

- [54] **COMPUTER CONTROLLED DEFIBRILLATOR**
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[73] Assignee: Health Technology Labs, Inc., Omaha, Nebr.
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[51] Int. Cl. A61n 1/36
[58] Field of Search 128/419 D, 419 P, 128/419 R, 420, 421, 422, 423; 324/111

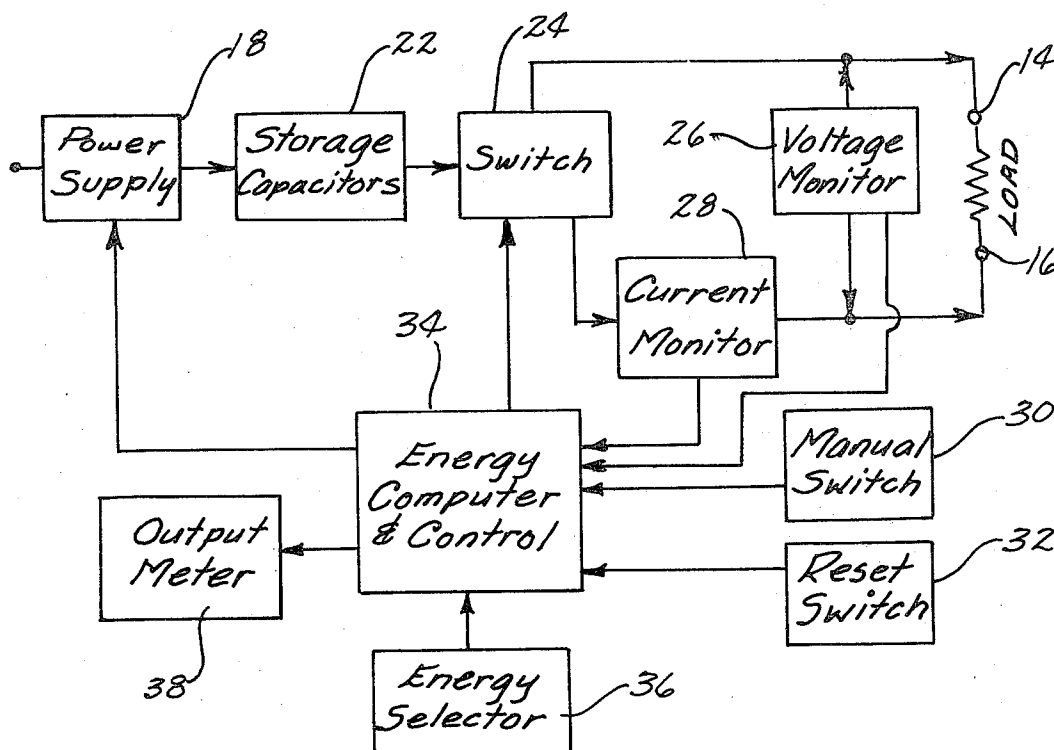
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- [57] **ABSTRACT**
A computer controlled defibrillator comprising a set

of electrodes which are engageable with a patient and which are connected to a source of electrical energy by a circuit means. The circuit means comprises storage capacitors, energy selector, computer, manual and reset switches, voltage monitor, current monitor, and output meter. The computer responds to certain external inputs, automatic and manual, and controls the output delivered to the patient. The energy selector permits the selection of the energy which is desired to be delivered to the patient. The sequence is started by closing the manual reset switch which zeroes the output meter and activates the power supply (electric energy) at a voltage which is dependent on the energy selector. The energy driven from the power supply is stored in the storage capacitors. The energy selector, which is manually set to the energy desired, also feeds an input to the computer. When the manual switch is activated, the computer causes the stored energy source to be connected to the patient through the electrodes. The current monitor and voltage monitor feed instantaneous signals to the computer which computes the energy as a continuous integration process. When the computer energy equals the selected energy, the computer causes the energy source to be disconnected from the patient. The total energy delivered to the patient is indicated as a steady reading on the output meter.

