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ELECTROCHEMOTHERAPEUTIC CARDIAC DEVICE

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2 Sheets-Sheet 1

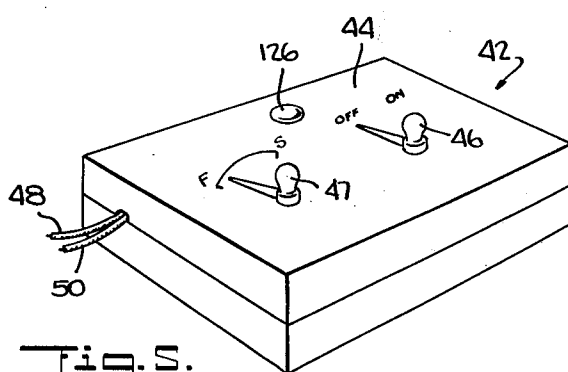
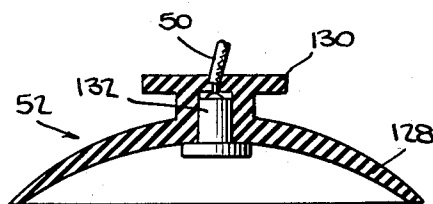
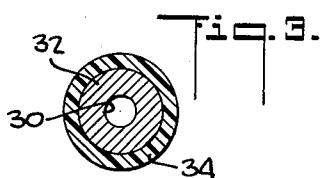
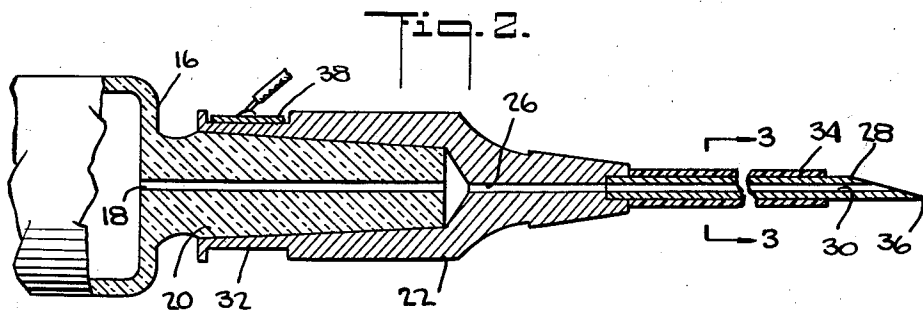
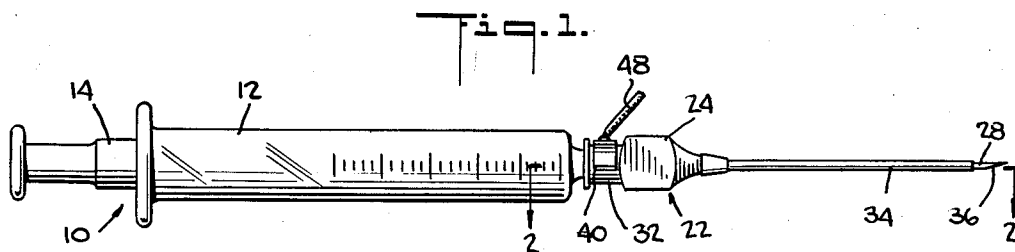


Fig. 4.

