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Hewson

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[54] **PORTABLE ELECTRONIC CARDIAC STIMULATOR**

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[73] Assignee: **Claude W. Daigle,** Ellsworth Falls, Maine ; a part interest

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[52] **U.S. Cl.** ..... **128/419 D,** 128/404

[51] **Int. Cl.** **A61n 1/36**

[58] **Field of Search**.... 128/404, 418, 419 C, 419 D, 128/419 E, 419 P, 421, 422, 423

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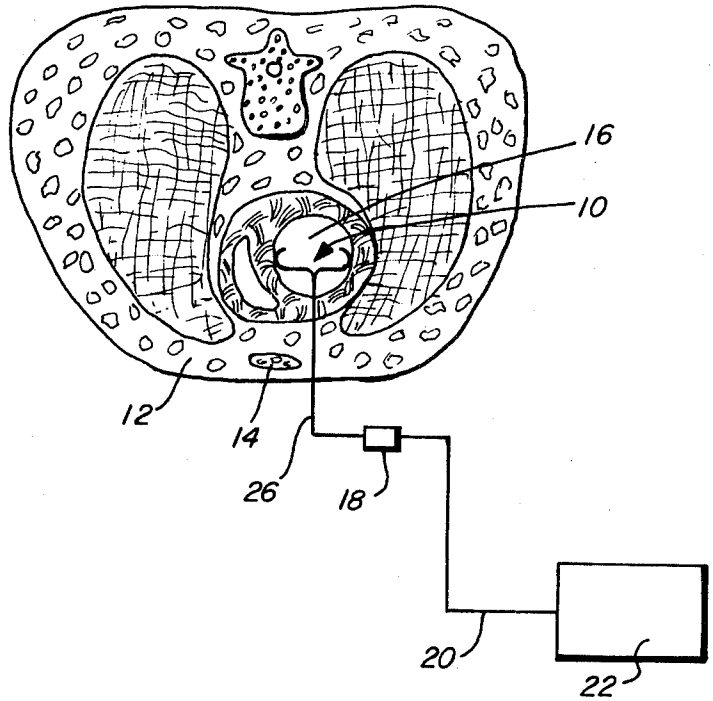
Primary Examiner—William E. Kamm

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[57] **ABSTRACT**

A light weight portable electronic cardiac emergency stimulator which includes separate defibrillation and pacemaking electronic circuits and a self-contained battery pack. The defibrillation and pacing circuits are selectively connectable, through a switch, to a pair of electrodes of special design which may be introduced rapidly into the patient's heart by a needle through his chest wall. The electrodes are self-spreading within the heart to establish firm electrical contact with opposite sides of its inner surface. After the electrodes have been introduced to the heart, as into the left ventricle, the circuits can be selectively connected to the electrodes through a switch to controllably apply either defibrillation or pacemaking electric pulses to the heart without delay.

