

[54] **CONSTANT CURRENT ELECTROTHERAPY
DEVICE WITH PLUG-IN CURRENT
CONTROL MEANS**

[75] Inventor: **Anton James Horn**, Creve Coeur,
Mo.

[73] Assignee: **Sybron Corporation**, Rochester,
N.Y.

[22] Filed: **Jan. 16, 1974**

[21] Appl. No.: **433,923**

Related U.S. Application Data

[63] Continuation of Ser. No. 244,843, April 17, 1972,
abandoned.

[52] U.S. Cl. 128/419 R

[51] Int. Cl.² A61N 1/36

[58] Field of Search 128/2.1 P, 2.1 R, 2.06 A,
128/172.1, 404, 405, 410, 411, 418 P, 418
PT, 419 B, 421 F, 422, 1 D

References Cited

UNITED STATES PATENTS

3,107,672 10/1963 Hofmann 128/405
3,180,338 4/1965 Moss et al. 128/422

3,612,041 10/1971 Ragsdall 128/2.06 A
3,720,199 3/1973 Rishton et al. 128/1 D
3,756,245 9/1973 Thaler et al. 128/419 PT
3,769,986 11/1973 Herrmann 128/419 PT
3,807,411 4/1974 Harris et al. 128/419 P

OTHER PUBLICATIONS

Assimacopoulos, "The American Surgeon" Vol. 34,
No. 6, June 1968, pp. 423-431, 128/419F.

Friedenberg et al., "Surgery Gynecology & Obstetrics,"
Vol. 131, No. 5, Nov. 1970, pp. 894-899.