4 Claims, 6 Drawing Figures



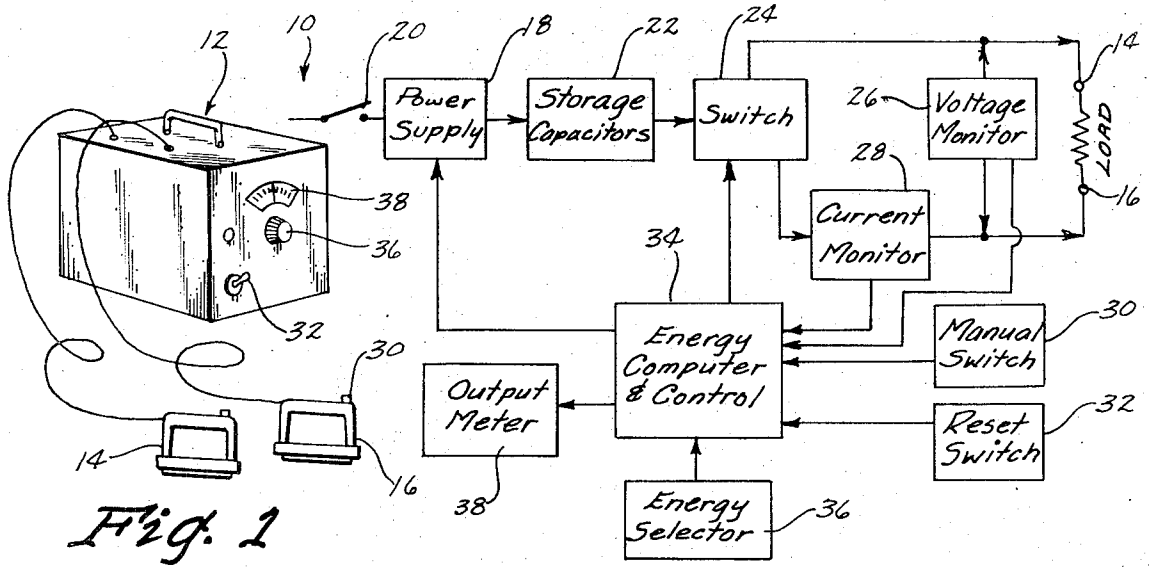


