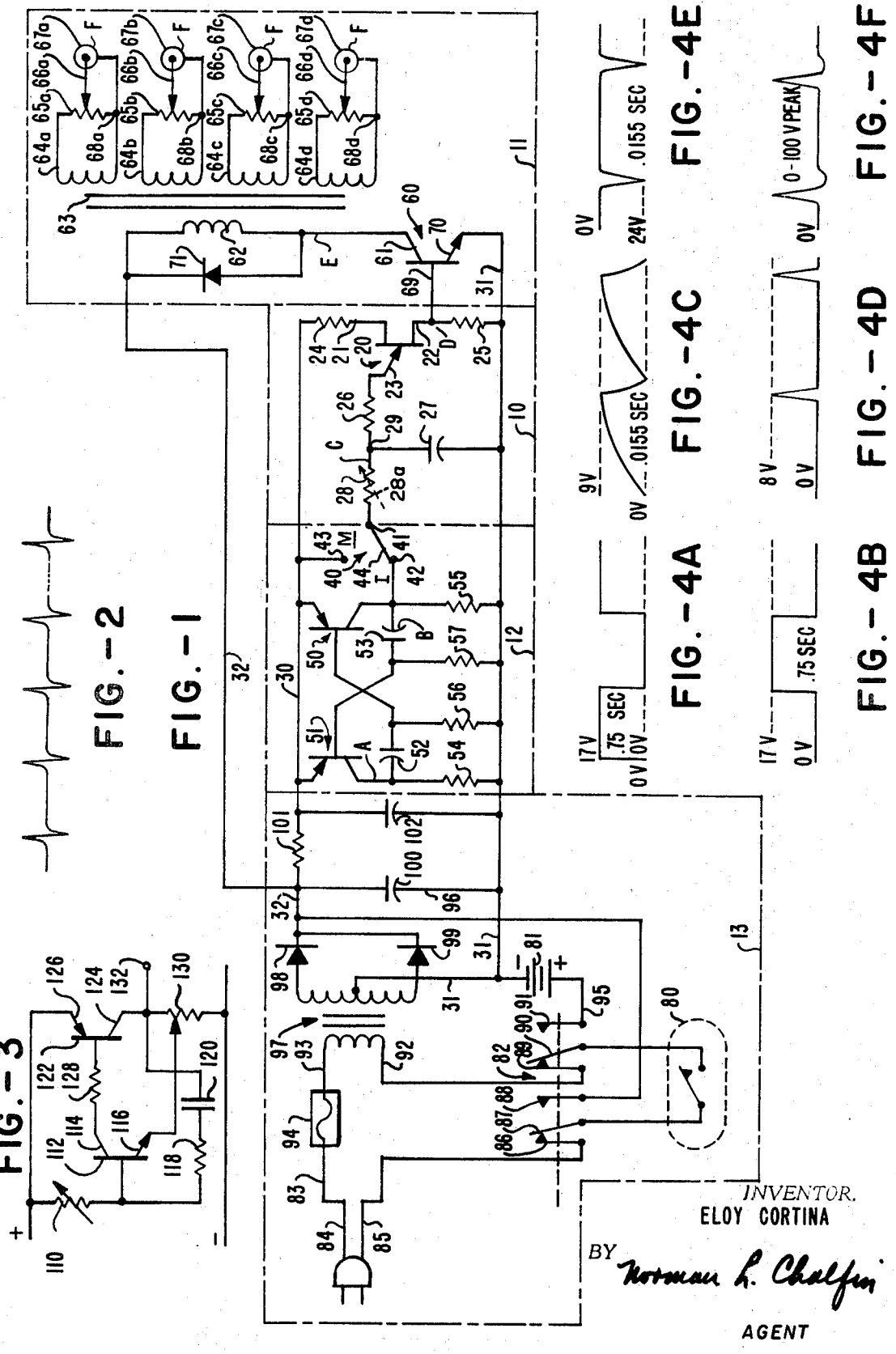
July 7, 1970 E. CORTINA 3,518,996

MUSCLE STIMULATOR

Filed April 17, 1967 2 Sheets-Sheet 1



July 7, 1970 E. CORTINA 3,518,996

MUSCLE STIMULATOR

Filed April 17, 1967 2 Sheets-Sheet 2

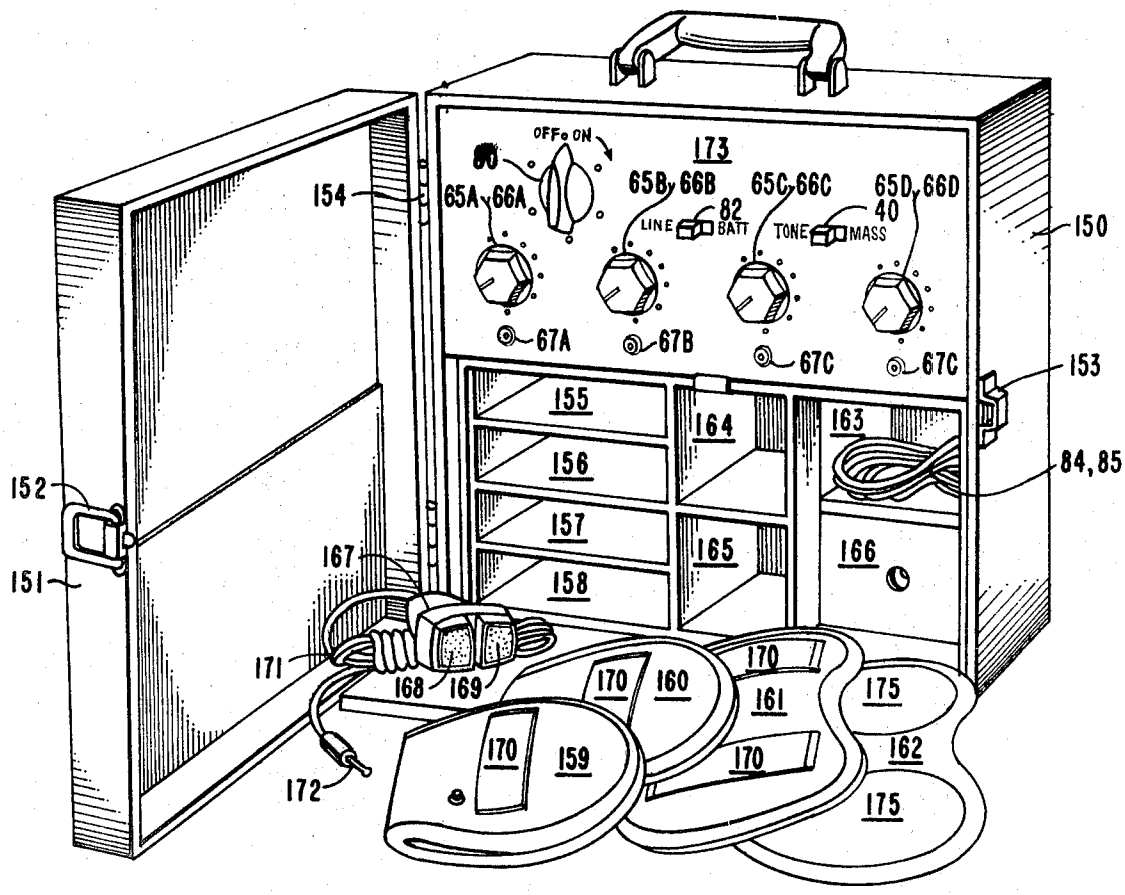


FIG.-5

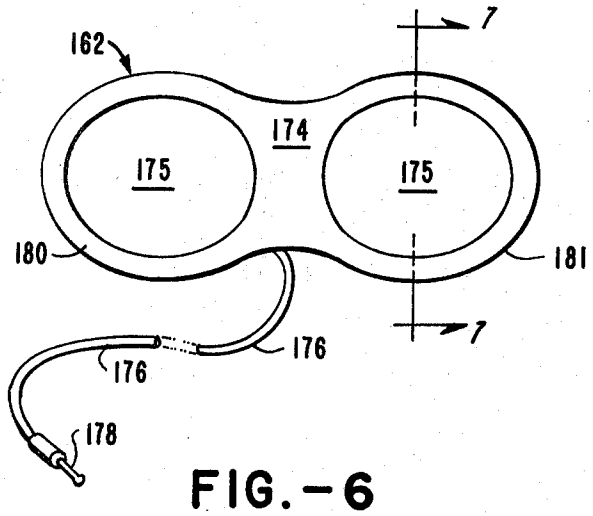


FIG.-6

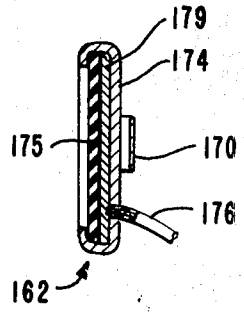


FIG.-7

INVENTOR.
ELOY CORTINA

BY Norman L. Chaffin

AGENT

United States Patent Office 3,518,996
Patented July 7, 1970

3,518,996

MUSCLE STIMULATOR

Eloy Cortina, 1655 10th St., Santa Monica, Calif. 90404

Filed Apr. 17, 1967, Ser. No. 631,207
Int. Cl. A61n 1/36
U.S. Cl. 128—422 2 Claims

ABSTRACT OF THE DISCLOSURE

A muscle stimulator is described wherein a generator of a train of relatively low frequency, generally spiked pulses of short duration compared with the interval between pulses is provided. The pulse train is operated continuously, or selectively, under the control of a multivibrator for predetermined on and off periods. The stimulator has a plurality of outputs each with an individual output control. It employes all transistors in its active circuits and may be operated from battery power sources or from the A-C power lines.

BACKGROUND OF THE INVENTION

This invention relates to electro-medical apparatus generally, and more particularly to an electric oscillation generator of novel design for use as a stimulator of muscle activity.

It is well known that by an electric stimulation of nerves, muscles can be excited to contract in a manner very like the voluntary contraction of muscle an individual experiences during various physical exertions and activities in a person's normal waking day.