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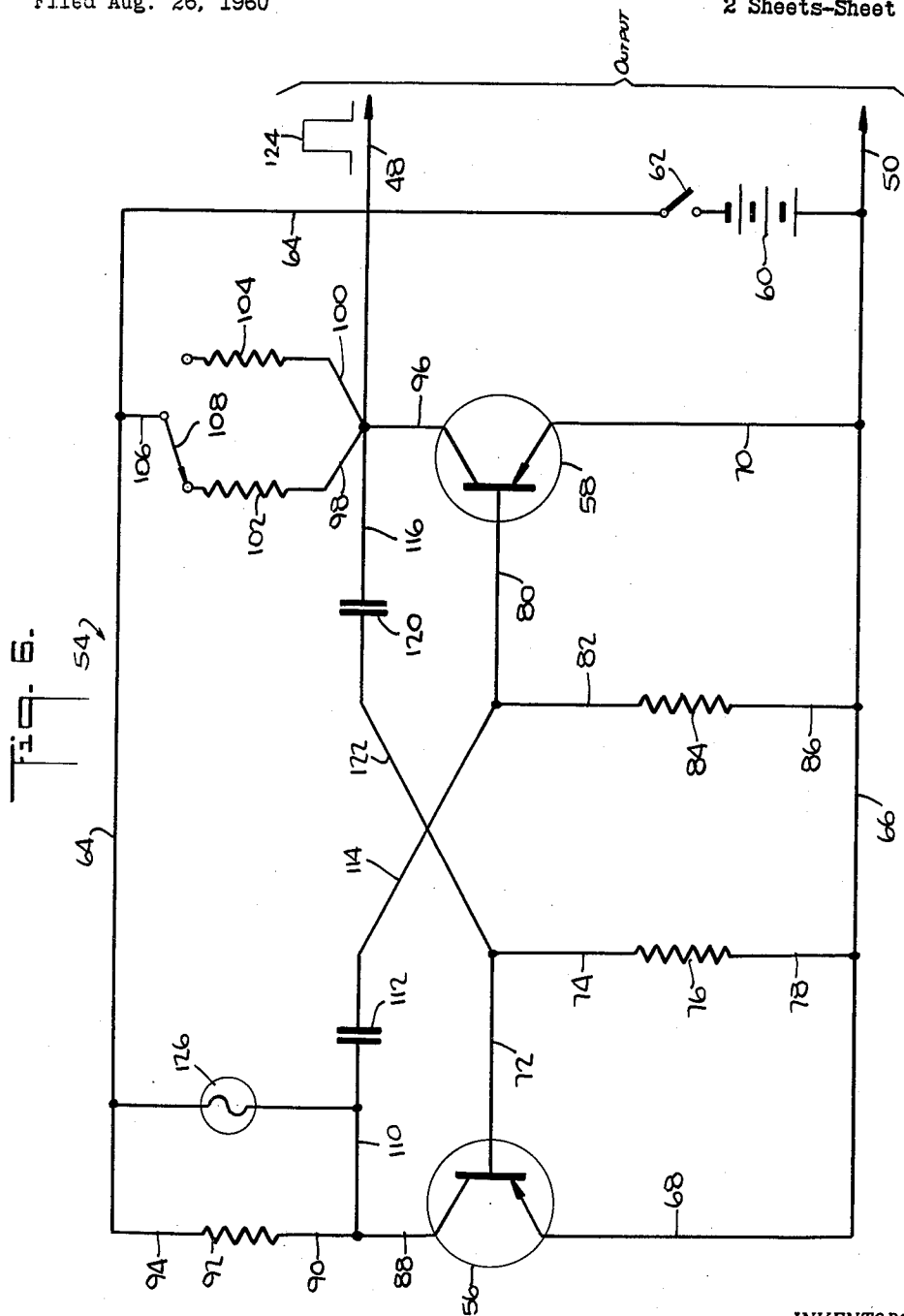
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ELECTROCHEMOTHERAPEUTIC CARDIAC DEVICE

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2 Sheets-Sheet 2

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1

3,078,850 ELECTROCHEMOTHERAPEUTIC CARDIAC DEVICE

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This invention relates to an electrochemotherapeutic cardiac device.

It is the principal object of the invention to provide an improved device of the character described which is capable of efficiently and effectively restarting a stopped heart, i.e. of resuscitating a person who is literally dead because his heart has ceased to beat.

It is another object of the invention to provide a device of the character described the results of which are far superior to those of conventional methods now practiced for a similar purpose.

