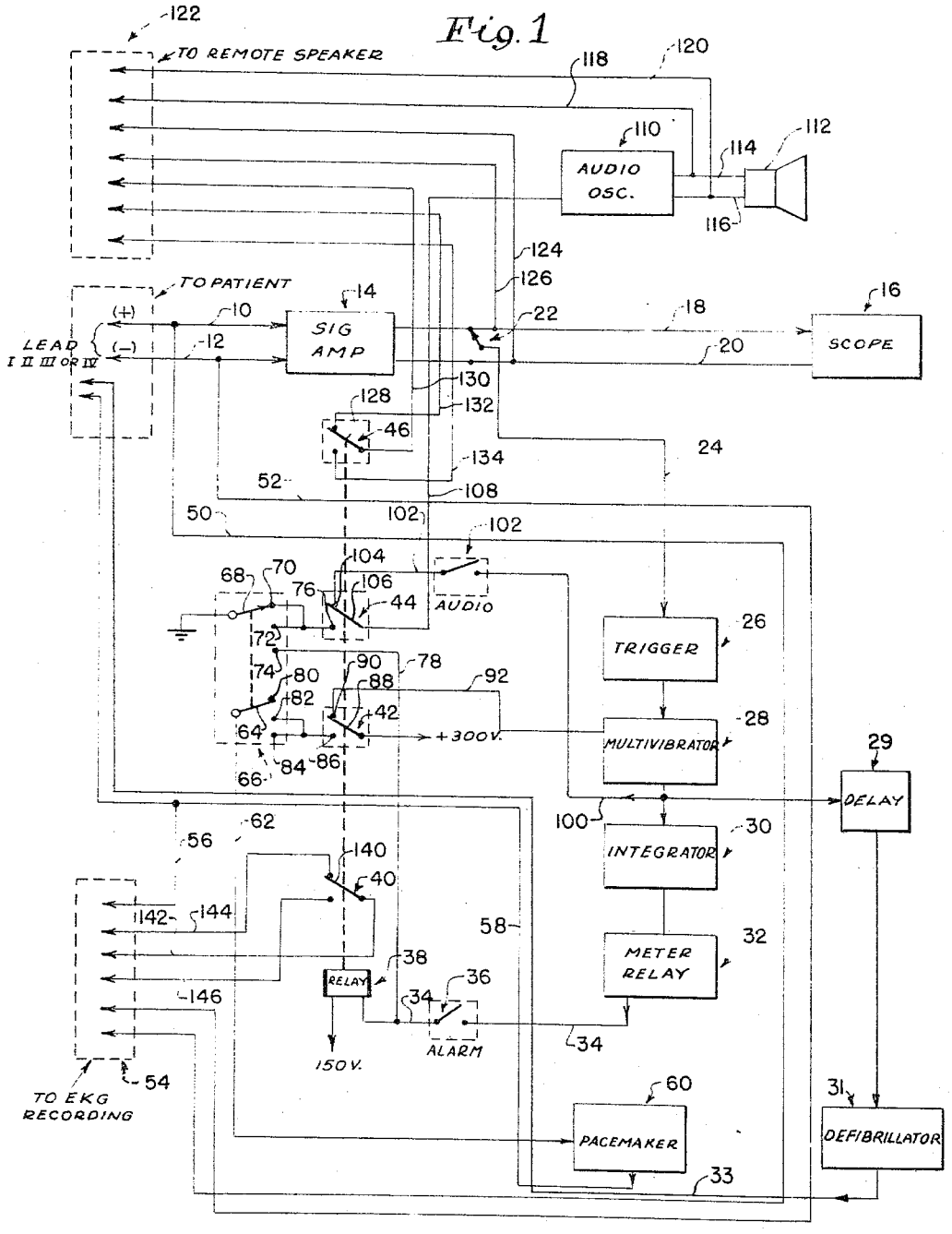
Feb. 22, 1966 B. V. BERKOVITS 3,236,239

DEFIBRILLATOR

Filed July 17, 1962 5 Sheets-Sheet 1

Fig. 1



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DEFIBRILLATOR