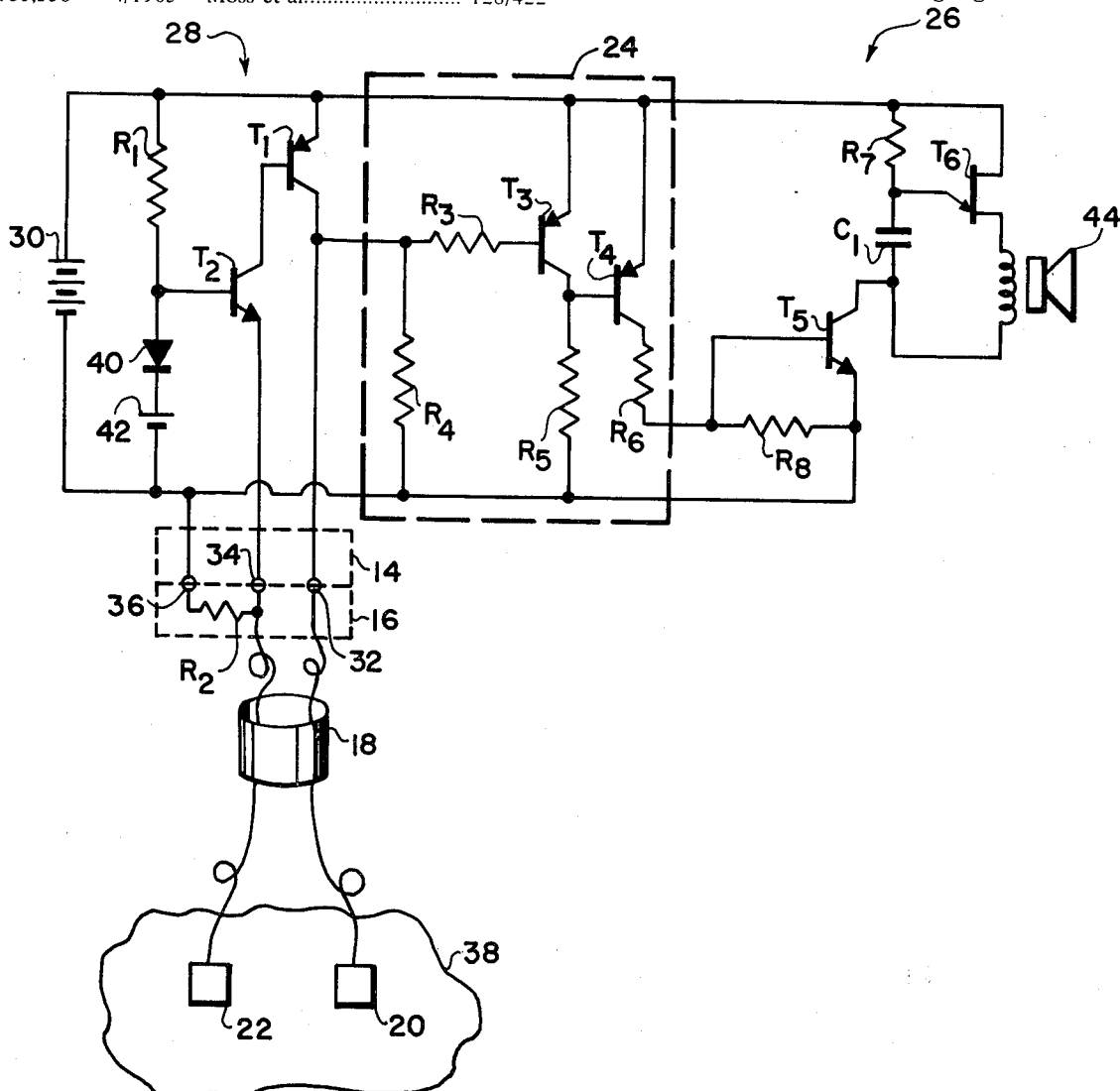
Primary Examiner—William E. Kamm

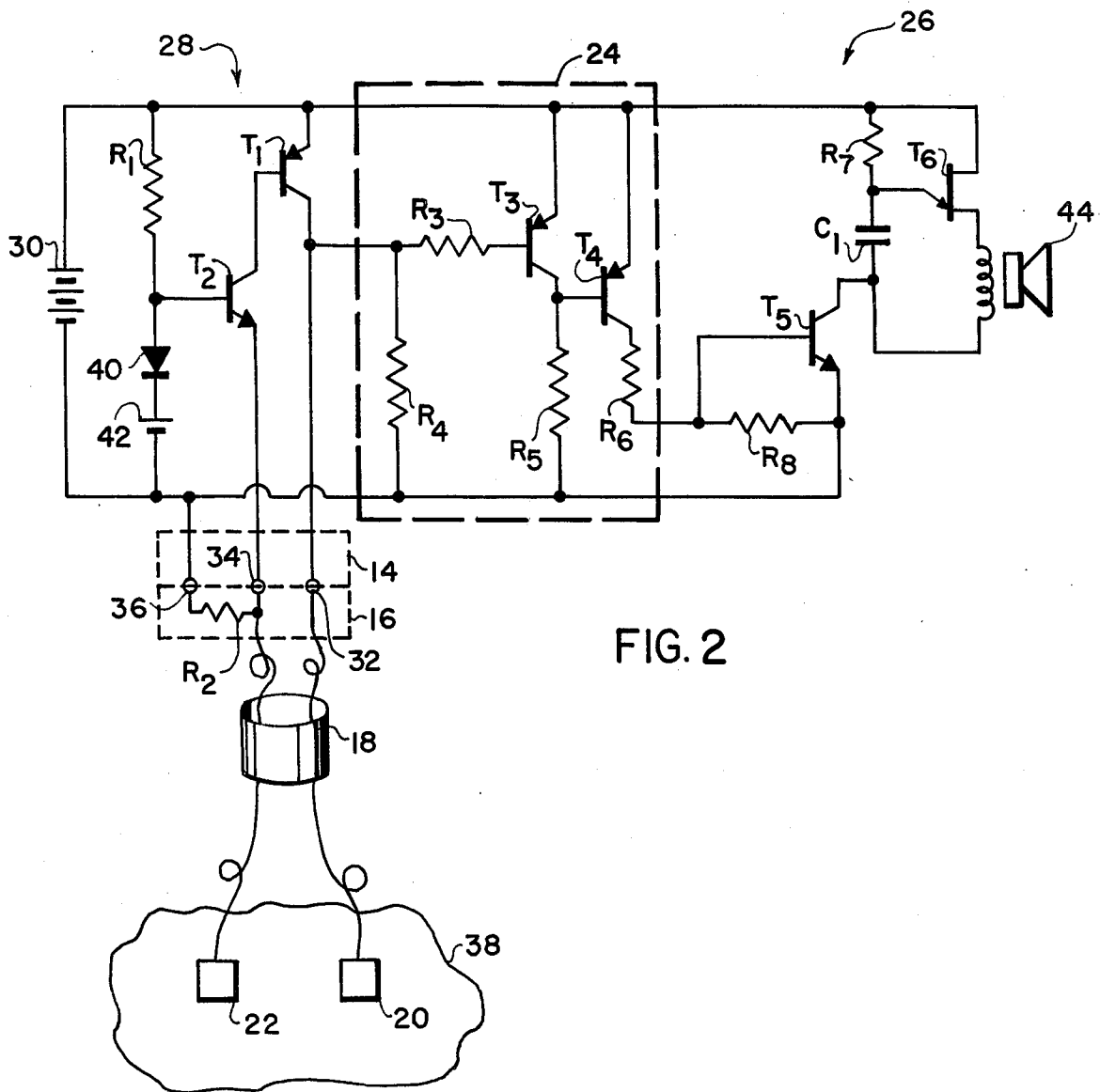
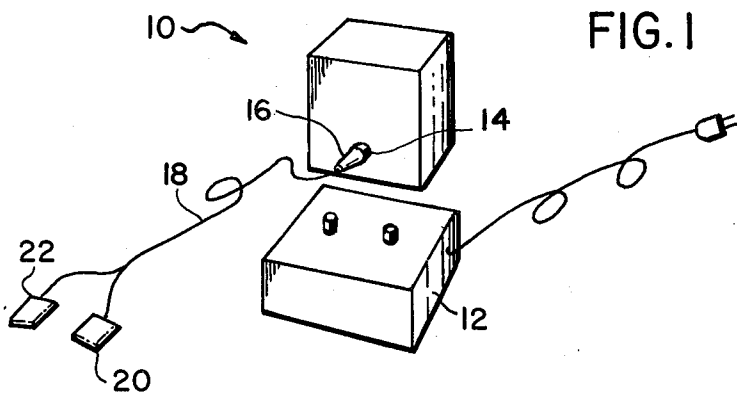
Attorney, Agent, or Firm—Theodore B. Roessel; Roger
Aceto; J. Stephen Yeo

[57] ABSTRACT

A low intensity direct current device for treating skin
ulcers and the like by electrotherapy, the device hav-
ing a simple tamper-proof arrangement to prevent the
patient or other uninformed persons from changing
the intensity of the prescribed current, and an alarm
to indicate an improper patient connection, or defect-
ive battery.

4 Claims, 2 Drawing Figures





CONSTANT CURRENT ELECTROTHERAPY DEVICE WITH PLUG-IN CURRENT CONTROL MEANS

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of my application, Ser. No. 244,843, filed Apr. 17, 1972, now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates to apparatus for the treatment of skin ulcers with a low intensity direct current to accelerate healing. More particularly, the present invention relates to such device having a relatively tamper-proof switching arrangement, for changing the intensity of the current.

Electrotherapy devices and techniques for accelerating the healing of skin lesions and ulcers are known. For a discussion of the treatment procedures and general description of the apparatus, reference is made to an article appearing on pages 795-801 of the Southern Medical Journal, Volume 62, No. 7, July 1969, and the reference cited therein. It is sufficient for purposes of the present invention merely to say that there are clinical tests which appear to demonstrate that healing of various skin lesions an ulcers can be accelerated by electrotherapy technique involving the application of low intensity direct current through electrodes attached to the area adjacent the lesion.