It is another object of the invention to provide a device of the character described which is very light, compact and portable and is extremely easy to employ so that it readily can be carried about by a physician as part of his emergency kit, or stored in emergency cabinets in hospitals and like institutions, or made a part of emergency apparatuses in general.

It is another object of the invention to provide a device of the character described which is sturdy and durable, and can be relied upon to perform at all times and under any circumstances.

It is another object of the invention to provide a device of the character described which constitutes relatively few and simple parts and can be made at a low cost.

It is another object of the invention to provide a device of the character described which applies electric pulses directly to the heart with the aid of a concurrently injected liquid whereby to minimize the resistance of body tissues in the region of the heart so as to obtain the maximum effect of the electrical pulses in stimulating a failing heart or restarting a stopped heart.

It is another object of the invention to provide a device of the character described which applies combined electrical and chemical stimuli to a failing or stopped heart whereby to create a powerful tendency to stimulate a failing heart or start a stopped heart.

It is another object of the invention to provide a device of the character described which concurrently applies electrical and chemical stimuli to the heart so that the two stimuli mutually reinforce one another and thus are able to create a maximum beneficial result.

It is another object of the invention to provide an electrochemotherapeutic method for applying electrical stimuli to the heart under chemical conditions which are favorable for stimulating a failing heart and restarting a stopped heart.

Other objects of this invention in part will be obvious and in part will be pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts which will be exemplified in the device and method hereinafter described, and of which the scope of application will be indicated in the appended claims.

In the accompanying drawings, in which is shown one of the various possible embodiments of this invention:

FIG. 1 is a plan view of a hypodermic syringe and hypodermic needle which jointly constitute one of the elements of the device embodying the present invention;

FIG. 2 is a fragmentary enlarged sectional view of the syringe and needle, the same being taken substantially along the line of 2—2 of FIG. 1, the terminal clip which

2

engages the hub of the needle being turned 90° for convenience of illustration;

FIG. 3 is a further enlarged sectional view taken substantially along the line of 3—3 of FIG. 2 and illustrating to an exaggerated scale the insulating sheath which surrounds the cannula of the hypodermic needle at the point where the section is taken;

FIG. 4 is a central sectional view through the body electrode which constitutes the second element of the device embodying the present invention;

FIG. 5 is a perspective view of a source of electrical pulses which constitutes the third element of the device embodying the present invention; and

FIG. 6 is a wiring diagram for the source of pulses shown in FIG. 5.

In general, the objects of the present invention are achieved by providing a device including a hypodermic syringe and a hypodermic needle, the needle cannula being electrically insulated except at the tip thereof, and said device further comprising a dependable regular source of electrical pulses which has two output terminals respectively connected to the hypodermic needle and to an electrode which is adapted to contact the patient's skin.

Referring in detail to the drawings, the reference numeral 10 denotes a conventional hypodermic syringe which is used in accordance with the instant invention. The particular construction of the syringe is of no importance and for this purpose there may be employed any syringe that includes a barrel, a plunger and means for mounting a hypodermic needle so that the liquid contained in the barrel can be hypodermically injected into a patient through the needle.

The syringe 10 illustrated in the drawings is of a particularly simple type, constituting a glass barrel 12 and a glass plunger 14 slidably and closely fitted in the barrel. The bottom wall 16 of the barrel is formed with a bore 18 which extends through the barrel tip 20, the latter as is usual being integral with the bottom of the barrel. Said tip is frustoconical, having a comparatively small taper for effecting a Luer-type coupling with the hub of a hypodermic needle.

It may be pointed out that it is within the scope of the invention to use any other construction of hypodermic syringe, as for example a cartridge type syringe, a screw type syringe, a disposable syringe i.e. an ampule type syringe, or a syringe with a metal tip or a lock tip.