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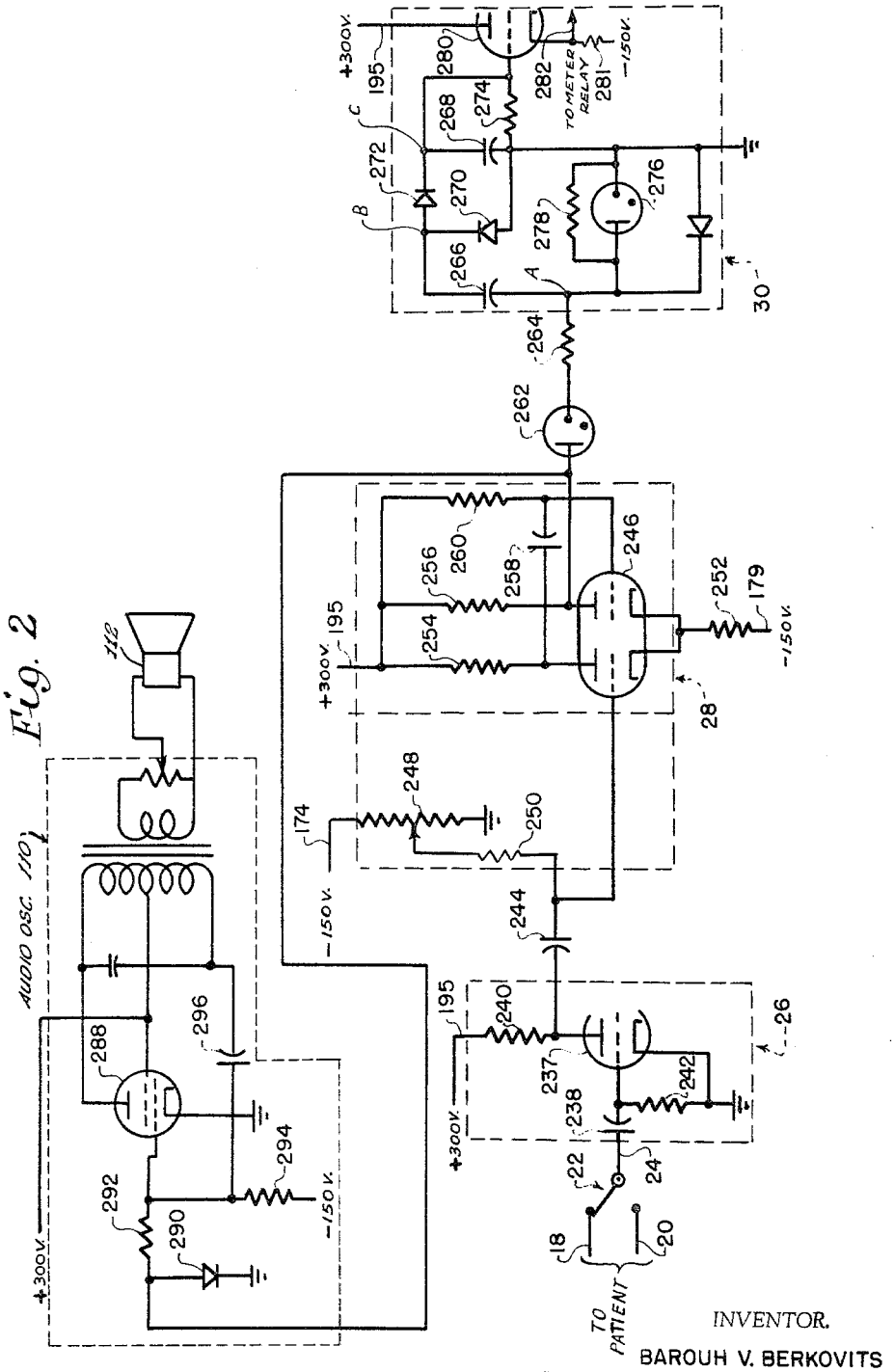

Fig. 2

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DEFIBRILLATOR

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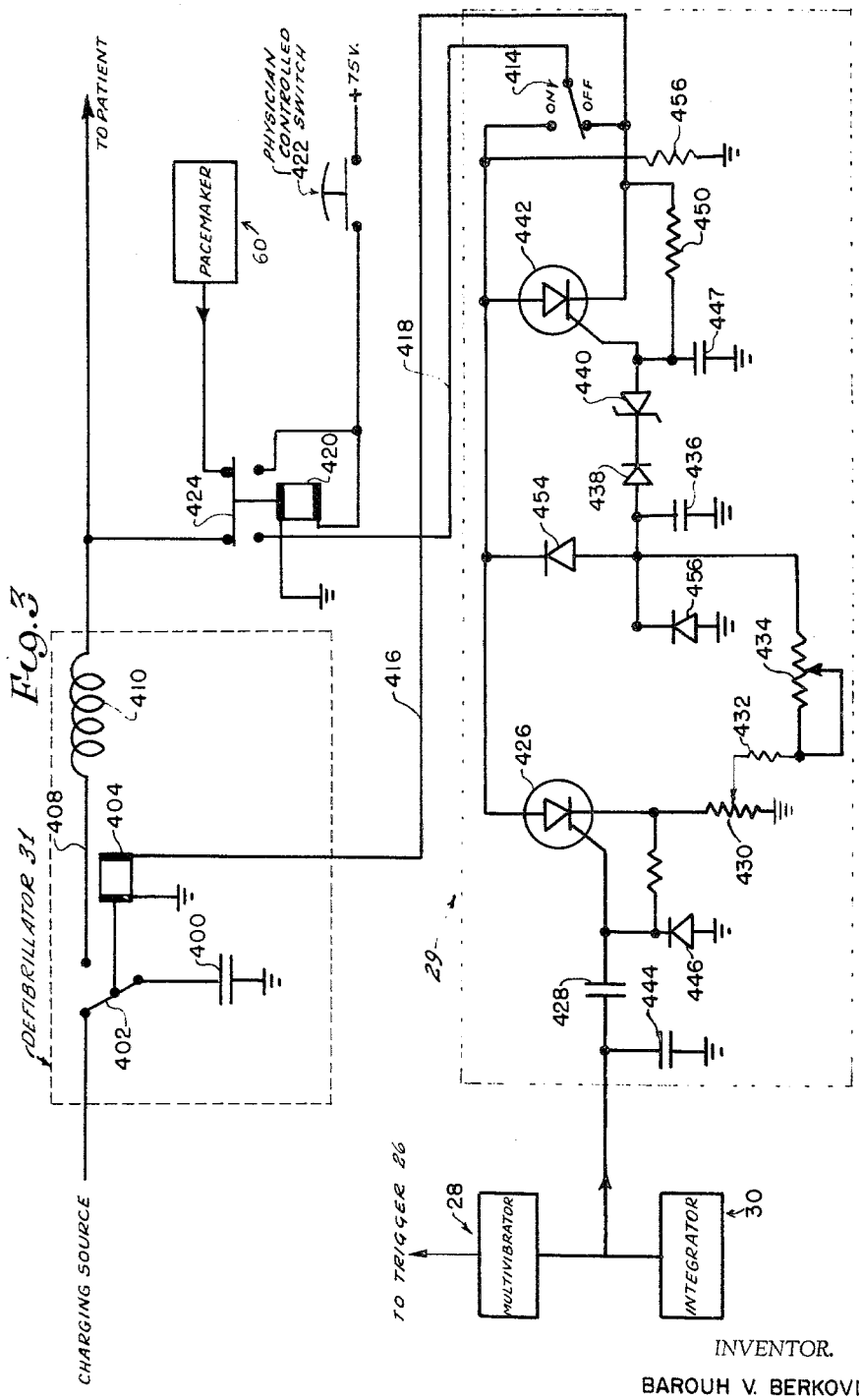