Fig. 2

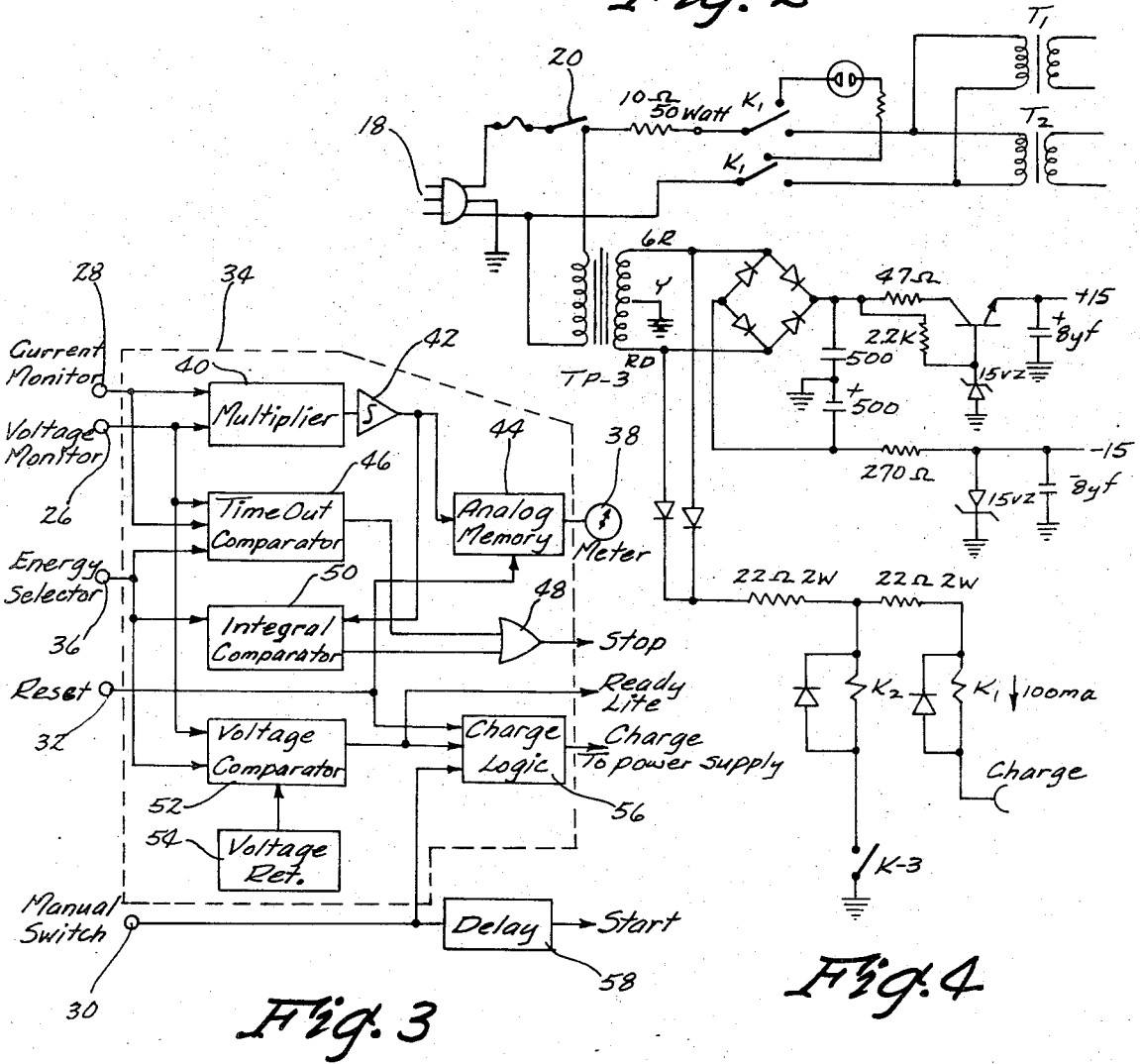


Fig. 4