7 Claims, 12 Drawing Figures



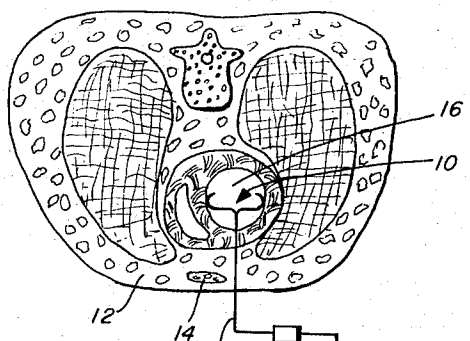


FIG. 1

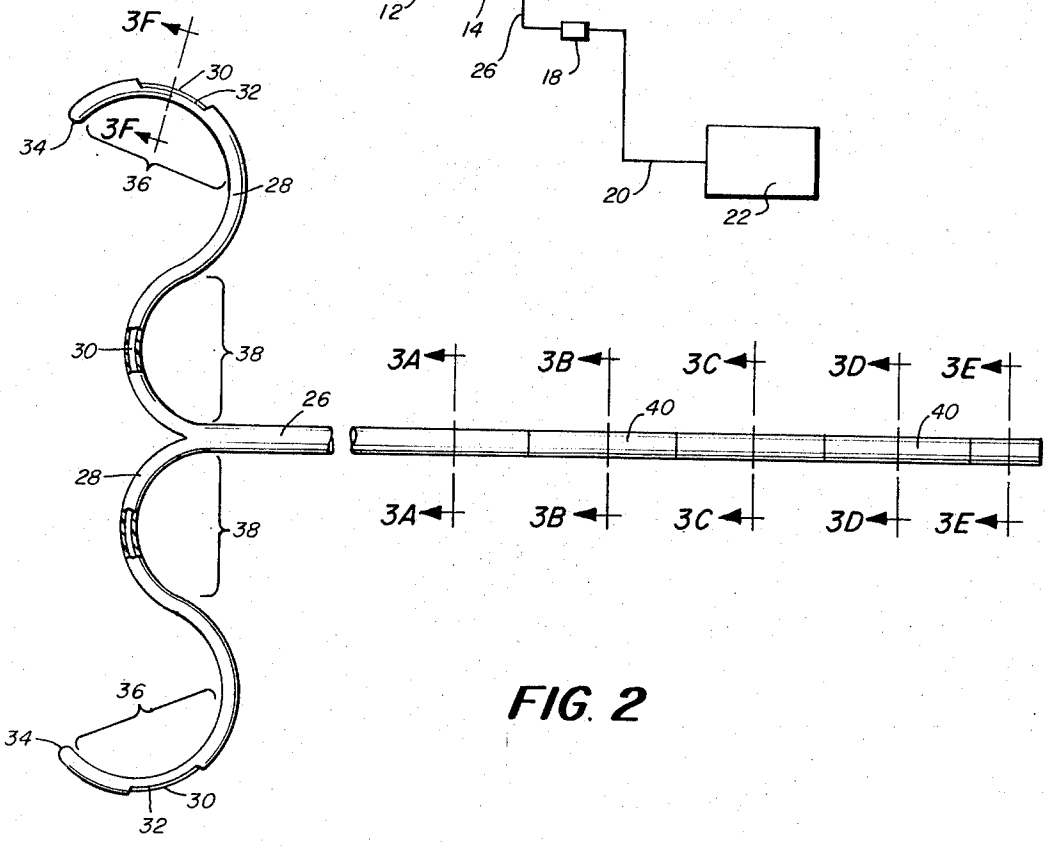


FIG. 2

FIG. 3A

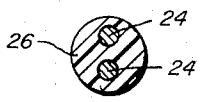


FIG. 3B

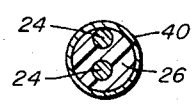


FIG. 3C

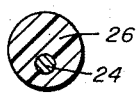


FIG. 3D

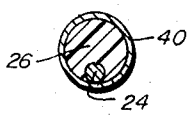
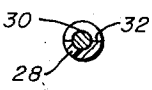