Some muscles are not usually exercised, especially by persons whose general activity is sedentary in nature and who thereby develop flabby muscle tissue. Frequently this flabby tissue gives the person an appearance of being "fat" when in fact it is only a condition requiring the toning up of the sagging or flabby muscle tissue to regain a more pleasing appearance.

The above mentioned electrical stimulation of muscles through excitation of the nerves which control them can be accomplished by the application of stimulating pulses of electric character through a person's body exterior.

The excitation of nerves is an "all or none" action. That is, the nerve is either excited or not, depending upon the intensity of the stimulus applied to it. Once excited, no further increase in the intensity of the stimulus will produce further transmission of the impulse leading to the nerve-directed activity. The muscle, for example, which is responsive to the nerve stimulated by the stimulus impulse, once reacting, remains in the reactive condition until the stimulus is removed.

To those familiar with electronic apparatus, this nerve-muscle stimulus behavior may be appreciated as resembling the behavior of a conductive electronic device normally biased for non-conduction, which, when the bias is overcome by an appropriate signal applied thereto, is fully activated to become conductive, and no further increase in the bias overcoming signal will increase the conduction. The device then remains conductive until the stimulating signal is removed, at which time the device returns to its non-conductive condition.

These nerve-muscle "bias-overcoming" signals, as has been pointed out above, may be applied to appropriate areas of the body exterior in the form of electrical impulses either applied for an extended period to produce a sort of "massaging" effect, or they may be applied over relatively short alternate periods of application and removal of the electric impulsive stimulating signal to produce repeated contraction and relaxation of the muscles being stimulated, generating thereby an involuntary form

of exercise of the muscles without the usual physical exertion normally associated with "exercise."

SUMMARY OF THE INVENTION

This invention contemplates a novel electrical impulse generating system and means for applying the impulses so generated to the appropriate areas of a person's body by which the above described "massaging" and "exercising" effects upon the muscles may be selectively achieved, as desired. The impulses generated by the new system are uniform, relatively narrow spiked pulses, or alternatively, may be rectangular pulses of short duration separated by intervals of somewhat longer duration. These pulses are hereinafter described as the higher frequency pulses. Additionally in the new system, longer duration pulses are produced to be used as interruption pulses of relatively low frequency to be applied to the narrow spiked pulse generator for on-off operation thereof.