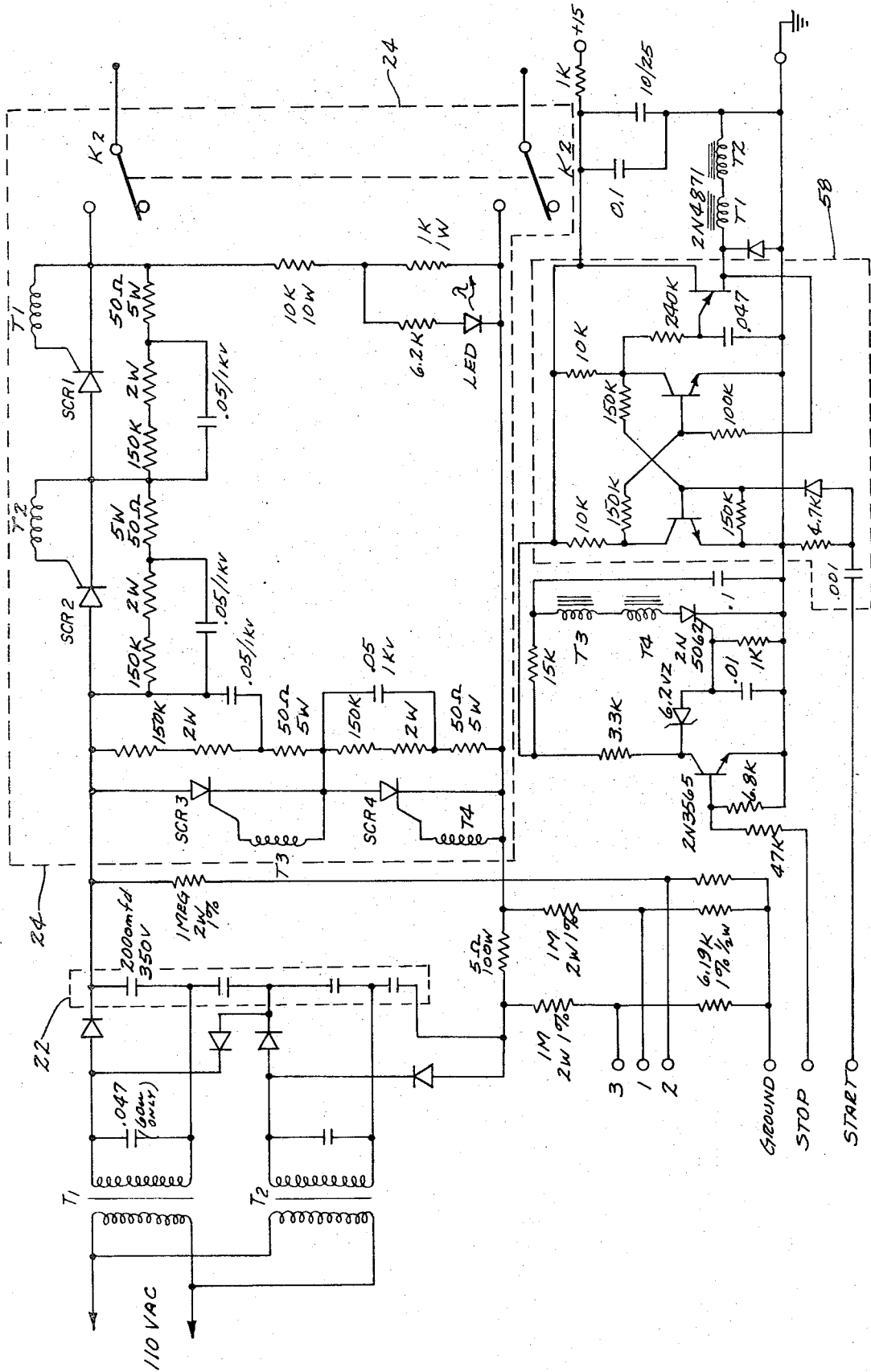
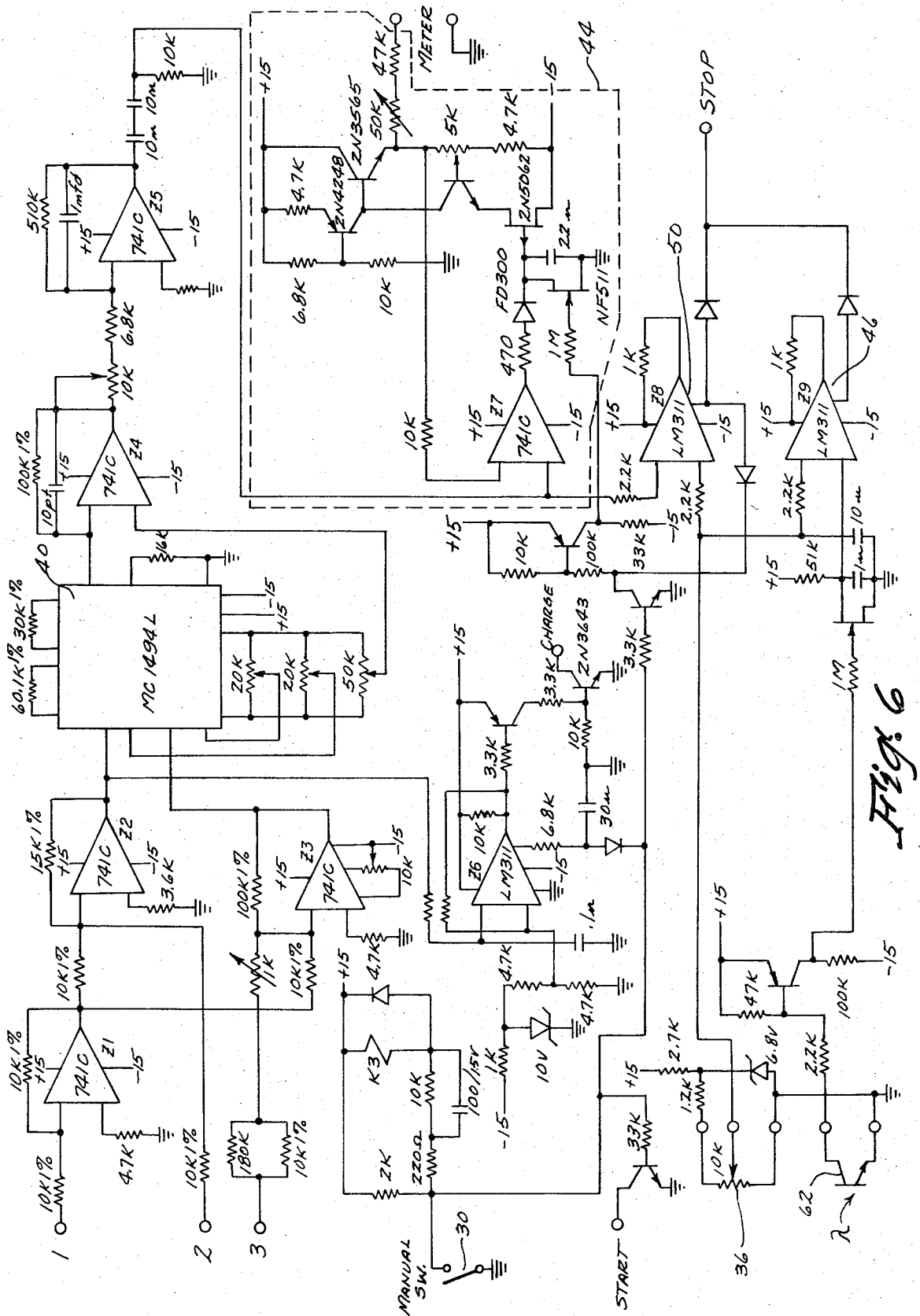