FIG. 3E



FIG. 3F



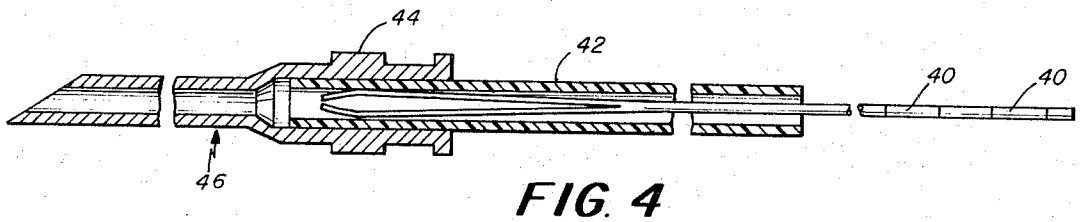


FIG. 4

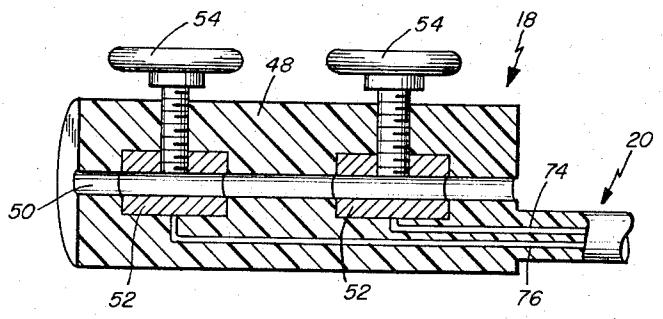


FIG. 5

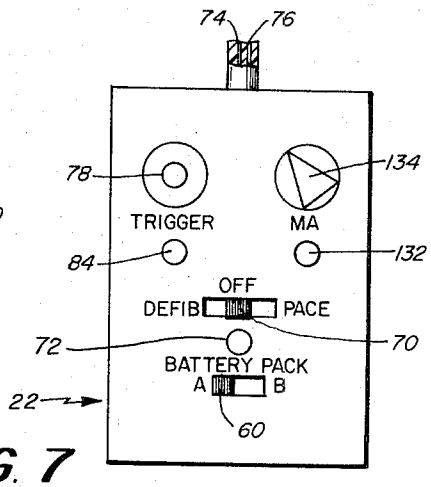


FIG. 7

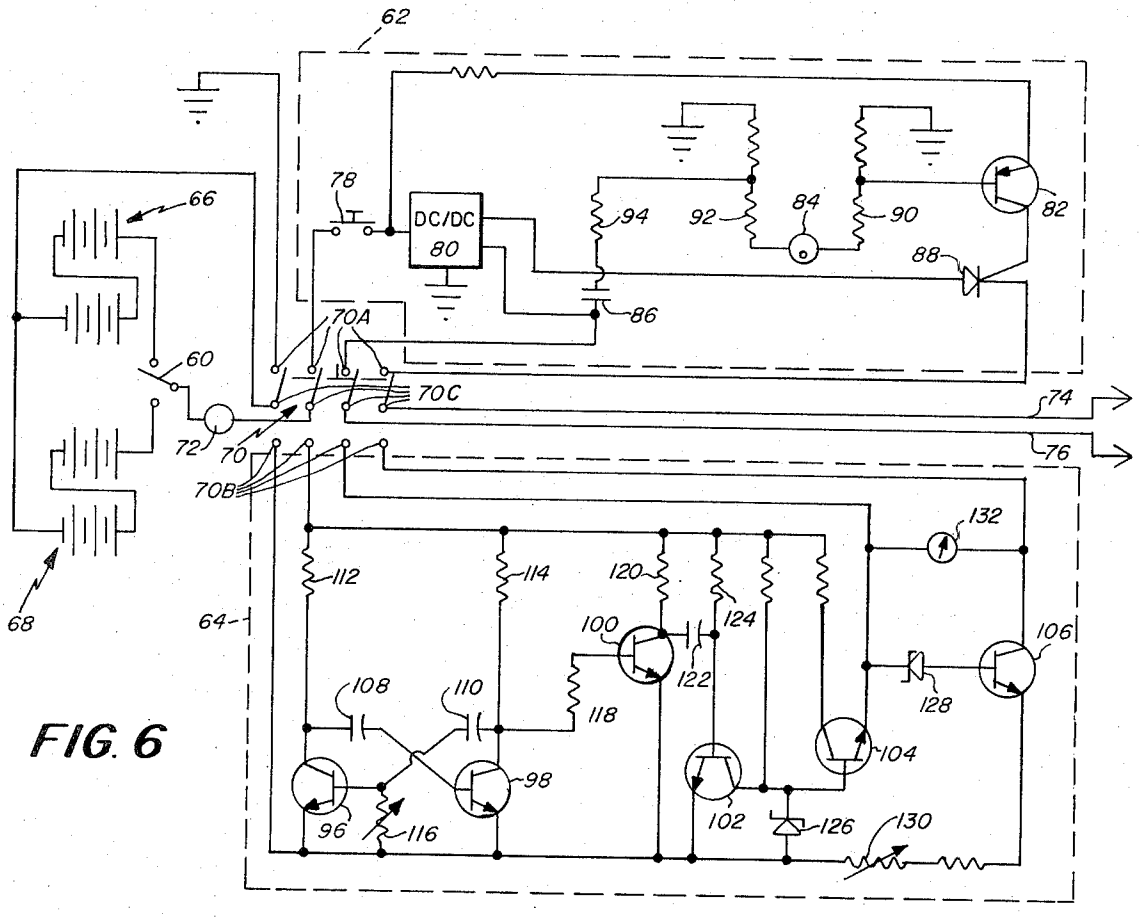


FIG. 6

PORTABLE ELECTRONIC CARDIAC STIMULATOR

BACKGROUND OF THE INVENTION

Cardiac disorders are believed to be among the major causes of death. Usually, acute disorders appear with no warning and where the patient is remote from medical assistance. While in some less severe cardiac disorders there is sufficient time to transport the patient to a hospital for treatment, in other more severe types of cardiac disorders, such as an acute myocardial infarction, immediate aid is often required. For example, in the United States, it is estimated that approximately 1,200,000 persons suffer an acute myocardial infarction each year. Of these, 200,000 people die within 15 minutes of the onset of their myocardial infarction, and another 50,000 die in the time interval between 15 minutes and 2 hours of the onset of their myocardial infarction. The death of a great proportion of the people in the latter group of 50,000 could largely be prevented by administering suitable medical aid quickly and without a delay. As to those persons who die of acute myocardial infarction within fifteen minutes of its onset, a great proportion could likewise be saved if proper medical attention could be employed immediately. Treatment of such acute cardiac disorders typically requires apparatus which is bulky and does not lend itself to portability. Thus, it has been necessary to transport the patient to a hopsital or other facility where such apparatus is available. The time interval ordinarily is too great and the patient dies.

In the great proportion (95 percent) of acute cardiac deaths, the patient is suffering from ventricular fibrillation. The remaining patients are in asystole, in which all heart activity has stopped. In each of these instances, there is no detectable arterial pulsation. As a result, the patient can deteriorate rapidly. For example, permanent brain damage can begin to occur approximately three minutes after pulsation stops.