The devices in use to apply such a low intensity direct current are fairly large, cumbersome, and not easily transportable because of their size and weight. The switching mechanism used in such devices for varying the current flow is also a problem area. Regulation of current flow is important in that tests have shown that healing is promoted and the ulcer is kept dry when a proper amount of current is applied. Too much current results in the ulcer bleeding, and too little current results in secretion of serous fluid from the ulcer.

One common way of switching to provide the proper current is to have a simple stepping switch, or variable rheostat, to change the value of the resistance in series with the patient. With such an arrangement, however, the patient himself or some uninformed person could intentionally or accidentally move the switch so as to change the prescribed current value. Any increase or decrease from the prescribed proper value, that is one which maintains the ulcer in a substantially dry condition, will cause the wound to either bleed, or secrete serous fluid as set out above, and will not promote healing.

The device of the present invention is relatively small, compact, and the current setting is patient safe, in that there is no switch or dial which can be manipulated by the patient to change the current. The device also incorporates a sensing portion which sounds an alarm whenever the electrode attaching the device to the patient is improperly applied, or the voltage of the battery powering the device drops below an acceptable level.

SUMMARY OF THE INVENTION

The present invention may be characterized in one aspect thereof by the provision of a battery-powered device, capable of producing a low intensity direct current within a range suitable for electrotherapy of skin ulcers and the like. A cable having a pair of electrodes for delivering a prescribed current to the patient is

plugged into the device, the cables placing a known resistance in series with the patient current, wherein varying the level of the current is accomplished by changing cables. Incorporated into the device is a circuit portion which sounds an alarm whenever the voltage across the patient and cable resistor is about one volt of the battery voltage.

OBJECTS OF THE INVENTION

One object of the present invention is to provide a low-intensity direct current electrotherapy device wherein the output of the device is not changeable by the patient.

Another object of the present invention is to provide a low-intensity, direct current electrotherapy device having a selection of output ranges, wherein the means for changing the output is patient safe.

A further object of the present invention is to provide a low-intensity, direct current electrotherapy device having a self-contained alarm system which sounds when the output of the battery powering the device falls below a desired level or when the resistance between electrodes is excessive.

A still further object of the present invention is to provide a low-intensity, direct current electrotherapy device which is relatively small, lightweight, battery-powered, and relatively inexpensive to manufacture.

A yet further object of the present invention is to provide a low-intensity direct current electrotherapy device having easily replaceable cables, wherein each cable includes a resistor of known value, the changing of cables comprising means for changing the current output of the device.

These and other objects, advantages and characterizing features of the present invention will become more apparent upon consideration of the following detailed description thereof, taken in connection with the accompanying drawings depicting the same.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the low intensity direct current device of the present invention; and

FIG. 2 is an electrical schematic of the apparatus of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, FIG. 1 shown the device generally indicated at 10. Also shown is a recharger 12 for recharging the battery in device 10. The recharger itself forms no part of the present invention.

The circuit for producing the low intensity direct current is described hereinbelow. FIG. 1, however, shows a socket 14 on the device to which is releasably attached the plug 16 of cable 18. The cable terminates in two electrodes, 20, 22, which are attached to the patient adjacent the ulcer or lesion for purposes of delivering a low intensity direct current to the patient.

FIG. 2 shows the low intensity direct current circuit. The circuit has generally three portions, a sensor portion 24 enclosed in dotted line; and alarm portion 26 which is generally that portion of the circuit to the right of the sensor; and a working portion 28 for supplying a constant flow intensity direct current to the patient, this circuit portion being shown to the left of sensor 24. The main power source for operating the device is a battery 30, which in the embodiment shown is preferably a 9 v. battery.

Referring to the operating portion of the circuit, the schematic shows that socket 14 has three terminals, 32, 34 and 36; terminal 36 represents common, terminal 34 is a reference terminal, and terminal 32 is the patient terminal. Terminals 32 and 34 are connected to the patient schematically shown at 38 via cable 18, its 3-prong plug 16 and electrodes 20, 22. The electrodes are attached to the patient in a manner well known in the art to ensure the flow of current to the patient adjacent the ulcer to be treated.