Mounted on the syringe tip 20 is a hypodermic needle 22 the construction of which is in all respects, save one, conventional. Thus the hypodermic needle includes a hub 24 having a bore 26 which when the hub is mounted on the tip is in axial registry with the bore 18 of the hypodermic syringe. A hollow tubular shaft, i.e. a cannula, 28 is permanently secured, e.g. by force-fitting, soldering or brazing, to the hub 24 with its longitudinal passageway 30 axially aligned with the bore 26. Although it is conventional, it is desired to note and stress that at least the cannula 28, and preferably the hub 24 as well, are made of an electrically conductive material, that is to say, metal. The hub 24 includes the usual cylindrical portion 32 which is used in accordance with the present invention to act as an electrical contact for a form of electrical clip soon to be described. However, it should be understood that the specific detail of the electric connection between the pulse source and the hypodermic needle is not critical to the proper operation of the invention. Some such connecting means must be present; any suitable physical structure can be employed therefor.

The hypodermic needle 22 of the present invention differs from a conventional hypodermic needle in that a substantial portion of the cannula 28 is electrically insulated,

as by an ensheathing sleeve 34 one end of which terminates adjacent the sharpened tip 36 of the cannula. Any suitable electrically non-conductive material of a non-toxic and inert nature can be used, for example, any one of the synthetic plastics. Typical appropriate plastics that can be employed for this purpose are: thermoplastics such as cellulose acetate, cellulose acetate butyrate, styrene, acrylic resins, polyamide resins, polyvinyl resins and synthetic rubbers. The sleeve 34 can be preformed, as by extrusion, and fitted onto the cannula; or it can be molded in place, or it can be provided by dipping the cannula in a solvent solution or lacquer of the synthetic plastic with a temporary protective coating covering the sharpened tip of the cannula which protective coating subsequently is removed to leave the tip bare. A suitable material for the protective coating is a sterile wax or gum. If desired, there may be employed a synthetic plastic material which is capable of being autoclaved, i.e. sterilized, at temperatures above the boiling point of water, and for this there can be utilized a high-melt synthetic thermoplastic or a thermosetting plastic e.g. an alkyd resin, a phenol formaldehyde condensation resin, a urea formaldehyde condensation resin, or a fluorocarbon resin. It will be appreciated that the latter materials are usually employed if the hypodermic needle is heat sterilized and the former are used if the needle originally is prepared and ensheathed and packed under sterile conditions and is to be expendable, i.e. thrown away after a single use.

The end of the sleeve 34 remote from the sharpened tip of the cannula preferably is located at or adjacent the hub 24 and even may extend onto the hub, provided, however, that an electrically conductive portion of the needle hub is left exposed for contact with one of the output leads from a source of electrical pulses.

In the form of the invention being described and which is illustrated in the attached drawings, electrical contact is made with the needle hub at the cylindrical portion 32 by a resilient clip contact terminal 33. The same comprises a yoke of springy electrically-conductive metal e.g. a nickel plated Phosphor bronze. The yoke constitutes a base and a pair of spaced resilient arms. The shape defined by said base and arms substantially conforms to slightly more than half of the cylindrical surface of the portion 32, the yoke being smaller than said portion and thereby being able to prehensilely grip the hub of the needle. For the purpose of expediting coupling of the resilient clip 33 to the cylindrical portion of the needle hub, the tips of the clip arms may be formed with outwardly sloped camming fingers 40.

There is provided as a part of the device embodying the present invention a source 42 of electrical pulses. Said source conveniently is housed in a casing 44 to enable it to be more easily carried and to protect it against the vicissitudes of handling. For example, the housing may be a rectangular hollow box of synthetic high impact plastic material such as polystyrene modified with a buna-S rubber. The electrical components which make up the source of electrical pulses are housed within the casing 44. Two of said components which soon will be described are switches and the manually manipulatable members for the same are external to the casing for easy handling. These two members are an "off-on" switch knob 46 and a "fast-slow" switch knob 47. Desirably each of the knobs includes an indicator pointer readable against suitable indicia on the surface of the casing to denote the condition of the corresponding electrical component. Optionally, a single knob may be provided which is capable of being set at any one of three positions, a first of which corresponds to an "off" condition for the source of electrical pulses, a second of which corresponds to a "slow" condition for the source of electrical pulses, and the third of which corresponds to a "fast" condition for the source of electrical pulses. A pair of insulated wires, 48, 50 lead from the casing, these being connected within the casing to the output of the source of electrical pulses. One of

the wires, e.g. the wire 48, is connected to the clip 33. The other output lead is connected to a body electrode 52 which will be described in detail hereinafter.

