitry, the defibrillation circuitry powered by the battery and including

a micro-controller programmed to conduct a self-test and programmed to perform a rescue by executing a program stored thereon, the self-test including at least some portion of the defibrillation circuitry, the self-test capable of determining an operational status of the external defibrillator;

an active status indicator comprising a first light source that illuminates, the first light source operated by the programming running on the micro-controller and mounted on a surface of the external defibrillator, the surface visible from an exterior of the external defibrillator, wherein when the self-test has determined that the defibrillator requires maintenance, the first light source illuminates to indicate that the defibrillator requires maintenance; and

wherein the self-test is conducted with the defibrillator being OFF from the perspective of a user.

6. The external defibrillator of claim **5**, wherein the self-test is selected from a group of self-tests of varying degrees.

7. The external defibrillator of claim **5**, wherein the illumination is blinking frequently.

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