When plug 16 is connected to socket 14, a resistor R2 incorporated into the plug, or cable, is connected across reference terminal 34 and common terminal 36 for purposes set out hereinbelow.

The operating portion 28 of the circuit which is connected to terminals 32, 34 and 36, includes a resistor R1, a PNP transistor T1, a NPN transistor T2, a diode 40 and a biasing battery 42, the biasing battery of the preferred embodiment being approximately 1.35 volts. This voltage, plus the voltage drop across diode 40 is sufficient to provide a bias of 1.6 volts on the base of transistor T2, to cause the transistor to conduct when plug 16 is inserted into socket 14, and the emitter circuit of transistor T2 is completed through reference terminal 34, resistor R2 and common terminal 36. The flow of the emitter current from transistor T2 placed a sufficient bias on the base of transistor T1 to start the flow of collector current from the transistor when the electrodes are attached to the patient. In other words, the patient is in the collector circuit of transistor T1, the circuit including patient terminal 32, electrode 20, electrode 22, resistance R2 and common terminal 36.

It should be apparent from FIG. 2 that raising or lowering the value of resistance R2 will in turn decrease or increase respectively the emitter current of transistor T2. Any increase or decrease in the emitter current of transistor T2 changes the bias on the base of transistor T1 to respectively decrease or increase the collector current of transistor T1. Thus, R2 can be used to effectively control the amount of current delivered to the patient in that any increase or decrease in the value of R2 will be reflected as a decrease or increase respectively in the low intensity direct current output or patient current.

It has been determined empirically that a direct current of between 200 and 800 micro-amperes will accelerate healing. Typically in this procedure, patient impedances run somewhat less than 8,500 ohms. This value varies somewhat depending upon the size of the ulcer and the distance between electrodes 20, 22. However, the direct current applied is not determined by the Patient resistance but by the value of resistance R2 in that the collector current of transistor T1, or patient current can be changed by changing the value of resistance R2.

As set out hereinabove, resistance R2 is incorporated into cable 18. For example, as shown in FIG. 2, resistance R2 can be located in the plug poriton 16, so as to be connected across reference terminal 34 and common terminal 36 when the plug and socket are connected. If several cables 18 are employed, each having a different value of resistance R2, it should be appreciated that each separate lead can be made to correspond to a desired current flow, and switching of current values can be accomplished by switching cables. With such an arrangement, the patient or un-informed person cannot change the current being applied to the pa-

tient, as in the case of having the current varied by a stepping switch or rheostat on the device.

In the present invention, changing of the current can only be accomplished by changing cables, that is unplugging plug 16 from socket 14 and removing the electrodes from the patient, substituting a new cable and attaching its electrodes to the patient.

Preferably, the present invention contemplates the use of four such cables, wherein resistance R2 for each cable has a value of about 1,500, 2,000, 3,000 or 6,200 ohms in order to provide currents respectively of 800, 600, 400 and 200 microamperes. With such an arrangement, the physician selects any one of the cables and observes the ulcer for bleeding or weeping of serous fluid. If there is no bleeding or weeping, the cable which has been selected remains with electrodes attached to the patient throughout the period of treatment. If either bleeding or weeping is observed, the cable initially selected would be replaced by a one providing respectively a lesser or greater amount of current flow. This procedure would be repeated until a cable 18 is selected which delivers the proper amount of current.