Where the patient is suffering from ventricular fibrillation, it is essential first that the fibrillation be stopped before the heart can resume more regular activity. The usual emergency procedure for treating a pulseless patient is to check his air passages and perhaps attempt mouth-to-mouth resuscitation. If that fails to restart the heart, a sharp blow is applied to the chest generally in the region of the heart. That failing, closed chest cardiac message is initiated primarily in order to maintain a semblance of blood circulation in an attempt to avoid or minimize brain damage. These techniques are rarely effective to defibrillate a fibrillating heart and do not generally restart the heart. They are employed primarily as supportive therapy until the patient can be brought to a hospital or facility where fibrillation or asystole can be more effectively treated. When the patient has reached the hospital the vigorous closed chest massage is continued until the electric defibrillation apparatus has been readied. Such apparatus generates a substantial electrical pulse which is applied to the patient by means of a pair of paddle-like electrodes which are applied to the patient's chest. In general, it has been found that the most effective way to defibrillate is by applying such an electric pulse to the patient. The urgency of immediate defibrillation cannot be overstated. When the patient has no apparent pulse, closed chest massage is at best a poor substitute for a normally beating heart. Thus, even with vigorous closed chest massage the patient's brain and heart deteriorate quickly. Lactic acid builds up due to poor oxygenation of tissue which is the direct result of poor cardiac output. Thus, even when the patient reaches the hospital where he can be defibrillated electrically, the degree of deterioration which he may have suffered often is such that the defibrillation apparatus is ineffective and the patient dies. Because of the relatively nonportable bulky nature of defibrillation apparatus, many people have died within the time interval necessary to transport the patient to the hospital.

In addition to the foregoing difficulties, even if a patient has been defibrillated, he may still remain pulseless, in asystole. Among the most effective treatments for this condition is the application of electrical pulses of a smaller magnitude to the heart at a rate approximating that of a normal heart beat. Application of such pacing pulses is of considerable assistance in restarting an asystolic heart and maintaining regular operation of that heart. However, even in a hospital environment this takes some time which may add further to the interval so critical to the patient. This is true even though the electrodes for the heart pacing arrangement are applied through a transthoracic catheter of the type shown in the Ackerman patent or through a major vein into the heart. These procedures take time in addition to the time already elapsed. Although closed chest massage is maintained throughout these intervals the patient deteriorates further. Moreover, it may be noted that ventricular fibrillation is recurrent and can begin again even after the heart has been defibrillated but before the pacing electrodes have properly placed in operation. In such instance, the procedure may have to be restarted with the attendant loss in time. It is among the primary objects of my invention to provide a device and technique which minimizes greatly any interval between the time at which medical or paramedical personnel reach the patient and the time in which proper electrical stimulation of his heart is provided.

SUMMARY OF THE INVENTION

My invention includes independent defibrillation and pacing circuits which are assembled in a compact portable housing. The housing also contains a battery power pack and a switching arrangement to enable either of the circuits to be connected to the power pack. The output from the device is connectable to an arrangement of electrodes which are adapted to be introduced directly into the heart by a transthoracic needle. The electrodes are arranged to make good electrical contact with the inner surface of the heart, such as within the left ventricle. After the electrodes are disposed properly within the heart, the defibrillation or pacing pulse can be applied immediately. Further aspect of the invention relates to the bipolar configuration of the electrodes. The electrodes are highly flexible and normally tend to assume a spread apart configuration. When introduced into the heart they spread apart and against opposite sides of the inner surface of the left ventricle. The portions of the electrodes which contact the wall of the ventricle are of a broad and curved configuration. The electrodes are arranged so that there is little tendency for the electrical pulse to short circuit through the blood in the heart. This ensures that the electrical pulse will be applied directly to the myocardium. Because of the direct contact of the electrodes with the heart, there is significantly less im-

pedance to the electrical pulse than that which is presented by the usual bulky defibrillation apparatus in which the pulse is applied to the exterior of the chest. As a result, there is a substantially smaller power requirement necessary which facilitates the portability of the device so that it may be carried easily to the patient thus saving time. Additionally, the electrode configuration is highly flexible and presents substantially no resistance to contraction of the heart.

It is among the objects of my invention to provide a portable cardiac stimulator capable of immediately applying defibrillation pulses to a cardiac victim.

Another object of the invention is to provide a portable defibrillation device which can selectively be employed to apply pacing pulses to the patient.

A further object of the invention is to provide a portable apparatus which avoids the critical lag in time incurred in the usual emergency treatment of such heart disorders.

Another object of the invention is to provide a portable cardiac stimulator which is capable of immediately and selectively applying either of a defibrillation pulse or a repetitive series of pacing pulses.

Further object of the invention is to provide an improved electrode arrangement employing a pair of poles which are self-spreading into contact with the opposite sides of the patient's ventricle.