In the electrical impulse generator according to the invention, a novel oscillator for producing the spiked narrow or rectangular pulses and a power amplifier have been devised utilizing semi-conductor devices. The resulting pulses are applied to a plurality of separate outputs, each of which may be individually adjusted as to output level. To each of the respective outputs electrodes may be attached. These electrodes are adapted for positioning on the body exterior on the areas where the muscles it is desired to stimulate will respond.

The impulse generator ineludes also a semi-conductor very-low frequency switching signal generator which may be selectively applied to the oscillator so as to turn it on and off for appropriate periods. Means may be provided to adjust the periodicity rate of the switching signal generator so as to produce uniform on and off periods for the oscillator, or the off periods may be made longer than the on periods at will, or vice-versa.

The above described objects of the invention and others will be more clearly understood from the specification which follows, taken together with the drawings and the appended claims.

It should be clearly understood that the embodiments shown and described are representative of the novel concepts of the invention and should not be construed as limiting the invention thereto since those skilled in the arts appertaining to the invention will be able to device other embodiments in the light of the teachings herein within the ambit of the claims.

DESCRIPTION OF THE INVENTION

FIG. 1 is a schematic circuit diagram of a muscle stimulator according to this invention;

FIG. 2 is a diagram of a typical waveform train such as may be produced by the circuit of FIG. 1 during continuous operation thereof;

FIG. 3 is a schematic circuit diagram of an alternative adjustable high-frequency pulse generator which may be used as part of the circuit arrangement shown in FIG. 1;

FIG. 4 (A through F) illustrate waveforms to be observed at various points in the circuit shown in FIG. 1;

FIG. 5 is a perspective view of a muscle stimulator instrument according to the invention showing its installation in a carrying case also designed to accommodate the accessory electrode pads which are also illustrated;

FIG. 6 is a plan view of one of the electrode pads shown in FIG. 5; and

FIG. 7 is a cross-section through 7—7 of FIG. 6.

In FIG. 1 a schematic circuit diagram of the muscle stimulator is shown. The stimulator circuit can be seen to include an oscillator **10**, an amplifier **11**, a switching circuit **12**, and a power supply **13**.

The oscillator **10** utilizes a unijunction transistor **20**

which has first base terminal **21**, a second base terminal **22** and an emitter **23**. A first base load resistor **24** is connected between first base terminal **21** and a positive potential line **30**. A second base load resistor **25** is connected between second base terminal **22** and a negative potential line **31**. A series resistance combination **28**, **26** is connected between an armature terminal **41** of a single pole double throw switch **40** and emitter terminal **23**. A capacitor **27** is connected between the junction **29** of resistors **26**, **28** and negative line **31**.

Switch **40** has a terminal **42** and a terminal **43**. Terminal **43** is connected to positive potential line **30** so that when the arm **44** of switch **40** is connected to terminal **43** identified with M, unijunction transistor **20** operates as a continuous oscillator generating a saw-tooth wave. The frequency of oscillation is a function of the values of capacitance of capacitor **27** and resistance of resistor **28**. The resistance of resistor **28** may be made variable as indicated by dashed line **28***a* in order to provide setting of the frequency of oscillator **10** as desired. Resistor **26** functions as a current limiting resistance in the emitter **23** circuit. When arm **44** is connected to terminal **42** identified with T, the oscillation of unijunction transistor oscillator **10** is interrupted so as to be operative only when transistor **50** is conductive as hereinafter described.

Amplifier **11** includes a transistor **60** shown here as an NPN device, but which may as well be a PNP device as would be obvious to those skilled in this art. If a PNP device is used, connections of the transistor will have different polarities. The collector **61** of transistor **60** (NPN) is connected through the primary **62** of an output transformer **63** to a positive potential line **32** at a different potential than that at line **30**. Transformer **63** has four identical independent secondary windings **64**, *a*, *b*, *c*, *d*, across each of which is connected respective potentiometers **65**, *a*, *b*, *c*, *d*. From respective variable arms **66**, *a*, *b*, *c*, *d* of potentiometers **65***a–d* output jacks **67**, *a*, *b*, *c*, *d* are connected. Each respective jack **67***a–d* has a respective return connection to one end **68**, *a*, *b*, *c*, *d*, of potentiometers **65***a–d*. It is to be noted that as a result of the individual character of the windings **64***a–d* each of the output terminals **67***a–d* will provide independent and separately usable signals as hereinafter delineated.