Describing now briefly the sensor portion 24 and alarm portion 26 of the circuit, it should be apparent from FIG. 2 that the voltage between patient terminal 32 and common terminal 36 is a function of transistor T1 collector current and the sum of the patient impedance and R2. This voltage drop is impressed upon the base of a PNP transistor T3 in the sensor portion of the circuit. The emitter of this transistor is connected to the positive terminal of battery 30, and therefore the emitter voltage is the same as the battery voltage. The sensor portion 24 of the circuit is arranged so that when the emitter voltage of transistor T3 drops to within less than 1 volt of the voltage on the base of the transistor, the transistor will begin conducting, which results in the sounding of an alarm 44 in the alarm portion 26 of the circuit. Thus, the sounding of alarm 44 indicates that the voltage of battery 30 has fallen to the point where it is within one volt of the transistor T1 collector voltage, that is the voltage drop between patient terminal 32 and common 36. This in turn indicates that battery 30 has decayed to a point where a replacement of the battery or recharge is desirable. In the alternative, the sounding of alarm 44 may indicate that there is an improper connection of electrodes 20, 22 to the patient. Such an improper connection would produce a relatively large voltage drop between patient terminal 32 and common terminal 36, and this also would result in a firing of transistor T3.

While all portions of the circuit have not been discussed in detail, it is believed that the portions which have been described together with the schematic of FIG. 2 and the parts list set out below will be sufficient to enable one skilled in the art to construct the device according to the present invention.

Parts List			
R1	3.9 Meg	C1	1.0 f
R3	3.9 Meg	T1, T3 & T4	2N 4250
R4	1.0 Meg	T2 & T5	2N 3565
R5	2.2 Meg	T6	2N 4871
R6	10.0 K	Diode 40	1N914
R7	3.3 K	Battery 42	1.35 v.mercury
R8	10.0 K	Battery 30	g v. dry cell
R 2		Patient Electrode Current	
6.2 K		200 ua	

-continued

Parts List	
3.0 K	400 ua
2.0 K	600 ua
1.5 K	800 ua

Thus, it should be appreciated that the present invention accomplishes its intended objects in providing low intensity direct current apparatus suitable for electrotherapy having a patient safe "switch" for setting the amount of current programmed into the patient. The amount of current can only be changed by unplugging cable 18, disconnecting electrodes 20, 22 from the patient, and then connecting a new cable to the device and new electrodes to the patient. The danger of having a manually operated step switch or rheostat for varying the current is eliminated. Furthermore, having a sensor portion of the circuit programmed to sound an alarm whenever the voltage drop across the patient is within one volt of the battery powering the circuit ensures that an improper electrode attachment to the patient or weak battery will be quickly detected, thereby reducing any danger of injury to the patient and increasing the effectiveness of the electrotherapy treatment.

Having thus described the invention in detail, what is claimed as new is:

- 1. A low intensity direct current device for electrotherapy uses comprising:
 - a. an electrical circuit means for producing a constant direct current of a predetermined value within a range of currents which promotes healing when passed through tissue containing a skin lesion, said circuit means having a pair of output terminals;
 - b. a cable for conducting the direct current produced by said circuit means to a patient, said cable having a socket at one end for connection to said terminals

- and a pair of electrodes at its other end for attachment to a patient;
- c. a battery connected to said circuit means for powering said circuit means;
- d. said circuit means having a sensor portion and electrically connected to at least one of said terminals and said battery, for comparing the voltage across said terminals to said battery voltage; and
- e. said circuit means having an alarm actuated by said sensor portion when the voltage across said terminals is within about one volt of said battery voltage.
- 2. A device as set forth in claim 1 wherein said sensor portion includes a transistor having its emitter electrically connected to said battery, its base electrically connected to one of said terminals, and its collector electrically connected to said alarm, said alarm being electrically connected to said battery the flow of collector current of said transistor being initiated when the voltage on the base thereof is within one volt of the emitter voltage, the flow of collector current resulting in the sounding of said alarm.
- 3. A device as set forth in claim 1 in which said circuit means includes:
 - a. a first transistor means functioning as a constant direct current source and connected to a first terminal of said two terminals and said battery for delivering a constant direct current through said first terminal and said cable to said patient, said direct current returning through said cable and the second terminal;
 - b. a second transistor means functioning as a bias for said first transistor means; and
 - c. a resistor electrically connected to said second transistor means for determining the bias level of said first transistor means and thereby the level of said constant direct current.
- 4. A device as set forth in claim 3 wherein said resistor is incorporated into said cable socket.

* * * * *