Fig. 3

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DEFIBRILLATOR

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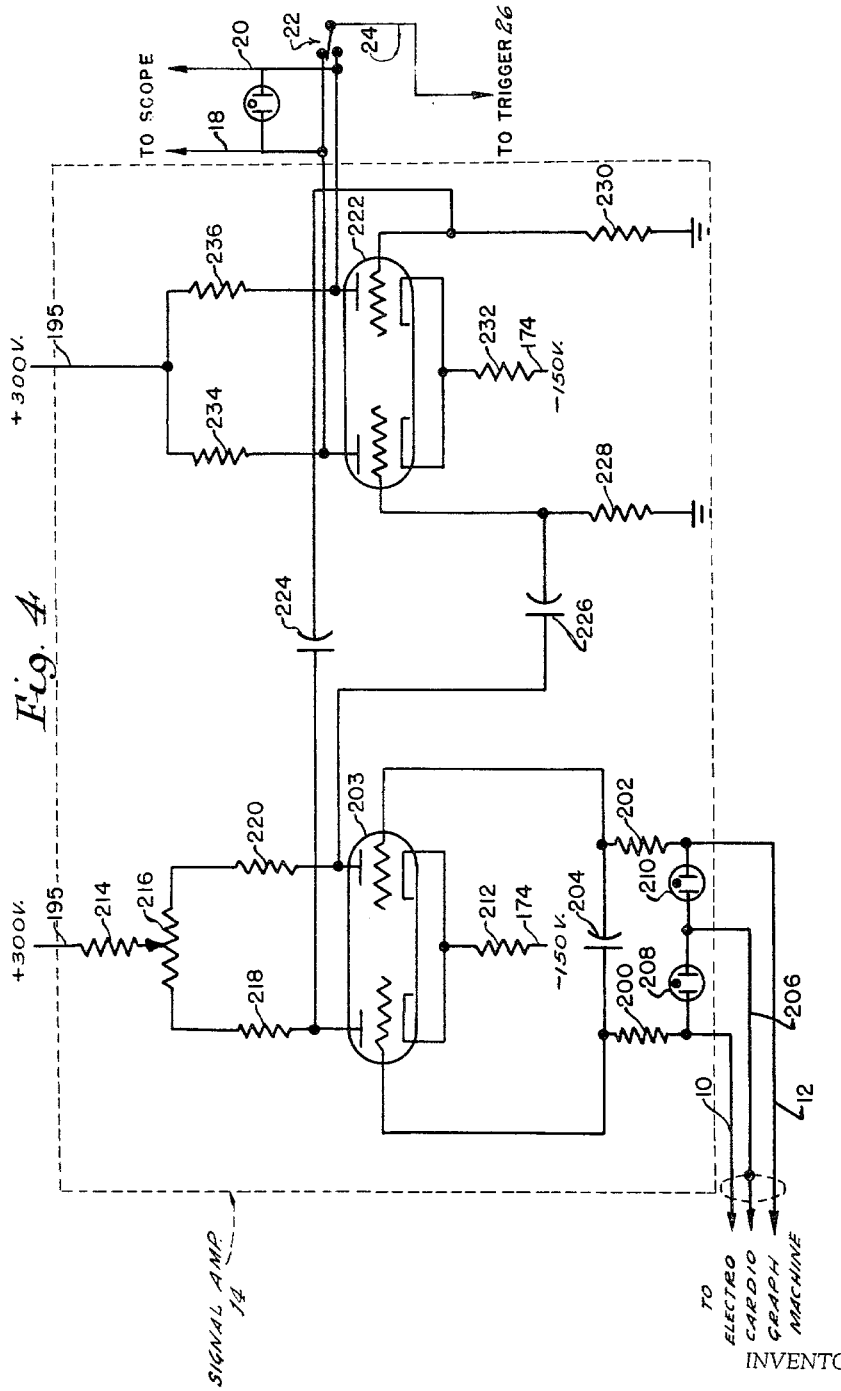

Fig. 4

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DEFIBRILLATOR

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Fig. 5.