Fig. 5



COMPUTER CONTROLLED DEFIBRILLATOR

The use of DC defibrillators in emergency resuscitation has become well established. Limitations due to weight have prevented more widespread use of the defibrillators. Most clinical defibrillators depend on the storage and discharge of energy through a stable RLC combination, thus requiring accurate capacitance, inductance and resistance. The conventional defibrillators employ a pair of electrodes or paddles which are placed in contact with the patient's chest. A defibrillation or electrical pulse is then applied to the patient, through the electrodes, to momentarily stop the heart so that fibrillation of the heart is stopped. Since time is critical in defibrillation techniques, it is extremely important that a sufficiently large impulse be applied to the patient during the first attempt. A majority of the prior art devices employ some means for selecting the energy to be delivered to the patient. However, it has been found that these devices generally deliver a smaller or lower output to the patient than that which was selected. A further complication is that the resistance of the patients vary greatly. Thus, the operator could possibly determine that it was necessary to apply an impulse of 200 joules to the patient. Quite often, the variances in the defibrillator and the variable resistance of the patient will result in considerably less than 200 joules being applied to the patient. If the pulse is insufficient to momentarily stop the patient's heart, the patient could possibly die.

Therefore, it is a principal object of this invention to provide an improved defibrillator.

A further object of this invention is to provide a defibrillator wherein the energy delivered to the patient substantially equals the selected energy.

A further object of this invention is to provide a defibrillator including a circuit means having an energy computer and control which computes the energy delivered to the patient and causes the energy source to be disconnected from the patient when the computed energy substantially equals the selected energy.

A further object of this invention is to provide a defibrillator which delivers the selected energy to the patient regardless of the resistance of the patient.

A further object of this invention is to provide a defibrillator which is light weight and portable.

A further object of this invention is to provide a defibrillator which is economical of manufacture, durable in use and refined in appearance.

These and other objects will be apparent to those skilled in the art.

This invention consists in the construction, arrangements, and combination of the various parts of the device, whereby the objects contemplated are attained as hereinafter more fully set forth, specifically pointed out in the claims, and illustrated in the accompanying drawings, in which:

FIG. 1 is a perspective view of the defibrillator of this invention.

FIG. 2 is a block diagram of the electrical circuitry of the defibrillator.

FIG. 3 is a block diagram illustrating the components of the energy computer and control and its relationship with other components of the device.

FIG. 4 is a schematic view of a portion of the circuitry of the invention.

FIG. 5 is a schematic view of more of the circuitry of the invention; and

FIG. 6 is a schematic view of more of the electrical circuitry of the invention.

The defibrillator of this invention is referred to generally by the reference numeral 10 and comprises a portable housing 12 having a pair of electrodes or paddles 14 and 16 connected to the circuitry therein as will be described in more detail hereinafter. The electrodes or paddles 14 and 16 are engageable with the patient to deliver a predetermined energy output to the patient to momentarily stop the patient's heart so that fibrillation of the heart is stopped.

The circuitry of the defibrillator is depicted in schematic form in FIG. 2 wherein the numeral 18 refers to a 110 VAC power supply having a switch 20 associated therewith. The power supply 18 is electrically connected to the storage capacitors 22 which are adapted to store energy derived from the power supply 18. A "switch" mechanism 24 is connected to the storage capacitors 22. Mechanism 24 is connected to the electrodes 14 and 16 as seen in FIG. 2 and to a voltage monitor means 26 and current monitor means 28. Manual switch 30 and reset switch 32 are connected to the energy computer and control means 34. Energy selector 36 is also connected to the computer and control means 34 as is the output meter 38. Energy selector 36 may be comprised of a conventional rotatable dial or the like for setting the energy to be delivered to the patient.