Still another object of the invention is to provide an improved electrode arrangement in which each of the poles of the electrode contact the inner surface of the ventricle along a substantial area and not just point contact.

A further object of the invention is to provide an electrode configuration which presents substantially no resistance or damage to the heart in the event of contraction of the heart.

DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and advantages of the invention will be understood more fully from the following detailed description thereof, with reference to the accompanying drawings wherein:

FIG. **1** is a diagrammatic cross section through a patient's thorax at the level of the fifth intercostal space, showing the invention with the self-spreading bipolar electrode inserted into the left ventricle of the heart;

FIG. **2** is an illustration of the electrode arrangement when in its spread configuration and having portions thereof broken away to illustrate its internal configuration;

FIG. **3A–3F** are cross sections of the lead to the bipolar electrode and the bipolar electrodes themselves showing the internal arrangement of the electrode leads along successive portions of the electrode and as seen along the lines **3A—3A, 3B—3B, 3C—3C, 3D—3D, 3E—3E** and **3F—3F** of FIG. **2**;

FIG. **4** is a longitudinal sectional illustration of the transthoracic needle by which the bipolar electrode may be inserted into the patient's left ventricle and showing the configuration of it in the manner in which the bipolar electrode is disposed within the needle in readiness to be inserted into the patient;

FIG. **5** is an enlarged illustration of the arrangement by which the electrode may be connected to the circuitry of the device;

FIG. **6** is a diagrammatic illustration of the circuitry of the invention; and

FIG. **7** is an illustration of the face of the control panel and housing for the circuitry.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** shows the invention in readiness to apply electric stimulating pulses to the patient. It includes the bipolar electrode **10** which has been inserted, in the manner described herein, through the patient's chest wall **12** at the level of the fifth intercostal space, to the left of the sternum **14.** When properly located, the bipolar electrode **10** is disposed within the left ventricular lumen **16** of the heart. The electrode leads are connected by a connector **18** to the output leads **20** from a compact integral and controllable pulse generator **22.** As described more fully below, the pulse generator includes independent circuits adapted to generate a defibrillating pulse and pacemaking pulses which can be selectively applied to the bipolar electrodes **10.**

The bipolar electrode **10** is formed from a pair of thin flexible electrically conductive wires **24** made from a metal which is biologically non-reactive such as No. 316 extra low carbon stainless steel wire. In the illustrative embodiment, the wires approximate 0.012 inches in diameter. A pair of such wires is embedded in a flexible insulative sheath which, in the preferred embodiment, has an external diameter of approximately 0.034 inches. The sheath should be made from an appropriate material which is similarly biologically non-reactive such as silastic.

The parallel insulated wires **24** and surrounding sheath **26** are bifurcated at the end of thee electrode to define a generally T-shaped configuration in which the ends of the wires **24** extend generally in opposite directions. The sheath **26** continues integrally along the separated electrode portions of the wires **24** to define electrode sheaths **28** which insulate the bifurcated electrodes **30.** The insulative sheaths **28** extend fully to and about the tips of the electrodes **30** except for cutout segments **32** through which the inner electrodes **30** are exposed.

The bifurcated electrodes **30** are fabricated so that they tend to assume the spread configuration shown in FIG. **2** which is somewhat S-shaped. The outer ends of the sheathed electrodes **30** are curved with their tips tending to extend inwardly. The arrangement is such that the lateral regions of the electrodes define a substantial convex configuration. It may be noted that the outer diameter of the electrode sheaths **28** is approximately 0.017 inches. At the outwardly facing side of each of the outer arcuate segments **36,** the electrode sheaths **28** are cut away at **32** to define outwardly exposed semicircular sections of the electrodes **30.** The cutout segments **32** preferably are approximately 3/16 of an inch long and begin approximately 3/16 of an inch from the tip **34** of each electrode **30.** The cutout segments **32** expose the electrode only laterally outwardly and over approximately 180° of the cross sectional circumference of the electrode. The portions of the electrodes **30** which are so exposed serve as the conductive terminal ends of the electrode and are intended to bear against and establish electrical communication with the opposite inner surfaces of the ventricle wall. The electrode configuration shown in FIG. **2** is that in its completely relaxed condition. The bifurcated end of the electrode is dimensioned so as to be somewhat greater than the inner diameter of the ventri-

cle. When the electrode arrangement is disposed within the ventricle and expands against diametrically opposite sides of the inner surface of the ventricle, the lateral arcuate segments **36** and, particularly the exposed surfaces of the electrodes **30** will bear against the ventricle wall snugly to establish firm electrical connection. When properly disposed within the ventricle, the electrodes assume a more T-shaped configuration than that shown in FIG. **2** with the reversely curved segments **38** of the electrodes being somewhat less curved than shown in FIG. **2.** This is suggested somewhat in FIG. **1.** While the dimensions of the electrode wire are such to enable it to be biased with sufficient firmness against the ventricle wall, it is sufficiently light as to present substantially no resistance to contraction or flexure of the myocardium. The foregoing arrangement ensures that electrical contact will be maintained with the ventricle during contraction or other movement of the heart.