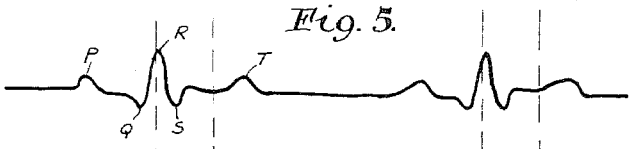


Fig. 6.

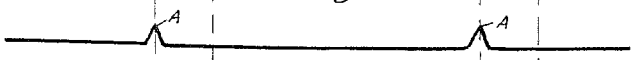


Fig. 7.

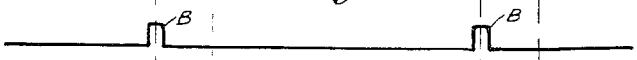


Fig. 8.

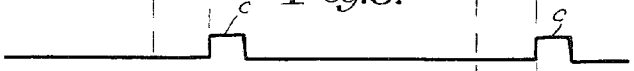
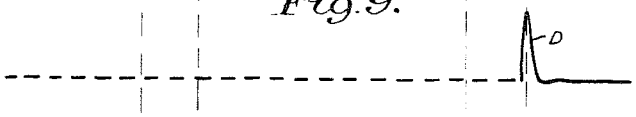


Fig. 9.



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United States Patent Office 3,236,239 Patented Feb. 22, 1966

3,236,239

DEFIBRILLATOR

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Filed July 17, 1962, Ser. No. 210,594
7 Claims. (Cl. 128—419)

This invention relates to electronic equipment for the treatment of cardiac disorders.

Classic treatment of most cardiac arrythmias involves the use of various drugs such as quinidine, procainamide, digitalis and the like. It has been known, also that electrical depolarizing impulses of rather high voltage and amperage can be effective in reverting certain arrythmias to normal sinus rhythm. However, due to the rather high mortality incident to the use of such depolarizing technique, it has heretofore been limited to use in conjunction with terminal events, for example ventricular fibrillation, and even here, usually only in those cases where the classic treatment, open chest cardiac resuscitation, is not indicated. In accord with the present invention, a therapeutic electrical stimulus derived from a charged capacitance is applied in controlled, timed relation to the cardiac cycle, it having been found that the high mortality previously associated with electrical depolarizing is due to application of the depolarizing impulse during one or both of two critical periods during the cardiac cycle. Of primary concern in connection with the present invention, then, is the provision of means enabling a physician to apply a capacitance discharge depolarizing impulse at a selected and precise point during the cardiac cycle which lies outside the above mentioned known critical areas. To achieve this effect, the present invention employs means for detecting the electrical activity of successive cardiac cycles and electrical depolarizing means controllable in timed relation to a known reference point occurring during a cardiac cycle as established from the means for detecting so as to intelligently apply the depolarizing impulse as aforesaid.

In general, this invention envisages equipment capable of providing electrical stimuli either directly or indirectly to a patient's heart for the purpose of reverting cardiac arrythmias.

Other objects and advantages of the invention will appear from the description hereinbelow and the accompanying drawings wherein:

FIG. 1 is a block diagram, partially schematic, illustrating basic component parts of the present system;

FIG. 2 is a schematic of a sub-assembly of the system as shown in FIG. 1;

FIG. 3 is a schematic of a defibrillator and defibrillator synchronizer which may be used in association with the system shown in FIG. 1;

FIG. 4 is a schematic of the signal amplifier;

FIG. 5 is a waveform illustrative of normal sinus rhythm;

FIG. 6 is a waveform showing the output of the trigger synchronized with the R waves of FIG. 5;

FIG. 7 is a waveform showing the output of the multivibrator triggered by and synchronized with the waveform of FIG. 6;

FIG. 8 is a waveform showing the output of the delay means; and

FIG. 9 is a waveform showing the output of the defibrillator.

The general principles of operation of a basic portion of the mechanism can be seen from a study of FIG. 1. In this figure, conductors 10 and 12 are adapted for connection to a selected one of the conventional leads of an electrocardiograph mechanism. Signals carried by the wires 10 and 12 are applied to a signal amplifier indicated

generally by the reference character 14, the specific details of which will be discussed hereinbelow and the amplified signal thus obtained is transmitted to an oscilloscope 16 over the conductors 18 and 20. A manually controllable switch indicated generally by reference character 22 is provided for picking off the positive or negative side of the signal transmitted over the leads 18 and 20 and to apply the same, through conductor 24, to trigger mechanism indicated generally by reference character 26. The trigger mechanism 26 controls a modified multivibrator circuit indicated generally by the reference character 28 and the signals therefrom are applied to an integrator 30 and a meter relay 32 which two components constitute a frequency meter circuit to detect cessation of heartbeat or too-low frequency of heartbeat. Also, the pulse output from the multivibrator 28 may be selectively applied to a delay means 29, the output signal of which is connected to the defibrillator or stimulus means 31 for application, through the electrode 33, of a high intensity, short duration, high current impulse to the patient. Although not shown in FIG. 1, switch means 422 (FIG. 3) is provided both to prevent simultaneous stimuli from the pacemaker means 60 and the defibrillator means 31 and to permit application of the impulse from defibrillator means 31 only as selected by an attendant physician. The meter relay 32 is operative to energize the conductor 34 under the above conditions so that, if the manual alarm switch 36 is closed, the energized lead 34 will operate the relay designated generally by reference character 38. The relay 38 controls a series of switches indicated by reference characters 40, 42, 44 and 46 to cause certain circuit conditions to exist as hereinafter more particularly pointed out.