The energy computer and control means 34 is illustrated in schematic form in FIG. 3. In FIG. 3, it can be seen that the current monitor 28 and voltage monitor 26 are electrically connected to the Multiplier 40 and that the Multiplier 40 is connected to an Integrator 42. Integrator 42 is connected to an Analog Memory 44 which is connected to the meter 38. The current monitor 28 and the voltage monitor 26 are also connected to a Time Out Comparator which is connected to the OR gate 48. The energy selector 36 is connected to the Time Out Comparator 46, Integral Comparator 50 and Voltage Comparator 52. The Integral Comparator 50 is connected to the OR gate 48 and to the Integrator 42 as depicted in FIG. 3. Voltage Comparator 52 is connected to the Voltage Reference 54 and to the Charge Logic 56. The Multiplier 40 is also connected to the Voltage Comparator 52.

The reset switch 32 is electrically connected to the Analog Memory 44 and to the Charge Logic 56 while the manual switch 30 is connected to the Delay-Start 58 and to the Charge Logic 56.

The heart of the control mechanism in the defibrillator is the energy computer and control 34 which responds to certain external inputs, manual and automatic, and controls the output delivered to the patient. In operation, the manual reset 32 starts the sequence by zeroing the output meter 38 and activating the power supply 18 at a voltage which is dependent on the energy selector 36. Thus, if it were desired to deliver an impulse of 200 joules to the patient, the energy selector 36 would be set at 200 joules. The energy derived from the power supply 18 is stored in the storage capacitors 22. The energy selector 36, which is manually set to the energy desired, also feeds an input to the energy computer and control 34. The electrodes or paddles 14 and 16 are then placed into contact with the patient and the

manual switch 30, located on either or both of the paddles 14 and 16, is activated.

When the manual switch 30 is activated, the energy computer and control 34 causes the stored energy source to be connected to the patient. The current monitor 28 and voltage monitor 26 feed instantaneous signals to the energy computer and control 34 which computes the energy as a continuous integration process. When the computed energy equals the selected energy, the energy computer and control 34 causes the energy source to be disconnected from the patient. The total energy delivered to the patient is indicated as a steady reading on the output meter 38.

More specifically, the circuitry of FIGS. 4, 5 and 6 operates as follows. The circuit of FIG. 4 is basically the power supply for the device. TP3 transformer feeds a full wave bridge rectifier to generate plus and minus DC voltage. The transistor and zener diodes regulate the DC to ± 15 v. and are of conventional design. The second set of diodes leading to the coils of K1 and K2 supply power to operate these relays. Contacts K3 operates coil K2. K2 operates the contacts on FIG. 5. K3 is operated off of control circuit FIG. 6. These devices, K2 and K3, control the main discharge from the firing circuit to the patient.

K1 which is controlled by the voltage comparator 52 and charge logic 56 switches 110 VAC to transformers T1 and T2. This circuit supplies power to the capacitor bank 22 in FIG. 5 as required to maintain 1,400 VDC.

The four rectifiers between T1 and T2 in FIG. 4 and the four capacitors 22 in FIG. 5 form two full wave voltage double circuits in cascade to generate 1,400 v. About 500 joules of energy are then stored in the capacitor bank. Initially all four silicone controlled rectifiers SCR are not conducting. The 150 K resistors around the SCRs are used to balance the off leakage current. The 0.05 mfd - 50 ohm networks around each SCR are to suppress switching transients.

Terminals 1, 2 and 3 are the monitor points. The voltage between 1 and 2 is proportional to the stored voltage and the voltage to the load. The voltage between 1 and 3 is proportional to the current in the load. The 5 ohm, 100 watt resistor serves the dual function of current shunt and crowbar protection.

The remainder of this circuit can be best explained by a typical operating sequence. Initially the capacitors are charged and all SCRs are off. The cycle starts with the start input going to a positive 15 v. This starts the 0.030 sec. timer 58. At the same time K2 relay begins to close. The timer delay is to allow K2 to close completely. When the unijunction transistor in the timer fires, a large current pulse is fed to trigger transformers T1 and T2. These pulses turn on SCR 1 and 2 applying power to the load. The LED is turned on by the applied voltage and is optically coupled to the photo transistor in FIG. 6. This transistor starts timeout comparator Z9. When the comparator circuit determines the required energy has been delivered, a positive voltage is applied to the stop terminal. This fires the small 2N5062 SCR generating a high current pulse in T3 and T4. This pulse fires SCR 3 and 4 which crow-bars the remaining energy in the capacitor bank.