The foregoing electrode arrangement provides a number of advantages. The exposed portions of the electrodes define a relatively substantial area of electrical contact thus tending to reduce the magnitude of impedance presented. It also reduces significantly the possibility of short circuiting through the relatively conductive blood within the left ventricle. The electrodes **30** are exposed only laterally and are biased firmly against the slightly into the ventricle wall which tends to cooperate with the insulative sheathing to isolate the electrode from the blood within the ventricle. This enhances the likelihood of the electrical pulse being applied to the ventricle wall and not being short circuited through the blood. In addition, the engagement of the electrodes with diametrically opposite portions of the ventricle further reduces the possibility of short-circuiting by maximizing the distance between the exposed portions of the electrodes. Still another significant advantage of the electrode configuration is that by applying the electrodes at opposite internal surfaces of the ventricle it is more effectively ensured that a substantial portion, if not all of the ventricle wall will be subjected to the electrical pulse. The arrangement of the insulated tips **34** by which they extend inwardly toward each other and away from the ventricle wall affords a further safety feature by eliminating the possiblity of accidental puncture of the ventricle wall. In this regard it may be noted that when the electrodes are properly disposed within the ventricle, the tips **34** extend inwardly toward each other even to a greater extent than that shown in FIG. **2.**

FIGS. 3A-3F show the cross section of the electrode leads at various locations along their length and the manner in which the leads may be connected to the pulse generator **22.** The wires **24** extend within the sheath and are connected to a pair of conductive sleeves **40** which are spaced along the distal end of the leads and are exposed about the circumference of the sheath **26.** The wires **24** are connected by appropriate means to the sleeves **40** as shown in FIGS. 3B and 3D.

The sleeved end of the sheath **26** is connected to the pulse generator **22** by a connector **18** in the manner described below.

The electrode is introduced transthoracically into the left ventricle of the heart before its trailing end is electrically connected to the pulse generator and by means of an arrangement shown in FIG. **4.** This arrangement includes a plastic tube **42** having an internal diameter of approximately 0.040 inches which encloses the bipolar electrodes as shown. The electrodes are sufficiently resilient as to be able to be slipped into the tube **42** with its normally S-shaped bifurcations being constrained in the substantially straight configuration shown. The outer diameter of the tube **42** is dimensioned to fit within the hub **44** of a **17** gage cardiac needle indicated generally at **46.** The electrodes are introduced by inserting the cardiac needle **46** into the ventricle then removing the obturator (not shown) normally within the needle and thereafter inserting the plastic tube **42** into the hub **44** of the cardiac needle **46.** The needle **46** and tube **42** are approximately each five inches long. The electrode then is advanced along the tube into and through the needle until the trailing end of the electrode sheath is flush with the end of the plastic sleeve. The length of the electrodes and sheath are related to the combined length of the cardiac needle **46** and tube **42** so that when the trailing end of the sheath is flush with the end of the tube **42** the electrode end of the sheath will have extended approximately 1 ¾ inches past the inner end of the cardiac needle **46** and will have spread into its generally T-shaped configuration. The needle and tube then may be withdrawn with the electrode properly disposed within the left ventricle and with its leads extending outwardly from the patient.

The outwardly disposed lead of the electrode is connected to the output leads **20** from the pulse generator **22** by means of an appropriate connector such as that shown in FIG. **5.** The illustrated connector is formed integrally with the end of the output leads **20** and has an enlarged cylindrical portion **48** formed from insulative material integral with the insulative material surrounding the output leads **20.** The cylindrical portion **48** has a center bore formed therethrough approximately 0.040 inches in diameter. The bore **50** is defined in part, at spaced locations along its length, by conductive sleeves **52.** Sleeves **52** are electrically connected to the conductive leads **20** and are spaced identically to the sleeves **40** disposed at the trailing end of the electrode leads. The trailing end of the electrode leads may be inserted into the bore **50** to align the sleeves **52** with the sleeves **40** and can be secured therein by a number of arrangements such as the screws **54.** The set screws **54** are of non-conductive material. Transthoracic insertion of the electrode arrangement into the ventricle and subsequent connection of the trailing end of the electrode arrangement to the pulse generator can be accomplished quickly and simply and requires no moving of the patient to a hospital or the like. After the electrodes have been connected, the pulse generator may be operated immediately either to apply a defibrillating pulse or a pacing pulse to the patient.