As shown, the two conductors 10 and 12 are also connected through leads 50 and 52 respectively to a suitable outlet or jack designated by the reference character 54 to a standard electrocardiograph recording mechanism. Also extending to this jack 54 is a lead 56 from the conductor 58 of the pacemaker assembly indicated generally by reference character 60. The pacemaker is controlled in its operation through the control lead 62 extending from the movable contact member 64 of a gang switch mechanism indicated generally by the reference character 66.

The switch 66 is manually controlled and includes in addition to the movable contact 64, the movable contact 68 ganged therewith for unison movement and each of which is movable to one of three positions. For the movable contact 68, there are three fixed contact members 70, 72 and 74, the first two of which are connected in common as in shown and extend to one of the fixed contacts 76 of the relay switch 44 and the latter of which extends through conductor 78 for connection to the conductor 34 leading to relay 38 so that when the manual switch 66 is in the position so that the movable contact 68 engages the fixed contact 74, relay 38 is energized to throw the pacemaker 60 into operation.

The movable contact 64 is engageable with any one of three fixed contacts 80, 82 and 84, the first of which is blank and the second two of which are bridged in common as shown to extend to the fixed contact 86 of the switch 42. The movable contact 88 of switch 42 is connected to a B supply and is operative to either engage the fixed contact 86 to energize the pacemaker 60 or to engage the fixed contact 90 to energize the multivibrator circuit 28, through the conductor 92. Thus, when the relay 38 is in the position shown in FIG. 1, the automatic heartbeat control mechanism represented by the circuitries 26, 28, 30, 32 and the pacemaker 60 when energized is operative whereas when the various relay switches 40, 42 and 44 are tripped from the position shown in FIG. 1, the pacemaker 60 is continuously in

operation. Thus, the switch assembly **66** is settable for either automatic or manual application of the pacemaker **60** as well as to the position as shown in FIG. 1 which is a standby or off position since even if the relay **38** is tripped under the condition shown in FIG. 1, energization of pacemaker **60** will not result inasmuch as the movable contact **64** of switch **66** is on the dead contact **80**.

In the connection between the modified multivibrator **28** and the integrator **30** there is a lead **100** extending to a manually controlled switch **102** that connects, in the position of the relay **38** as shown, through conductor **102** and the fixed contact **104** and the movable contact **106** of relay switch **44** to the lead **108** extending to the audio oscillator indicated by the reference character **110**. Thus, the signals from the multivibrator **28** are used to trigger the audio oscillator **110** to produce an audio heartbeat signal through the speaker **112**. At the same time, the output of the audio oscillator as indicated by the conductors **114** and **116** is fed through conductors **118** and **120** to a remote speaker jack indicated generally by the reference character **122**. The remote speaker jack **122** is provided with two additional leads **124** and **126** which are connected to the signal amplifier output leads **18** and **20** previously described.

In the normal position of the relay **38**, the movable contact **128** of the switch **46** thereof connects conductors **130** and **132** whereas in the opposite position of the switch **46**, conductor **130** is connected to conductor **134**, in coordination with operation or cessation of the multivibrator signal. Correspondingly, the relay switch **40** is operative through the movable contact **140** thereof to connect either the two leads **142** and **144** or the two leads **142** and **146**.

From the above general description, it will be clear that the oscilloscope **16** provides means by which continuous monitoring of heart action may be obtained. At the same time, the heart action is automatically monitored by the combination of the trigger **26**, the multivibrator **28**, the integrator **30** and the meter relay **32**. At any such time as this latter monitoring means is operative, an audible monitor in the form of the oscillator **110** and associated speaker **112** may be obtained, under control of the switch **102**. Once the automatic monitoring system detects abnormal heartbeat frequency, it shuts itself off and simultaneously actuates the pacemaker **60** so that artificial stimulation and pacing of the heart action occurs. When it is desired to reset the automatic monitoring system and cease artificial heart stimulation, the switch **36** is simply opened momentarily. This will reset relay **38** and resume operation of the monitoring system **26**, **28**, **30** and **32**. Then, when switch **36** is closed, the relay **38** will remain in the normal position as shown in FIG. 1 until such time as there is an absence of normal heart action.

Signal amplifier

Although the signal amplifier **14** forms, per se, no part of the present invention, the preferred circuitry therefor is shown in FIG. 4. As shown, the electrocardiogram leads **10** and **12** are connected, through biasing resistors **200** and **202**, to the grids of a dual triode **203**, preferably a 12AX7. A suitable by-pass condenser **204** is connected between these grids to isolate them from undesirable transients and the ground **206** for leads **10** and **12** is provided with a pair of neon bulbs **208** and **210** connected as shown to provide a visual indication of the presence of a signal from the leads **10** and **12**.

The cathodes of tube **203** are connected in common, through dropping resistor **212**, to the negative supply line **174** whereas the plates are connected through dropping resistor **214**, potentiometer **216** and load resistors **218** and **220** to the positive supply line **195**. The amplifier signal is coupled to the grids of tube **222**, preferably another 12AX7, through capacitors **224** and **226**, these grids being suitably biased by resistors **228** and **230**. The cathodes of this second amplifier are connected through resistor **232** to the negative supply line **174** while the plates are connected through load resistors **234** and **236** to the positive supply line **195**. The amplified signal is transmitted over conductors **18** and **20** to the oscilloscope **16** and through switch **22** and conductor **24** to the trigger circuit **26**.