With respect to FIG. 6, amplifiers Z1, Z2 and Z3 form two DC differential amplifiers. These amplifiers convert the essentially floating inputs 1, 2 and 3 to ground referenced signals. The two outputs are $v(t)$ from Z2 and $i(t)$ from Z3. These signals are fed to 40

which together with Z4 form an analog multiplier. The output of Z3 in mathematical terms is $v(t) \times i(t)/K$.

This signal is proportional to the power being delivered to the load at any instant of time. Z5 is an integrator which integrates power with time to give energy. The AC coupling network on the output of Z3 removes the long term DC drift. The output at this point is approximately an increasing ramp voltage. This ramp is compared to the setting of the pot 36, by comparator 50. When these are equal the comparator sends the stop output high. The peak value of the ramp is stored on the 0.22 mfd capacitor in analog storage circuit 44. The four transistor amplifier has a gain of +1. This allows the energy delivered to be displayed on the meter.

Comparator Z9 (46) performs a similar function to 50 except it compares the pot 36 setting with time. In this way the output pulse width is limited to a maximum value for any given setting. This circuit does not affect operation for loads of less than 150 ohms.

Comparator Z6, controls the charging of the capacitor bank. Z6 compares the output of amplifier Z2 which is proportional to the bank voltage to a zener diode. A certain amount of positive feedback is used as controlled hysteresis to prevent chatter of relay K1.

The remaining transistors are used as switches to turn on or off certain functions when the manual switch 30 is closed. For example, the voltage comparator Z6 is turned off and comparator 56 and 50 and analog memory 44 are turned on.

The operation described causes the selected energy to be delivered regardless of the variable patient load resistance. The limits are zero resistance at the patient (which will occur if the paddles are touched together) or an open or high (over 100 ohm) patient resistance. In case of the low limit, all of the energy stored in the capacitors would be dissipated within the defibrillator. In the case of the high limit, the defibrillator would attempt to deliver the selected energy but would take too long and the time out input will terminate the discharge before the selected value is reached. The meter 38 will indicate to the operator that the energy that was selected was not delivered and the load was abnormal.

Thus it can be seen that a novel defibrillator has been provided which insures that the energy delivered to the patient will be substantially equal to the selected energy regardless of the variable patient load resistance. The circuitry of the defibrillator permits a light weight and portable defibrillator to be provided so that the defibrillator can be easily transported to the patient. In summary, it can be seen that the defibrillator provides the following:

1. Pre-selection of the energy to be delivered;
2. Automatic Energy Control to deliver the energy selected independently of load; and
3. Verification by computation of energy delivered and indication on an output meter.

Thus it can be seen that the defibrillator accomplishes at least all of its stated objectives.

I claim:

1. A defibrillator comprising in combination, an electrical power source, a set of electrodes engageable with a patient, circuit means connecting said power source to said set of electrodes comprising, a computer means, a storage capacitor means for storing energy derived from said power source, an energy selector means for selecting the energy to be delivered to the pa-

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tient, said energy selector also feeding an input to said computer means, a switch means for causing the stored energy to be connected to the patient, said switch means being operatively electrically connected to said computer means, a power monitor means for feeding signals to said computer means when said stored energy is delivered to the patient, said computer means computing the energy delivered to the patient and causing the delivery of energy to the patient to be discontinued when the computed energy substantially equals the selected energy.

2. The combination of claim 1 wherein said power monitor means comprises a voltage monitor means and a current monitor means.

3. The combination of claim 1 wherein said circuit means has a visual output meter which indicates the energy delivered to the patient.

4. A defibrillator comprising in combination, an electrical power source,

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a set of electrodes engageable with a patient, circuit means connecting said power source to said set of electrodes comprising, a computer means, a storage capacitor means for storing energy derived from said power source, an energy selector means for selecting the energy desired to be delivered to the patient, a switch means for causing the stored energy to be connected to the patient, said switch means being operatively electrically connected to said computer means, a power monitor means for feeding signals to said computer means when said stored energy is delivered to the patient, said circuit means having a visual output means for indicating the energy delivered to the patient, said computer means computing the energy actually delivered to the patient and causing said visual output means to indicate the energy actually delivered to the patient.

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