The specific circuit and electrical components of the source of electrical pulses are not critical to the operation of the instant invention. However said components and circuit must be such that they are capable of producing upon demand even after long periods of inaction, a reliable i.e. dependable steady, series of electrical pulses of a desired amplitude, which preferably are unidirectional, which further preferably are of comparatively short duration, which further preferably have steep leading wave fronts, which desirably have steep trailing wave fronts so that the pulses are essentially spike-like due to their short duration and steep sides, and which essentially repeat at a rate which approximates the same frequency as the human heart beat, i.e. in the vicinity of 60 electrical pulses per minute.

By way of example there is shown in FIG. 6 a suitable set of electrical components and a suitable circuit 54 for achieving the foregoing ends. The circuit 54 is a simple dependable arrangement which constitutes an astable free-running two-stage transistor multivibrator with coupled collectors. Said multivibrator includes a pair of PNP transistors 56, 58. In the particular circuit being described the transistors are of the Tungsol #342 type. (The specific electrical components that are employed in the circuit will be detailed as to type and values as they are mentioned, this being done solely for the purpose of exemplification and with the understanding that the invention is not to be limited thereby.)

The multivibrator is powered by a small lightweight battery 60, e.g. an Eveready #146 battery, which supplies 9.8 volts and has a 350 milliamper output. One terminal of the battery 60 is connected to a single pole single throw "off-on" switch 62 which is manually actuatable by the knob 46. Said switch selectively applies voltage to one power lead 64. The other terminal of the battery 60 is connected to the other power lead 66.

Lead lines 68, 70 respectively connect the emitter electrodes of the transistors 56, 58 to the power lead 66.

The base electrode of the transistor 56 is connected by a lead wire 72 to a lead wire 74 which is connected to a one-half watt resistor 76 having a resistance value of 4700 ohms and which in turn is connected by a lead wire 78 to the power lead 66. The base electrode of the transistor 58 is connected by a lead wire 80 to a lead wire 82 which is connected to a one-half watt resistor 84 having a resistance value of 4700 ohms and which in turn is connected by a lead wire 86 to the power lead 66.

The collector electrode of the transistor 56 is connected by a lead wire 88 to a lead wire 90 which is connected to a one-half watt resistor 92 having a resistance value of 2000 ohms and which in turn is connected by a lead wire 94 to the power lead 64. The collector electrode of the transistor 58 is connected by a lead wire 96 to a pair of lead wires 98, 100 arranged in parallel. The lead wire 98 is connected to a one-half watt resistor 102 having a resistance value of 470 ohms. The lead wire 100 is connected to a one-half watt resistor 104 having a resistance value of 100 ohms. The opposite ends of the two resistors 102, 104 are selectively connectable to a lead wire 106 by a single pole double throw "fast-slow" switch 108 which is manually actuatable by the knob 47. The lead wire 106 in turn is connected to the power lead 64.

The junction of the lead wires 88, 90 is connected by a lead wire 110 to a 25 volt 100 microfarad condenser 112 which in turn is connected by a lead wire 114 through the lead wire 80 to the base electrode of the transistor 58. The junction of the lead wires 96, 98, 100 is connected by a lead wire 116 to a 25 volt 100 microfarad condenser 120 which in turn is connected by a lead wire 122 through the lead wire 72 to the base electrode of the transistor 56.

The output lead wires 50, 48 are respectively connected to the power lead 66 and to the collector electrode of one

or the other of the transistors 56, 58, as shown, the connection being to the collector electrode of the transistor 58.