Trigger, multivibrator and integrator

The trigger, multivibrator and integrator circuits are shown in FIG. 2. In general, the trigger circuit operates to control the multivibrator **28** to supply a positive-going pulse to the integrator circuit once every cardiac cycle. The integrator circuit is operative, should the frequency of such pulses fall below a predetermined rate, to automatically control the pacemaker **60**. Additionally, in the system herein contemplated, the output of the multivibrator **28** provides a reference point from which a timed defibrillating pulse may be applied to the patient. Thus, the trigger-multivibrator circuit not only controls the application of the pacemaker **60** but also controls the defibrillating means, hereinafter described in detail.

To appreciate the operation of the trigger, multivibrator and integrator, it will be understood that in one or more of the twelve conventional leads of an electrocardiograph mechanism, a peak voltage will occur during each cardiac cycle. In normal or sinus rhythm, the pulse P or P wave is indicative of sinoartrial node discharge, which impulse travels down the atrioventricular node (P–R interval) and activates the ventricles, the Q–R–S complex being indicative of ventricular activity. The T wave or recovery wave is indicative of the repolarizing wave as it moves back across the heart. In the conventional electrocardiograph leads, the R wave of the Q–R–S complex represents the type of peak voltage referred to hereinabove which can be used for triggering the multivibrator **28**. The trigger, it will be seen, is essentially a signal-biased triode clipper comprising tube **237** having its grid coupled to conductor **24** by the capacitor **238** and resistor **242**. The plate of this tube is connected to positive potential through the load resistor **240** and the cathode is grounded as shown. Since the cathode of the trigger tube **237** is grounded, the maximum amplitude peak of the input signal will therefore be clamped to zero potential so that the major portion of the signal will be below cutoff, permitting the trigger tube **237** to conduct only during a portion of the maximum amplitude peak. Dependent upon the condition of the heart being monitored and the particular electrocardiograph lead used, the maximum amplitude peak during each heartbeat may be either positive-going or negative-going. Switch **22** is positioned to select the most favorable condition to produce only one output pulse from the trigger tube for each heartbeat.

The output of the trigger is coupled to the grid of the left-hand side of multivibrator tube **246** by means of the capacitor **244**, the resistor **250** and a portion of the potentiometer **248**. Normally, the left-hand grid is biased below cutoff by the potentiometer **248** and adjustment of this potentiometer is made to select that portion of the input which will drive the left-hand side of the multivibrator tube **246** conductive to produce the positive multivibrator output pulse at the right-hand side of the tube. The left and right-hand plates of the multivibrator tube **246** are connected to the positive supply line **195** through the load resistors **254** and **256** and the cathodes are connected to the negative supply line **179** through the resistor **252**. The right-hand side of the multivibrator tube **246** is normally conductive by virtue of its grid being connected to the positive supply line **195** through the resistor **260**. When the left-hand side of the tube **246** is driven conductive as aforesaid, the corresponding plate

potential drop will drive the right-hand side of the tube, by means of the coupling capacitor **258**, non-conductive.

Integrating circuit

It will be seen that the square wave output of the modified multivibrator **28** is at the same frequency as the patient's heartbeat. The purpose of the integrator **30** is to provide a voltage output whose amplitude is proportioned to the frequency of the modified multivibrator output, so that by coupling this output to a suitable meter relay operative to actuate relay **38** whenever the output of the integrating circuit falls below a predetermined range, operation of the pacemaker **60** may be automatically coordinated with failure of the patient's heartbeat rate to fall within the predetermined frequency range.

As shown in FIG. 2, the output of the multivibrator **28** is coupled to the integrator through the gas filled diode **262** and the dropping resistor **264**. The diode **262** fires at every positive output pulse of the multivibrator **28** and the square wave pulses appearing at junction A are clipped by the gas filled diode **276** and its associated resistor **278**. The capacitor **266** charges through the diode **270** and, as will be apparent, whenever the potential at point B becomes more positive than the potential at point C, the capacitors **266** and **268** will be placed in charge-exchanging relation across the diode **272**.

The constant amplitude positive pulses appearing at point B are of fixed duration as established by the multivibrator **28**, the intervals between such pulses being variable in accord with the heartbeat frequency. During such intervals between pulses, the potential at point C is decaying exponentially toward zero by virtue of the time constant of the capacitor **268** and the resistor **274**. Thus, the potential existing at point C when a positive-going pulse appears at point B will be dependent upon the elapsed time between such pulse and the last preceding pulse, as established by the heartbeat frequency. The net effect will be to produce a D.C. level voltage at junction C which is proportional to the heartbeat frequency. This voltage is applied to the grid of the cathode follower tube **280** having a load resistor **281** and a conductor **282** extending to the previously mentioned meter relay. When the output of this tube **280** falls below a predetermined value, the meter relay will be actuated to energize relay **38**, see FIG. 1.

Audio oscillator

The audio oscillator **110** is of conventional form and is shown in FIG. 2 as using a 6AQ5 tube **288** connected as shown. A diode **290** is used to limit the amplitude of the square wave input from the modified multivibrator **246** and correct amplitude to cause oscillation during such input is further controlled by dropping resistor **292**. Grid bias is provided by bias resistor **294** and capacitor **296** is also connected to the grid. The audio oscillator is operative at any such time as switch **102** is closed and relay **38** is deenergized.