The base **69** of transistor **60** is directly coupled to second base **22** of unijunction transistor device **20**.

The emitter **70** of transistor **60** is connected to negative potential line **31**.

The operation of transistor amplifier **60** is essentially conventional with the exception of the direct coupling of base **69** to second base **22** of unijunction transistor **20**. The signals appearing on second base load resistor **25** drive amplifier **60**; the amplified output appearing across primary winding **62** of transformer **63**. Diode **71** is connected across primary **62** to suppress inverse polarity pulses so that only unipolar pulses are present in primary **62** to generate in each of secondaries **64***a–d* the pulse waveform shown in FIG. 2.

In the dashed block **12**, PNP transistors **51**, **50** are shown connected in a conventional multivibrator configuration. Capacitors **52**, **53** and resistors **56**, **57** are the frequency determining elements of the multivibrator operation, resistors **54**, **55** are collector load resistors. The frequency determining elements **52**, **53**, **56**, **57** can be made adjustable so as to provide adjustment of the operating frequency of multivibrator **12**.

In normal use oscillator **10** operates at frequencies in the range of 20 through 100 pulses per second. Multivibrator **12** is normally used at much lower rates from about 10 per minute to about 30 per minute. It is to be understood that these pulse rates are the rates at which the oscillator **10** can be turned on and off when arm **44** of switch **40** is connected to terminal **42**. It is to be noted that terminal **42** is connected with the collector of transistor **50**. Thus when transistor **50** is conductive during the multivibrator operation oscillator **10** is on. When multivibrator transistor **50** is not conductive then oscillator **10** is off. This is because during the conductive condition of transistor **50** the emitter **23** of unijunction transistor **20** is returned through transistor **50** to the positive potential line **30** and the oscillator circuit is thereby completed.

The operation of multivibrator transistors **50**, **51** can be adjusted by the appropriate values of resistors **56**, **57** and capacitors **52**, **53** so that either the on periods of oscillator **10** are longer than the off periods, or the reverse condition may be effected in which the off periods are longer than the on periods, or the periods of on-off operation may be made uniform as desired for particular medical requirements.

The system hereinabove described may be powered either from the A-C power lines through a rectifier circuit, or batteries may be used. The on-off operation of the power supply **13** is normally under the control of a timer **80** which is set for a predetermined treatment interval.

A novel switching arrangement has been incorporated in this instrument so that the user may at will employ the self-containing battery **81** or the power line **83** and in either case have the advantage of the same timer switch **80**. This is accomplished through the use of a double pole double throw switch **82**.

Switch **82** includes switch arms **87** and **90** which are manually operable to contact either terminals **86** and **89** or terminals **88** and **91**. In the first instance power line wire **85** and primary return wire **92** from power transformer **97** are connected through arms **87** and **90** and terminal contacts **86** and **89** to timer **80**. Timer switch **80** is a typical mechanical clock driven switch of conventional design similar to those well-known to the photographic industry for operating exposure lamps for predetermined intervals and in household equipment for cooking timing functions.

Power line wire **83** is connected through a fuse **94** to the other side **93** of the primary of power transformer **97**.

So long as timer switch **80** is closed by its clock mechanism when switch **82** is in the power line position A-C power from the line is applied to transformer **97** and induced in the secondary thereof to be rectified by full wave semiconductor rectifiers **98** and **99**. A D-C potential is thus developed on line **32**. When the timer switch is open power is removed.

Resistor **101** connected between lines **30** and **32** and capacitors **100** and **102** provide filtering and voltage dropping action so that the D-C voltage on line **32** is higher than that on line **30**.

When the arms **87–89** of switch **82** are in contact with terminals **88** and **91** thereof timer switch **80** is connected between line **96** and the positive terminal of battery **81** to apply the positive potential through switch **80** to line **32**. The negative terminal of battery **81** is permanently connected to negative line **31** which is common to both A-C rectified and battery D-C power supplies.