The foregoing circuit operates as a free running astable multivibrator, upon closure of the switch 62, to generate square waves 124, i.e. pulses, having a pulse duration of approximately 100 milliseconds. The repetition rate of said waves when the switch 108 connects the resistor 102 in circuit is about 40 cycles per minute. When the switch position is changed to connect the resistor 104 in circuit the repetition rate is about 70 cycles per minute, both said rates being within the normal range of frequency of human heart beats. The pulses 124 have an amplitude of from about 2.5 to 7 volts and a peak current of about 24 milliamperes.

To provide the doctor who is operating the device with a visual indication of the repetition rate of electrical pulses being generated a pilot lamp, e.g. a gas-filled electric lamp bulb 126 may be connected across the power lead 64 and the lead line 110. Said lamp is so mounted as to be visible through an opening in the casing 44.

The output lead wire 50 is connected to the body electrode 52, this being an electrode such as is conventionally employed for electrocardiograph operation. For example, the electrode 52 may simply constitute a metal plate with a strap to hold it against the body. However, for convenience and speed of use said electrode 52 may comprise a flexible rubber suction cup 128 having a handle 130 wherein there is located a metal stud 132 to which the lead wire 50 is connected. The head of the stud protrudes into the interior of the suction cup so that when the cup is pressed against a person's skin the head of the electrode will contact the same and thereafter will remain in position until the suction cup is deliberately released. To minimize contact resistance the operative face of the suction cup and the head of the stud 132 conventionally are coated, prior to use, with a water soluble electrically conductive paste or unguent.

The device constituting the hypodermic syringe, the hypodermic needle and the source of electrical pulses is adapted to stimulate a failing heart or to restart a stopped heart. The principal use of the device is in an emergency. When such a condition occurs the syringe is filled with a chemotherapeutic cardiac stimulant, e.g. adrenalin, if it is not already so filled. The clip 48 is connected to the electrically conductive hypodermic needle if it is not already so connected and the switch 46 is turned to "on" position.

The doctor, either through previous knowledge of the patient or through his expert appraisal of the patient when he sees him, estimates whether fast or slow electrotherapeutic stimuli should be applied and sets the switch 108 to what he considers the proper position, i.e. "fast" or "slow." Thereupon, or even before he energizes the source of electrical pulses, the hypodermic needle is plunged into the patient's chest to such an extent that the sharpened tip 36 enters the heart. Then the doctor depresses the plunger 14 to inject adrenalin into the patient's

heart. It will be appreciated that the doctor thus concurrently applies both chemical and electrical stimuli to the failing or stopped heart.

It has been found that these electrochemotherapeutic stimuli acting conjointly have on several occasions quickly restored normal beating action to patients whose hearts have been failing or stopped and such efficient restoration is believed to have been due to the combined effect of the electrical and chemical stimuli which concurrently acted with a speed and efficiency substantially in excess of the speed and efficiency of either of such stimuli used independently.

It will thus be seen that there is provided a device in which the several objects of this invention are achieved, and which are well adapted to meet the conditions of practical use.

As various possible embodiments might be made of the above invention, and as various changes might be made in the embodiment above set forth, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described the invention, there is claimed as new and desired to secure by Letters Patent:

1. An electrochemotherapeutic cardiac device comprising a hypodermic syringe having a hypodermic needle with an electrically conductive hollow liquid-conducting cannula, an electrically non-conductive sheath surrounding a substantial portion of the length of the cannula and leaving the tip bare, a source of electric pulses having a voltage in the order of 2.5 to 7 volts and a peak current in the order of 24 milliamperes, said source of pulses having a pair of output terminals, said pulses having a repetition frequency of approximately the same frequency as human heart beats, circuit means connecting one of said terminals to said cannula, a body electrode, and circuit means connecting the other terminal to the body electrode.

2. A device as set forth in claim 1 wherein the source of electric pulses is constructed and arranged to generate pulses having steep leading wave fronts.

3. A device as set forth in claim 1 wherein the hypodermic syringe is loaded with a cardiac stimulant.

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