Defibrillator

As has been mentioned hereinabove, it is beneficial for reverting certain cardiac arrythmias to subject the heart muscle to a high intensity, short duration, high current impulse. For example, in the treatment of ventricular fibrillation, it has been found that the application of an impulse as stated above by means of a pair of precordial electrodes may successfully revert such condition. However, as it is also stated hereinabove, it is important to time the application of such impulse with respect to the cardiac cycle.

As shown in FIG. 3, the defibrillator consists essentially of the capacitor **400** which is selectively connected by movable relay switch **402** to either a suitable charging source or a conductor for discharge to the patient. The switch **402** is controlled by the relay **404** and the patient-connected conductor **408** includes the coil **410** as shown. When the delay means or synchronizer **29** is turned to the off position by means of switch **414**, direct connected is made between conductors **416** and **418** so that control of relay **404** is achieved by the relay mechanism **420**, in turn controlled by a suitable normally open switch **422** which may be manual or foot operated. The movable contact **424** of relay **420** normally completes the circuit from the pacemaker **60** to the patient and the movable contact **424** thus disconnects the pacemaker from the patient at any time during which the defibrillating impulse is being applied to the patient.

Defibrillator synchronizer

In order to accurately time the defibrillating impulse with respect to the cardiac cycle, the delay means or synchronizer **29** is used in conjunction with the defibrillator. In this fashion, the operator may successfully avoid those portions or periods of the cardiac cycle during which application of the defibrillating impulse would be fatal. As shown in FIG. 3, the control electrode of the silicon controlled rectifier **426**, preferably a 2N1595, is coupled through capacitor **428** to the output of the multivibrator **28**. The characteristics of rectifier **426** are such that it will conduct heavily (switch **414** being "on") in response to the presence of the positive input signal. The movable tap of the potentiometer **430** constitutes, with the resistor **432** and variable resistor **434**, a variable resistance connection to the capacitor **436** so that the time constant of this portion of the circuit is variable for purposes hereinafter apparent. The capacitor **436** is coupled, through diode **438** and Zener diode **440** to the control electrode of the silicon controlled rectifier **442** preferably a 2N1595. This rectifier, like the rectifier **426**, has its anode connected to conductor **418** through switch **414** and cathode is connected to conductor **416**.

Thus, it will be apparent that whereas the rectifier **426** will fire in synchronization with the output of the multivibrator **28**, the rectifier **442** will fire with delay by an amount of time determined by the time constant of the resistor chain **430**, **432**, **434** and the capacitor **436**. Since, as aforesaid, this resistor chain is variable, the precise time of firing of rectifier **442** may be controlled thereby so as to apply the stimulating pulse in desired timed relation to the pulse triggering the multivibrator **28**. Therefore, by positioning switch **414** in the "on" position and depressing switch **422**, variable resistor **434** being adjusted for desired delay, the stimulating pulse will be applied at the desired instant.

To prevent firing the rectifiers **426** or **442** by parasitic capacitance when the power supply voltage is applied through switch **414** upon energization of relay **420**, the capacitors **444** and **447** are connected as shown. The firing points of these two rectifiers are controlled by the resistors **448** and **450** respectively, diode **446** being connected to pass any negative transients. The two diodes **452** and **454** and the resistor **456** are for the purpose of restoring the capacitor **436**.

The values of the circuit components in the several figures of the drawings are as follows:

FIG. 2

Resistors:

240		220K
242	meg__	1
248		250K
250	meg__	1
252		33K
254		100K
256		100K
260	meg__	1
264		10K
278		220K
279	meg__	2
281		100K
292		47K
294	meg__	3.3

Capacitors:		
238	μf.	.47
244	μf.	.1
258	μf.	.1
266	μf.	.1
268	μf.	5
296	μf.	.1
Tubes:		
237, 280		12AX7
246		12AT7
262		10501–15
270		1N2069
272		1N2069
274		1N70
276		10501–18
288		6AQ5
290		1N2069

FIG. 3

Resistors:		
430	ohms.	1000
432	do.	100
434	do.	20
448	do.	4700
450	do.	1000
456	do.	1000
Capacitors:		
400	μf.	16
428	μf.	0.1
436	μf.	100
444	μf.	.005
447	μf.	.005
Tubes:		
426		2N1595
438		1N69A
440		RS6
442		2N1595
446		1N69A
452		1N69A
454		1N2069
Inductance	millihenries	100
	ohms	—20

FIG. 4

Resistors:		
200		10K
202		10K
212	meg.	1
214		220K
216	meg.	1
218		470K
220		470K
228	meg.	1
230	meg.	1
232		100K
234		220K
236		220K
Capacitors:		
204	μf.	0.15
224	μf.	0.47
226	μf.	0.47
Tubes:		
203		12AX7
208		NE–2
210		NE–2
222		12AX7

With reference now more particularly to FIG. 1 and FIGS. 5–9 inclusive, FIG. 5 illustrates a normal sinus rhythm waveform as it may be picked up by a conventional lead from the electrocardiograph machine. This signal, when amplified by the signal amplifier **14**, is applied in the form shown in FIG. 5 to the conductor **24** in FIG. 1 for application to the trigger **26**. The trigger **26** is adjusted to produce output pulses A as indicated in FIG. 6 which are synchronized with peaks of the waveform applied through the conductor **24**. In the particular case shown, the peaks are the R waves of the amplified electrocardiograph signal and the pulses A are thus coincidental with such R waves. The waveform output of FIG. 6 is applied to the multivibrator **28** and this multivibrator, in turn, produces output pulses B which are synchronized with the pulses A of FIG. 6. The output of the multivibrator **28** when applied to the delay means **29** produces a delayed pulse output C (FIG. 8) from such delay means **29** for application to the defibrillator **31**. If, now, the physician closes the switch **422** (FIG. 3—switch **414** being in the "on" position) at some time prior to the second pulse C shown in FIG. 8, the defibrillating pulse D will be applied through the electrode **33** to the patient. The pulse D is, of course, the waveform resulting from the discharge of the capacitor **400** through the inductor **410** (FIG. 3).