The circuitry shown in FIG. **6** generally includes switch **60,** defibrillator circuit **62,** pacemaker circuit **64,** and energy supply means. The source of electrical energy comprises battery banks **66** and **68** which are mutually exclusively connectable by switch **60** to mode switch **70.** Each of the battery banks includes a pair of commercially available **8.4** volt mercury batteries connected in series. When the unit is to be operated the switch **60** is thrown to select either bank **66** or **68.** The unused battery bank remains readily available as a spare power source.

A battery failure indicator **72** couples to the common contact of switch **60** and indicates when the battery output falls to **85** percent of the full battery power, thus

indicating the need to switch to the spare set of batteries by throwing switch **60** to its alternate position.

The mode switch **70** is a four position/double throw switch having a set of common contacts **70C** and two sets of fixed contacts **70A** and **70B**. With switch **60** connected to either of the battery banks **66, 68,** switch **70** can either be in its neutral position with its movable contacts **70C** open, or it can be moved to either the "defib" position where the movable contacts **70C** couple to the fixed contacts **70A**, or the "pace" position where the movable contacts **70C** connect to the fixed contacts **70B**. When switch **70** is in the defib position energy is coupled to the defibrillator circuit **62** and an output signal is developed across output lines **74** and **76.** In FIG. **6** the switch **70** is shown in the defib position. Alternatively, the switch can be moved to the pace position wherein energy is coupled to the pacemaker circuit **64** which develops its output across lines **74, 76.**

When switch **70** is in the defib position power is coupled to trigger button **78** which is a typical normally open momentary contact switch. When trigger button is depressed the high voltage defibrillatory shock pulse is generated and applied to the bipolar electrode thru lines **74, 76.** The defibrillation circuit **62** illustrated may be considered as being of conventional design and generally comprises a DC to DC converter **80,** transistor **82,** neon tube **84,** capacitor **86,** SCR **88,** and a series of resistors appropriately interconnected. The circuit **62** is substantially identical to the pulse circuit shown in U.S. Pat. No. 3,614,955 and operates as follows: When button **78** is depressed a relatively high voltage signal, approximately 2,500 volts, is established at the output of DC to DC converter **80.** This voltage is developed across capacitor **86.** The resistor chain and the tube **84** are interconnected in such a manner that when the voltage across capacitor **86** reaches a full 2,500 volts, the tube **84** conducts. When the capacitor **86** is fully charged, the transistor **82** becomes conductive, due to the now-conducting neon tube **84.** When the tube conducts there is a sufficient conduction path by way of resistors **90, 92** and **94** to cause conduction of transistor **82.** Concurrently therewith, a drive current is provided to the gate of SCR **88** and the SCR also conducts, applying the voltage from the capacitor **86** across the output lines **74, 76.** The output of circuit **62** has a preferable pulse width of approximately 100 milliseconds as determined by the time constant of the network. The energy output is of the order of **15** joules at a current of approximately 25ma. This is significantly less than the energy requirements for previous defibrillation devices. The neon tube **84** serves the double function of being an integral part of the trigger circuit and, because it also lights up for an instant during voltage buildup in the converter **80** it also indicates that the circuit is in operation.

The device may be controlled to immediately apply lower voltage "pacing" pulses by operation of the switch **70** to the position in which the movable contacts **70C** are connected to the fixed contacts **70B**. The power from one of the battery banks **66** or **68** is coupled to the circuit **64** and the cyclic output of that circuit is coupled to the output lines **74, 76.** A typical output from circuit **64** is a signal 0 to 30 milliamp, of 2.8 millisecond duration at a repetition rate of 70 pulses per minute.

The pacing circuit **64** comprises a conventional astable multivibrator including transistors **96** and **98,** a pulse width regulator including transistors **100, 102,** a voltage regulator including transistor **104** and a current source including transistor **106.** The astable multivibrator is of conventional design and includes cross-coupling capacitors **108, 110** and collector resistors **112, 114.** A potentiometer **116** is coupled to the base of transistor **96** for varying the frequency of operation of the astable multivibrator.

The output of the multivibrator couples by way of resistor **118** to transistor **100.** The collector of transistor **100** couples through resistor **120** to the power source and also by way of capacitor **122** to resistor **124** and to the base of transistor **102.** When transistor **100** is not conducting capacitor **122** is discharging and transistor **102** is non-conductive. When transistor **100** conducts because of a change of state of the astable multivibrator, capacitor **122** is charged by way of resistor **124** and after a predetermined time period transistor **102** conducts. Transistor **102** conducts in one embodiment for approximately 2.8 milliseconds before transistor **100** can change its state causing transistor **102** to stop conducting. During the brief time that transistor **100** conducts Zener diode **126** is shorted out and transistor **104** becomes conductive via Zener diode **128** to transistor **106.** When this occurs, transistor **106** also conducts and a constant current is fed by way of switch **70** to output leads **74, 76.** The potentiometer **130** is used to control the output current which may be varied from **0** to **30** milliamps. A pulse indicator **132** may be coupled from the collector of transistor **106** to the emitter of transistor **104** for verifying that the pacemaker circuit is functioning properly. The indicator **132** may also be coupled, in an alternate embodiment, directly to the astable multivibrator.