Because of the polarization of rectifiers **98** and **99**, there will be no effect upon the battery **80** or transformer **97** in the configuration used; they are non-conductive for the polarity of battery **81** with respect to lines **96** and **31** and diodes **98** and **99**.

In the waveform diagrams of FIGS. 4A through 4F, the letter designations A through F correspond to the letter designations "A" through "F" appearing at various points in the circuit diagram of FIG. 1.

For example, the rectangular waveform shown in FIG. 4A is to be observed at "A" the collector of transistor **51**, while the waveform of FIG. 4B is to be observed at the collector "B" of transistor **50**. The saw-toothed waveform shown at 4C may be observed at "C" in FIG. 1 across capacitor **27**. The spiked waveform shown in FIG. 4D is observed at "E" on the collector **61** of transistor **60** and across the primary **62** of transformer **63**.

The output waveform shown at 4F appears at each of the output jacks **67***a–d* as indicated by "F."

When switch arm **41** of switch **40** is connected to terminal **43** a continuous train of pulses as shown at 4F appears across each of controls **65***a–d* and each of respective secondary winding between **64***a–d* and **68***a–d*, and at output jacks **67***a–d* (points "F").

When switch arm **41** is connected to terminal **42** as shown in FIG. 1 a train of pulses such as shown in FIG. 4F occurs continuing only for the period of the pulse shown in FIG. 4B, a period of .75 second. If the values of resistors **56**, **57** and/or capacitors **52**, **53** are changed, the period of the pulse of FIG. 4B may be shortened or lengthened, giving a longer or shorter train of pulses as in 4F.

Ordinarily, for general public use of the muscle stimulator, a fixed pulse duration for pulses shown at 4F and at 4B is employed in instruments made available to the general public.

For medical use and hospital use of muscle stimulators, according to the invention a circuit such as that shown in FIG. 3 may be employed to provide selectively different pulse durations or duty cycles for the pulses such as shown in FIGS. 4D, 4E and 4F and also variations in frequency or repetition rate of these pulses may be made. In the circuit of the pulse generator shown in FIG. 3 variable resistor **110** provides for duty cycle variations or selection and variable resistor **130** can be adjusted to provide for different pulse repetition rates as desired for the pulses shown at 4D, E and F.

In FIG. 5 there is shown a representative encasement for a muscle stimulator according to this invention. The encasement includes a relatively deep case **150** to receive the electronic equipment and store the accessories of the invention device, and cover **151** attached removably by hinges **154**. Trunk type clasp **152**, **153** interfit to hold cover **151** on case **150** when the case is closed. Compartments **155–158** are provided to receive electrode pads **159–162** for storage thereof. The pads shown at **159**, **160** are folded as they are stored in compartments such as **155–158**. The pad **161** is face down, and pad **162** is face up. On the backs of the pads **159**, **160**, **161** loops are provided so that the electrode pads may be assembled on body or limb encircling belts (not shown) such as are well known in the surgical and therapeutic arts. Such belts may be stored in compartment **164**.

A different form of electrode structure is shown in FIG. 5 at **167**. This is known as a "facial" electrode and its two terminal sponge pads **168**, **169** are positioned so as to stimulate and exercise facial muscles when applied to a patient's face. The sponge pads **168** and **169** may be moistened with conductive jellies or fluids. It is said that this tones the facial muscles which may be sagging in the same manner as the pads **159–162** provide body and limb musculature toning when applied thereto. The electric cord **171** and plug **172** are provided to permit facial electrode **167** to be inserted in one of the jacks **67***a–d* on the front panel **173** of the muscle stimulator.

The compartment **163** in case **150–151** is provided for storage of electric power cord **84**, **85** and covered compartment **166** for storage of the battery **81** (FIG. 1).

On the instrument panel **173** are identified the controls, jacks, and switches forming the control devices identified in the circuit of FIG. 1. These control devices and jacks bear the same reference characters in FIG. 5 as those in FIG. 1 and correspond accordingly.