From the above, it will be appreciated that a defibrillating pulse D as shown in FIG. 9 will be applied in timed relation to the cardiac cycle as represented by the waveform of FIG. 5. The trigger **26** and multivibrator **28** form a pulse generating means producing output pulses B (FIG. 7) synchronized with peaks occurring during successive cardiac cycles; the peaks occurring at the R waves in the particular instance shown. The delay means **29** produces a delayed output pulse C which, in turn, may actuate the defibrillating means if the switch **422** (FIG. 3) is closed by the physician; provided also that the switch **414** as shown in FIG. 3 is in the "on" position. It will be appreciated that the discharge of the defibrillator causes all heart activity to be extinguished for a short time subsequent to the application of the defibrillating pulse D, such time ordinarily being in the order of several seconds. Thereafter, normal heart rhythm should occur.

I claim:

1. A device useful in cardiac therapy, comprising in combination,

pulse generating means adapted to be connected to a patient for detecting peak voltages in successive cardiac cycles indicative of heart muscle activities which are similar in such successive cardiac cycles and said pulse generating means having output pulses coinciding with said peak voltages,

an electrode adapted to be electrically connected to a patient for electrical stimulus of the heart muscle,

a defibrillator including a capacitor, a charging source for said capacitor, and switch means movable between one position connecting said capacitor to said charging source and a second position connecting said capacitor to said electrode,

delay means for selectively actuating said switch means from said one position thereof to said second position thereof in predetermined timed relation subsequent to one of said output pulses of the pulse generating means,

and a normally open physician-controlled switch for controlling actuation of said switch means to said second position thereof by said delay means.

2. A device according to claim **1** wherein said defibrillator includes an inductor connected to said electrode and which is placed in series with said capacitor when said switch means is in said second position thereof.

3. The device according to claim **2** wherein said capacitor has a value of about 16 microfarads and said inductor has a value of about 100 millihenries.

4. A device useful in cardiac therapy, comprising in combination,

pulse generating means adapted to be connected to a patient for detecting peak voltages in successive cardiac cycles indicative of heart muscle activities which are similar in such successive cardiac cycles and said pulse generating means having output pulses coinciding with said peak voltages,

an electrode adapted to be electrically connected to

a patient for electrical stimulus of the heart muscle,

a defibrillator including a capacitor, a charging source for said capacitor, an inductor, and switch means movable between one position connecting said capacitor to said charging source and a second position connecting said capacitor, said inductor and said electrode in series,

delay means for selectively actuating said switch means from said one position thereof to said second position thereof in predetermined timed relation subsequent to one of said output pulses of the pulse generating means,

and a normally open physician-controlled switch for controlling actuation of said switch means to said second position thereof by said delay means.

5. The device according to claim 4 wherein said capacitor has a value of about 16 microfarads and said inductor has a value of about 100 millihenries.

6. A device useful in cardiac therapy, comprising in combination,

pulse generating means adapted to be connected to a patient for detecting peak voltages in successive cardiac cycles indicative of heart muscle activities which are similar in such successive cardiac cycles and said pulse generating means having output pulses substantially coinciding with said peak voltages,

electrode means to be electrically connected to the patient,

a defibrillator including a capacitor, a charging source for said capacitor, and means normally coupling said capacitor to said charging source whereby to charge said capacitor, said means including a switch actuable to couple said capacitor to said electrode means whereby to discharge the capacitor through the electrode means into the patient's heart,

actuating means for actuating said switch to couple said capacitor to said electrode means in predetermined timed relation to a peak voltage produced by one of said cardiac cycles in response to an output pulse from said pulse generating means,

and a physician-controlled switch for selectively coupling said actuating means to said pulse generating means to control actuation of the first mentioned switch by said actuating means.

7. A device useful in cardiac therapy, comprising in combination,

pulse generating means adapted to be connected to a patient for detecting peak voltages in successive cardiac cycles indicative of heart muscle activities which are similar in such successive cardiac cycles and said pulse generating means having output pulses substantially coinciding with said peak voltages,

electrode means to be electrically connected to the patient,

a defibrillator including a capacitor, a charging source for said capacitor, and switch means having a normal condition in which said capacitor is coupled to said charging source without being coupled to said electrode means whereby to charge said capacitor, said switch means having a second condition in which said capacitor is coupled to said electrode means whereby to discharge the capacitor through the electrode means into the patient's heart,

actuating means for actuating said switch means to said second condition thereof to couple said capacitor to said electrode means in predetermined timed relation to a peak voltage produced by one of said cardiac cycles in response to an output pulse from said pulse generating means,

and a physician-controlled switch for selectively coupling said actuating means to said pulse generating means to control actuating of said switch means to said second condition thereof by said actuating means.

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