FIG. **7** shows the control panel with mode switch **70** which may be in any of its off, defib or pace positions. When the switch **70** is in its defib position, depression of the trigger button **78** causes almost instantaneous charging and discharging of the defibrillator circuit **62** and an attendant flashing of neon bulb **84** associated therewith. This indicates that the high voltage pulse has been coupled to the output leads **74** and **76.** When the switch **70** is in the pace position, indicator **132** reveals a pulse rate of **70** beats per minute, for example. The milliamperage rating from the output of the pace circuit is adjusted by dial **134** shown in FIG. **7** which is coupled to the potentiometer **130.**

Thus, I have described my invention which enables controlled electrical pulses to be selectively applied to a cardiac patient both as an emergency first aid measure as well as in a hospital environment. It should be understood, however, that the foregoing description of the invention is intended merely to be illustrative thereof, and that other modifications and embodiments may be apparent to those skilled in the art without departing from the spirit.

Having thus described the invention what I desire to claim and secure by Letters Patent is:

1. A portable emergency cardiac stimulator comprising:

defibrillation circuit means for generating a high voltage electrical pulse for defibrillating a fibrillating ventricle of a heart when applied directly to the wall of said ventricle;

pacing circuit means for generating repetitive low voltage electrical pulses at a predetermined rate;

transthoracically insertable bipolar cardiac electrode means for directly contacting substantially diametrically opposite portions the ventricle, said electrode means having leads trailing therefrom, such that when said electrode means are disposed interiorly of said ventricle the trailing ends of said leads may extend transthoracically and be disposed exteriorly of the patient;

switch means, having an input, said switch means further including a common output lead, for selectively connecting the output of either of said defibrillation circuit means or said pacing circuit means to said common output lead;

means for detachably connecting, in electrically conductive relation, the trailing leads of said electrode means to said common output lead to enable said electrode leads to be connected to said common output lead after transthoracic insertion of said electrode means into said ventricle; and

battery means connected to the input of said switch means for powering said defibrillation circuit means and said pacing circuit means.

2. A device defined in claim **1** further comprising:

said battery means including pair of identical storage batteries and second switch means for selectively connecting either of said storage batteries to the input of said first mentioned switch means.

3. A bipolar cardiac electrode comprising:

a pair of flexible, electrically conductive wires, each of said wires having a leading end and a trailing end, said leading ends of said wires extending generally transversely and away from each other when relaxed to assume a generally T-shaped configuration whereby when disposed within said cardiac lumen, the most laterally disposed regions of the leading ends of said wires may contact substantially diametrically opposite portions of the inner surface of said cardiac lumen;

said leading ends of said wires being resilient and flexible to enable said leading ends to be constrained into a substantially parallel configuration thereby to enable said leading ends to be retained within and passed through a cardiac needle and to spread and return toward said T-shaped configuration when said leading ends pass through the end of said needle into said cardiac lumen;

insulation means surrounding said wires fully along the length of said wires;

the outer extremities of the leading ends of said wires being curved inwardly toward each other, when relaxed, thereby defining curved convex configurations at the lateral extremities of said relaxed leading ends so that the lateral extremities of said wires are defined by regions between the longitudinal extremities of said leading ends thereof;

means defining a window in said insulation means surrounding each of said leading ends, each of said windows being disposed at the curved convex lateral extremity of its associated wire, each of said windows exposing its associated conductive wire outwardly and transversely;

means for exposing each of said wires at their trailing ends to enable said wires to be connected to a source of electricity.

4. A bipolar cardiac electrode as defined in claim **3** further comprising:

said windows are defined by generally laterally outwardly facing openings in said insulation and circumscribing approximately **180°** of the cross section of said wire.

5. An electrode arrangement as defined in claim **4** wherein said window is approximately 3/16 of an inch in length.

6. A bipolar cardiac electrode as defined in claim **3** further comprising:

each of said leading ends being of substantially S-shaped configuration when relaxed, said S-shaped configuration including said convex curved outer extremity of said leading end in a reverse curved segment, the reverse curved segments of said leading ends merging into a common insulative sheath at the trailing lead of said electrode.

7. A bipolar cardiac electrode as defined in claim **4** wherein the leading ends further comprise:

said wire being biologically nonreactive and being of a diameter of approximately 0.012 inches; and

said insulative sheath being biologically non-reactive and having an outer diameter of approximately 0.017 inches.

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