In FIGS. 6 and 7 are shown respectively a face plan view and cross-section (7—7) through a typical body and limb musculature electrode pad as such as shown in FIG. 5 at **159–162**. The unit **162** is selected for the ensuing description:

The electrode pad **162** comprises a pair of electrode elements **180**, **181** forming an overlapping double oval enclosure **174** in which are inserted pairs of conductive rubber pads **175** each backed by a metal contact plate **179** (see cross-section diagram, FIG. 7). The conductors of electric connection leads **176** are soldered to the metal contact plates **179** and terminate in a plug **178** which may be inserted into any one of the jacks **67***a–d*. Leads **176** are covered with insulation.

In use the muscle stimulator is operated by inserting the plugs **178** of pads **159–162** or similar pads into selected jacks **67***a–d* in panel **173**. If the unit is operated on A-C power lines the cord **84–85** is plugged into the A-C outlet and switch **82** positioned for A-C operation. If the internal battery **81** is used switch **82** is positioned for battery operation. The equipment is rendered operative in either battery or A-C operation by rotating time switch **80** to its desired time of operation. The operation will continue for this selected time interval. The amplitude of output pulses applied via electrodes **159–162** is adjusted by controls **65**, **66***a–d*. The continuous (massage) operation of the pulse output or interrupted output (tone) operation is selected by the appropriate positioning of switch **40**.

There has been described hereinabove a signal generator for muscle stimulation comprising in combination a unijunction transistor oscillator **10**, a power amplifier **11** with multiple outlets, a multivibrator switching pulse generator **12** switching means for selectively operating the oscillator in a continuous or an interrupted mode, and a power supply **13** selecitvely operable from either a battery or an A-C power line rectifier source under the switching control of a clock operated timer for predetermined intervals.

What is claimed as new is:

1. In a muscle stimulator

a unijunction transistor having a pair of bases and an emitter, one of said bases having an output load resistor connected thereto, said emitter having a frequency determining network connected thereto;

a source of potential having respective negative and positive potential lines, the negative potential line being connected to said output load resistor, and the positive potential line being connected to the other of said bases as a circuit return;

an amplifier circuit connected to said load resistor and having an output transformer in the output of said amplifier with a plurality of outputs;

an astable transistor multivibrator; and

a circuit selection switch connected between said multivibrator, said frequency determining network and said positive potential line so that in one position of said switch said emitter and the frequency determining network can be connected to said multivibrator to the turned on and off at frequency of said multivibrator frequency so that said unijunction transistor will oscillate intermittently at a frequency determined by said frequency determining network, an in another position of said switch, said frequency determining network is connected to said positive potential line so that the unijunction transistor will oscillate continuously at said frequency of said frequency determining network,

said respective continuous or intermittent oscillations being produced in said plurality of outputs of said output transformer.

2. A muscle stimulator comprising

an oscillator operable at one oscillation frequency

a single pole double throw switch;

an amplifier connected to said oscillator;

an output transformer connected to said amplifier;

a multivibrator for generating pulses at a lower frequency than said one frequency:

at least one electrode pad;

a power supply means connected to an A-C supply source;

a battery power source; and

a mechanically settable timing switch means connected

between said power supply means, and said battery and said oscillator, multivibrator, and amplifier, so as to selectively apply said power supply means or said battery to said oscillator multivibrator and said amplifier for a selected time interval set on said timing switch, so as to operate said stimulator for said selected interval.

and said single-pole double throw switch including an arm an first and second poles, said arm being connected to said oscillator and said respective poles being connected to said multivibrator and to said power supply means respectively so that said oscillator can be maintained selectively in a continuously operating condition or in an interrupted oscillating condition at the frequency of said pulses, and said transformer being connected to said at least one of said electrode pads for applying said selected continuous or interrupted oscillations to muscles of the body

when said pad is positioned on said muscles to stimulate the contraction and relaxation of said muscles during said interrupted operation and massaging operation during said continuous operation of said oscillations.

References Cited

UNITED STATES PATENTS

2,838,672	6/1958	Paust	128—422
3,025,858	3/1962	Browner	128—422
3,108,597	10/1963	Moss et al.	128—422
3,279,468	10/1966	Le Vine	128—410

FOREIGN PATENTS

826,766	1/1960	Great Britain.

WILLIAM E. KAMM, Primary Examiner